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Production of bioethanol from biomass in the conditions of Northern Kazakhstan

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Abstract. This article describes using renewable energy for bioethanol production. Kostanay Region is a developed agricultural region. Most part of its area is under grain crops and corn, oil crops and vegetables. In the course of production, transportation, storage and processing of agricultural crops, a large part of them becomes unsuitable for use; in future they cannot be used for the intended purpose. Substandard product often stays in the fields to rot or is thrown away. Information considered in this article demonstrates that agricultural waste can be used to produce rather inexpensive bioethanol. Most part of the population in this region is rural. Settlements are far apart from each. It would be reasonable to use bioethanol as a source of electric and thermal energy to meet the needs of rural residents and infrastructure. Wastes from bioethanol production can be used for feeding animal stock what is also important for rural areas and reduces environmental burden. In the course of human life, solid waste is formed that is suitable for producing bioethanol, and consequently, for generating thermal and electric energy. Presented calculations show the feasibility of processing municipal solid waste into bioethanol. EU countries successfully use researches performed by their scientists for developing technologies for the production of bioethanol and synthetic fuels. Kazakhstan, with its experience in cultivation of oilseeds and required planted area, can successfully develop bioethanol industry. No researches in this respect have been conducted to this day in Kazakhstan. Using bioethanol provides consumers with their own energy sources that meet quality standards, thereby increasing energy security of region, reducing the amount of harmful emissions into the atmosphere, and creating small-scale energy enterprises where rural residents can work.

Key words: biomass, bioethanol, municipal solid waste, sewage sludge, renewable energy sources.

INTRODUCTION

Biomass is the most universal source of renewable energy. As a result of photosynthesis, plants are able to accumulate energy and to flexibly use it for different purposes. As a rule, solid biomass, gas obtained from biomass and liquid combustible substances suitable for combustion in internal combustion engines and furnaces are used. Using biomass can reduce the problems associated with the processing of household and agricultural waste. Moreover, agricultural regions receive a double benefit: they create additional jobs both in agriculture and forestry, and in the process of bioenergy conversion (Rocha-Meneses et al., 2017). Growing crops for bioenergy provides farmers with a new activity area.

Bioenergy allows decentralizing energy production and creates a closed cycle of materials and energy. Biomass emits only the amount of carbon dioxide that was absorbed by plants during their growth. Biofuel is neutral in terms of CO_2 balance (Kundas et al., 2009).

Bioenergy sources can vary a lot. They differ in the way of generation, properties obtained during burning, and possible use. Bioenergy can be used to produce solid, liquid and gaseous fuels (Sibikin & Sibikin, 2009; Chetoshnikova, 2010).

Solid biomass being the most widely used renewable energy source has been used for generating energy for a long time all around the world. Solid biomass includes all types of dry or dried plants or their parts, in particular, wood, wood pellets and briquettes, wood chips, straw and straw granules, rice husk, etc. Energy obtained from burning solid biomass in modern heating systems is used with high performance (Yang et al., 2019). Wood is the primary source of energy, especially in the form of firewood, chips and pellets (McKendry, 2002; Girones & Peduzzi, 2018).

Biogas is used mainly in block-type thermal power stations but it is also used for direct supply to natural gas supply systems.

Currently, the main types of biofuels are biodiesel and bioethanol. Bioethanol is mainly used for vehicles.

Plants containing a large amount of oils, such as rapeseed, sunflower seeds, soybeans, nuts and palm seeds (Ismuratov et al., 2019), are used to produce biodiesel. Bioethanol is obtained from biomass containing sugar and starch.

Using biofuels is less dangerous for people and environment. Biofuel combustion is almost neutral in terms of CO_2 balance.

Like ordinary alcohol, bioethanol is obtained by fermentation of sugars with yeast and then purified. If grain crops are used, then enzymatic reaction leads to starch breaking and its conversion into sugar. This results in the formation of a by-product in the form of distillers grain that contains about 30% protein and is therefore a valuable animal feed (Glushchenko et al., 2019). In the production of bioethanol from sugar beets, the waste is distillers grain and the pulp of sugar beets that are used as animal feed or fertilizer (Kundas et al., 2009). Production of one liter of bioethanol results in one kilogram of post-alcohol distillers grain. Thus, one hectare of sugar beet produces amount of fuel that is sufficient for a mileage of more than 80,000 km, and the resulting feed is enough for 9 months, per 1 cow.

