Processing of agricultural waste in the Penza region

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Annotation. In this work we considered the impact of uncontrolled waste of the agricultural sector on the biosphere. We estimated assessment of the energy potential of the Penza region and its technologically utilization. We compared the obtained data with the volumes of energy supplies. We carried out the analysis of existing technologies of processing and utilization of agricultural waste. In this work we studied the influence of various operational factors on the efficiency of processing different types of waste and the utilization of the resulting fuel. We issued recommendations for the introduction of new technologies and effective utilization.

1. Conduct

Penza region has vast areas of arable land, gardens, pastures and greenhouses. The region is located in the zone of temperate climate, forest-steppe zone, soils with a predominance of Chernozem [1]. The flat terrain and sufficient moisture create favourable conditions for the production of cereals, fodder and industrial crops, vegetables and fruits.

The region has developed dairy and meat livestock. Poultry farm is represented by large agricultural holdings that produce chickens, broilers, turkey meat and eggs [1]. A significant amount of food production is provided by private and farms. All this characterizes the Penza region as an agricultural region with great prospects for development.

Wastes of different agricultural industries are hydrocarbon compounds of different composition and structure. In crop production it is stems, leaves, husks, husks, roots.

Animal husbandry and processing gives manure, droppings, fat and oil waste, defective and expired products. In the process of harvesting and primary processing, waste is obtained in dry form or in the form of a wet mass. Animal’s manure is most often obtained in liquid form-pulp, and bird droppings-in dry form. Sometimes manure comes in a mixture with sawdust, straw, litter material.

Nowadays, the technology of processing and utilization of waste in the region is poorly developed. The bulk of the waste is taken to the fields and ploughed. Part goes to composting and organic fertilizers. Sometimes they are dumped. In some cases, waste accumulates for years and presents a serious danger to the environment and humans. The decomposition products penetrate into the soil, into the aquifer and carry away by the wind for considerable distances.

The problem of waste accumulation is manifested for processing enterprises. Production of sunflower oil, sugar, seeds requires significant amounts of raw materials. In this case, waste is accumulated in warehouses, stored in open areas and not exported on time. The rotting processes begin with long-term storage in wet weather. In dry weather there is a danger of fires. Waste is a food base for birds and small rodents, which act as carriers of many diseases. This creates the risk of epidemics.
2. Research methods and materials

Processing and utilization of agricultural waste is carried out in the following ways:
1. Utilization for animal's feed.
2. Processing into fertilizer.
3. Processing into fuel.
4. Burning.
5. Removal to landfills and burial.

Most enterprises in the agricultural sector have implemented the first two. The problem of utilization agricultural waste as fuel becomes actual as a result of increased prices in energy and the development of alternative energy technologies. Waste is a renewable resource and is replenished annually. Recycling can completely replace the supply of traditional fuels or reduce the volume of purchases.

Processing of agricultural waste into fuel is carried out in the following ways:
1. Combustion in solid fuel boilers
2. Briquetting.
3. Production of pellets.
4. Processing into gas fuel.
5. Processing into liquid fuel.

The technology of briquetting and pellets production has mastered in the Penza region nowadays. The waste in dry form is used for distributed generation of thermal energy. But the total volume of processing does not exceed 7 %. The most promising and convenient in the application is to obtain gaseous fuel. The production of gaseous fuel in the area far from the main gas pipelines would allow the use of modular gas fired boilers houses and establish the generation of electric energy.

Nowadays the world practice has developed and is widespread two directions of processing agricultural waste into gas fuel - biotechnology and thermal technology. Biotechnologies are based on the cultivation of several generations of bacteria for the processing of organic substances [2]. They are more efficient, but require expensive equipment and strict adherence to technological processes.

Biogas is a product of biomass processing of different origin, which is much cheaper than conventional fuel. Its production is environmentally safer and cleaner. Biogas is produced in bioreactors, in which biological waste is decomposed by bacteria without air access [2].

The state Russian program "Bio-2020" adopted in 2012. The aims is to accelerate the development of biotechnology. The transition to biofuels will reduce the economy's dependence on fluctuations on the oil stock market. The main tasks of the program "Bio-2020" is the development of the bioenergy industry, in which a significant place is given to the production of biogas and bioethanol [2].

Table 1 shows the volume of crop production in the Penza region on the example of 2015. The table sets the volume of waste in the processing of the main crops and the possible volume of gaseous fuel production by different technologies [2].

| № | Culture    | Production mass Th. ton | Waste mass Th. ton | % yield | Gross biogas volume Th. cubic meters | % yield | Gross synthesis gas volume Th. cubic meters | % yield | Gross pyrrol gas Volume Th. cubic meters |
|---|------------|-------------------------|--------------------|---------|-------------------------------------|---------|---------------------------------------------|---------|-----------------------------------------|
| 1 | Wheat      | 95.6                    | 239.2              | 80      | 114433                              | 40      | 95680                                       | 95      | 227240                                  |
| 2 | Barley     | 277                     | 69.5               | 80      | 32076                                | 40      | 27700                                       | 95      | 65787                                   |
| 3 | Corn       | 207                     | 1035               | 80      | 491832                               | 38      | 393300                                      | 90      | 931506                                  |
| 4 | Sunflower  | 262                     | 2096               | 70      | 865648                               | 32      | 670720                                      | 90      | 1886412                                 |
| 5 | Sugar beet | 1500                    | 750                | 60      | 256050                               | 32      | 240000                                      | 88      | 660008                                  |
| Total |            | 4189                    | 1760040            | 142740  | 3770928                               |         |                                             |         |                                         |
The volume of gas obtained on the basis of biotechnology, will comprise 1.76 billion cubic meters by the method of gasification of 1.43 billion cubic meters, piroliza – of 3.77 billion cubic meters. Production and accumulation of biomass is carried out over a large area. Collection and delivery of raw materials from remote sources is economically unprofitable. Really, it is possible to sell about half of this volume, a maximum of 2 billion cubic meters of gas.