The goal of this research is to study potential sources for developing bioethanol production in the region. It offers a comprehensive solution to the problem of environmental pollution, as well as meeting social needs for environmentally friendly

fuel sources and development of renewable energy in combination with the existing cultivation of agricultural crops and the processing of human waste.

Watermelons are grown in the northern part of Kazakhstan, and their waste can be used for bioethanol production. More than 5,103.4 tons of melons are grown in the Kostanay region. Farm households of the region grow 3,673 tons. In addition, melons are imported from other regions of Kazakhstan. The most part of these cultures is produced in southern regions: South Kazakhstanskaya (64%), Zhambylskaya (15%), Kyzylordinskaya (6.4%) and Almatinskaya (5.4%) regions. More than 80% of melons are grown in farm households (Source: Republic of Kazakhstan Statistics Committee, 2018). Analysis of statistical data shows that increased production of melons leads to increased waste from these cultures. Therefore, it is reasonable for this region to develop the production of bioethanol as a by-product. Traditional farms of the Kostanay region grow cereals, corn, sunflower and potatoes; waste from these crops is suitable for obtaining bioethanol. Another high-potential source for bioethanol production is municipal solid waste (Chandra et al., 2012; Raud et al., 2014). The amount of household waste is calculated exponentially. Human activity generates waste, and only human is able to change this process for the benefit of society and environment.

MATERIALS AND METHODS

Analysis of the potential for obtaining bioethanol from biomass

To determine the potential, a comparative analysis of crops used for bioethanol production was carried out based on the experience of EU and American countries. Standards for bioethanol yield from different crops were studied. For this, academic papers made by world-class scholars in this field were used. Based on statistical reports of the Ministry of Agriculture of the Republic of Kazakhstan and Agriculture Department of the Kostanay region over the past ten years, we determined crops among those grown in the Kostanay region that were suitable for bioethanol production. Based on this material, a list of crops with their gross yield, amount of waste and bioethanol yield was developed. Based on world prices for bioethanol, total cost of bioethanol was defined.

Analysis of the potential for obtaining bioethanol from municipal solid waste

Studying and analyzing the experience of leading countries in recycling municipal solid waste allows making conclusions on its application in the region. On the basis of materials provided by Atameken National Chamber of Entrepreneurs, the country has a very low rate for the recycling municipal solid waste, in particular, plastic. Waste potential was defined using methods for assessing the gross potential of municipal solid waste according to population data. Population base of the region was determined on the basis of demographic data for this region.

RESULTS AND DISCUSSION

Only in the Kostanay Region, cereals and oil crops are annually grown (Table 1) that produce significant amount of waste, and they can be used to obtain bioethanol.

The agricultural sector of Kazakhstan has traditionally been growing watermelons for public consumption (Glushchenko et al., 2019). In recent years, the area under gourds

increased by about 40%. Production of gourds in Kazakhstan fully meets the needs of population.

If we talk about watermelons, overripe and damaged during growth watermelons remain in fields. Watermelons can be damaged by birds, so they can't reach full ripeness, lose marketable appearance and rot in fields. Part of them is damaged during transportation and becomes unsuitable for use.

More than 20% of watermelons do not hit store shelves due to the lack of a 'marketable' appearance: they are damaged or irregular in shape, so, they can be used to produce bioethanol.

Table 1. Potential for producing bioethanol from crops

Type of biomass	Gross yield, (thousand tons)	Amount of waste, (thousand tons)	Ethanol yield per ton of raw material, (thousand tons)	Ethanol yield, total (ton)	Price per ton, (tenge)	Total, (thousand tenge)
Grain crops	4,454.56	668,184	455	304,023.7	52,780	16,046,371.9
Corn for grain	125.06	18,759	412	7,728,708	49,010	378,783.9
Watermelons	205.83	41,166	21	864,486	36,569	31,613.4
Potatoes	373.31	37,331	94	3,509,114	60,320	211,669.8
TOTAL						16,636,825.6

In addition to specified biomass sources, ethanol can be produced from straw and fruits of cultivated plants: apples, cherries, pears. In the area of Northern Kazakhstan, despite its extremely continental climate, fruits are cultivated; so, the waste and low-quality fruits can be used for ethanol production (Bauer et al., 2009; Vissarionov, 2009).

This study demonstrates the feasibility of processing agricultural waste into bioethanol.

In addition to abovementioned sources for the production of ethanol, municipal public owned treatment plants, organic waste from certain industrial sectors, and municipal solid waste landfills can also be used (Raud et al., 2014).

Norms for municipal solid waste (MSW) are the following:

– for urban residents – 1.2 kg per[1] day at the humidity of 50%;

– for rural residents – 0.52 kg per[1] day (it is assumed that food waste in rural areas is used for feeding domestic animals and birds and is not included in waste).

Table 2. Economic potential of solid waste

Name of district or settlement	Population (number)	Gross energy potential (SW) (ton of reference fuel)
Altynsarinsky	14,114	535.77
Amangeldinsky	16,673	632.91
Auliekolsky	42,991	1,631.94
Denisovsky	18,824	714.56
Dzhangildinsky	12,550	476.40
Dzhetygarynsky	48,755	1,850.74
Kamystinsky	12,764	484.52
Karabalyksky	27,966	1,061.59
Karasusky	25,834	980.66
Kostanaysky	70,468	2,674.97
Mendygarinsky	27,841	1,056.84
Naurzumsky	11,080	420.60
Sarykolsky	20,976	796.25
Taranovsky	25,432	965.40
Uzunkolsky	21,479	815.34
Fedorovsky	25,953	985.18
Arkalyk	41,354	3,622.61
Kostanay	239,652	20,993.52
Lisakovsk	40,842	3,577.76
Rudny	130,068	11,393.96
TOTAL		55,671.52

Calorific value (MSW) is set equal to 0.2 tons of reference fuel (oil equivalent) per ton of dry matter (MSW). Household waste is considered dry at the humidity of 50% (Vitkovskaya et al., 2012).

Economic potential of solid waste generated in the region during one year is shown in Table (Table 2).

According to 'Atameken' National Chamber of Entrepreneurs, by 2018 Kazakhstan produced over 43 billion tons of production and consumption waste, only 9% of which are recycled. Paper, tires and some types of plastic are most often recycled in this country. Separate waste collection campaigns have been started in major cities, and new processing plants are being launched. Main raw material here is recycled waste paper.

Paper and packaging waste is collected throughout Kazakhstan: it is not only about 14 regional centers and three cities of republican subordination. There are also partners in several border regions of Russia.

As a result of solid waste recycling, about one million tons of ethanol can be produced (Table 3).

If we assume that every third resident uses about two kilograms of newspapers and magazines a year, then we can additionally get more than six hundred tons of ethanol (Grinin, 2002).

Table 3. Potential for bioethanol production from solid waste

Type of biomass	Gross yield, (thousand tons)	Ethanol yield per ton of raw material, (ton)	Ethanol yield, total (ton)	Price per ton, (tenge)	Total (thousand tenge)
SW	55,671.52	17	946,415.8	9,425	8919,969,292
Newspapers and magazines	22,182	29	643,278	5,655	3637,737

CONCLUSIONS

The above calculations show that settlements of the region can in whole or partially meet its needs for energy sources. Considering that about one million tons of solid waste is burned in Kostanay landfills during one year, waste recycling will completely provide the city with fuel.

In addition to saving energy resources, such a source creates a culture of waste processing and the most careful attitude to nature and provides energy independence from centralized suppliers of electric and thermal energy.As a result of this study, we can make the following conclusions:

– Processing agricultural waste into bioethanol will allow peasant farms receiving an additional source of renewable energy;

– Distillers grain being the result of processing crop waste can be used for feeding animals;

– plastic recycling will reduce environmental stress, contribute to establishing plants for processing this waste and offer the society a non-waste production algorithm;

– Obtained this way environmentally friendly fuel can be used for the production of thermal and electric energy in conditions of remoteness of consumers from the central gas supply.

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