Table 2 shows the indicators of animal husbandry and production of gas fuel in the cultivation and slaughter of livestock.

| №  | Name                | Livestock | Waste mass | yield | Gross biogas volume | yield | Gross synthesis gas volume | yield | Gross pyrrol gas volume | yield |
|----|---------------------|-----------|------------|-------|---------------------|-------|---------------------------|-------|-------------------------|-------|
|    |                     | Th. heads | Th. ton    | %     | Th. cubic meters    | %     | Th. cubic meters          | %     | Th. cubic meters         | %     |
| 1  | Pork                | 259       | 286        | 80    | 228800              | 50    | 143000                    | 95    | 271700                  |
| 2  | Cattle              | 180       | 572        | 80    | 457600              | 50    | 286000                    | 95    | 543400                  |
| 3  | Small cattle        | 119       | 133        | 80    | 106400              | 53    | 70490                     | 90    | 119700                  |
| 4  | Poultry (million)   | 187       | 133        | 80    | 168000              | 52    | 29120                     | 60    | 33600                   |
| 5  | Blank (thou- sand tons) | 253   | 112        | 80    | 44800               | 48    | 53760                     | 88    | 98560                   |
|    | Total               | 854400    | 582370     |       | 1066960             |       |                           |       |                         |

The energy potential of animal husbandry is inferior in volume to crop production, the maximum gas production does not exceed 1.07 billion cubic meters.

3. The research results
The thermal process of recycling waste into gas or liquid fuel consists in breaking high-molecular compounds into simple compounds and hydrogen saturation. The yield of gas fuel depends on the processing method, feedstock and process flow diagrams. For this purpose we are used the methods of gasification, steam conversion and pyrolysis. Figure 1 represents a comparative analysis of different technologies of thermal processing of agricultural waste.

The most effective is the gasification process, which is carried out at a temperature of up to 600 °C.
and gives a gas yield of up to 40% by weight of raw materials. At a temperature of 400-600 °C the slope of the curves is approximately the same, the increase in heat costs gives a noticeable increase in gas output. High-temperature pyrolysis requires significant fuel costs. This pyrolysis is ineffective.

Gasification of wastes on gas output is inferior to biotechnologies. But technological processes are much simpler, more cost-effective and can be implemented in small farms. Waste gasification requires minimal financial expenses for equipment and personnel training. These technologies will allow to produce gas fuel and to establish local generation of electric and thermal energy [3].

High-temperature processing technologies allow to safe processing of a wide range of bioresources. The volume of sludge after gas production is reduced approximately half, the costs of transportation and utilization of waste are reduced.

4. Conclusion
The following analysis demonstrates that the structure of agricultural production has a huge energy potential, which is not being used. The realization of potential requires significant initial capital investment and support at the state level. For large agro-enterprises and processing enterprises there is an opportunity of delivery of equipment to leasing. The energy potential of agricultural production in the Penza region is 4.84 billion cubic meters of gas fuel, of which 2.4 billion cubic meters are technically accessible. Natural gas supplies, according to Mezhregiongaz-Penza, average 2.5 billion cubic meters per year. The potential is sufficient for the complete gas supply.

Processing of waste of livestock, food industry and wood processing requires the use of high-temperature pyrolysis plants. These technologies are more expensive and can be used only in large agricultural firms. But at the same time significantly increases the yield of gas fuel and possible utilization of hazardous waste.

The introduction of technologies for processing agricultural waste into gas fuel will change the environmental situation in the region. The impact of uncontrolled decomposition of waste on flora and fauna will be reduced, and the microbiological situation will improve. The volume of waste that requires burial in landfills and burial grounds will be significantly reduced.

Combustion products that are released as a result of fires will reduce atmospheric pollution. Finally, the habitat takes a well-groomed view and creates conditions for landscape design.

References
[1] Official site "The Agriculture Ministry of Penza region" [Electronic resource] URL: http://pnzreg.ru/branches/agriculture/ (access date: 01.08.2019)
[2] "State coordination program for the development of biotechnology in the Russian Federation until 2020 "BIO-2020" [Electronic resource] URL: http://biotech2030.ru/gosudarstvennaya-koordinatsionnaya-programma (access date: 01.08.2019)
[3] Golobokov S, Brostilova T, Divnenko A, Lesin I. 2019 Prospects for gas fuel from agricultural waste in Penza region Proceedings of the II International Conference «Sustainable and Efficient Use of Energy, Water and Natural Resources» p 58