

# The structure of closed energy cycle with self-regenerating soil fertility

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**Abstract** – This article describes the use of biomass and human waste products for producing heat and electrical energy, considering the characteristics of the region. The article considers the possibility of using agricultural waste and animal waste, municipal solid waste and sewage sludge to ensure the energy autonomy of settlements and the restoration of the fertile soil layer. Potential of biomass and bio-ethanol for energy production was estimated. Opportunities of using municipal solid waste and sewage sludge for autonomous power supply was determined. The structure of closed energy cycle with self-regenerating soil fertility was proposed. Using of renewable energy sources provides consumers with their own energy sources that meet the quality standards. This will increase the energy security of the region, to reduce the amount of harmful emissions into the atmosphere, to create small generators (energy enterprises).

**Keywords** – biomass, ethanol fuel, municipal solid waste, sewage sludge, renewable power sources, calorific value, gross energy potential.

## I. INTRODUCTION

Kostanay region occupies 196001 km of the territory with the length of power lines totaling hundreds of kilometers.

Population migration caused a decrease density of population and electricity consumption [1].

The population density is 4.5 people per square mile (4.5 / km<sup>2</sup>). The most densely populated cities are Kostanay, Rudny and Lisakovsk, the least populated are southern areas of the region, density of which is from 0.4 to 0.8 people per square kilometer.

The transition to market relations eliminated almost all large agricultural enterprises: instead of 2 thousand large agricultural enterprises, were organized more than 60 thousand small farms, which led to the destruction of the centralized power supply system in rural areas. [1].

Decrease electricity consumption in remote region areas has stipulate to the emergence of low-load overhead power lines with a long voltage of 110 kV and above, which generate reactive power. The structure and characteristics of electricity consumage has changed, which significantly affect the operating modes of the electrical system. Large wear damage of power lines, substation equipment reduces the system reliability and the quality of electricity, increases

technological losses and, consequently, increases the prime cost of production [1].

One of the ways to solve this problem is include local power sources into the system, using renewable and non-traditional energy sources.

## II. LITERATURE REVIEW

Biomass is plant or animal material used for energy production, heat production, or in various industrial processes as raw material for a range of products[1]. It can be purposely grown energy crops (e.g. miscanthus, switchgrass), wood or forest residues, waste from food crops (wheat straw, bagasse), horticulture (yard waste), food processing (corn cobs), animal farming (manure, rich in nitrogen and phosphorus), or human waste from sewage plants.[11]

Biomass as a renewable energy source has a number of significant advantages [1].

These include:

- The word “data” is plural, not singular. - prevalence and availability;
- usage for all seasons;
- the possibility of obtaining a variety of final products (in addition to traditional combustion to produce electricity and heat can be obtained synthesis gas, bio-oil, ethanol, biogas, hydrogen);
- reduction of anthropogenic impact on the environment.

Emission of carbon dioxide into the atmosphere from usage of biomass is equivalent to carbon dioxide absorption while Biomass grows (with the growth of Biomass). In addition, as distinct from organic fuels, biomass does not lead to the release into the atmosphere of pollutants such as heavy metals, carbon monoxide, sulfur oxides [2,3].

Commercial energy use of biomass is mainly focused on agricultural and livestock waste (straw, cake, husk, manure, etc.) [9].

Large share of potential biomass is solid domestic waste (SDW). It is estimate that the average urban resident produces 300-400 kg of SDW per year. With an average calorific value

of SDW 5-6 GJ/t, this means that in a city with a population of 1 million people, SDW can produce 2-3 PJ / year of energy [6,7,8].

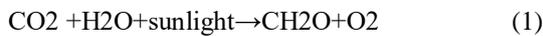
III. RESEARCH METHODOLOGY

Any organic matter can be attributed to biomass both plant and animal origin. Since ancient times, people used wood, waste products of wood processing and animal waste products to obtain energy. All of the above substances can be divide into groups according to the stage of use in the primary and secondary and the source of origin of plant and animal.

As a result, impact of solar energy, in plants, occurs photosynthesis, which results in the conversion of carbon and hydrogen compounds into carbohydrates and oxygen. Phytomass also contains phosphorus, nitrogen, potassium and other elements known as effective organic fertilizers.

There are two ways to get energy from biomass: direct combustion or fuels production of different consistency.

The process of photosynthesis can be generally shown by the following reaction:



where CH<sub>2</sub>O is a generalized formula for carbohydrates (sugar, starch, cellulose).

Energy using of biomass determined by the following reaction



A comparison of these two reactions shows that at the result of photosynthesis and the usage of the created biomass, a closed cycle is realized, in which solar energy is accumulated and then converted into useful heat, at the same time, virtually without harmful emissions.

IV. PRACTICAL SIGNIFICANCE

Unique feature of North Kazakhstan is the developed agricultural production, characterized by the territorial division of numerous consumers of electricity and other fuel resources, relatively small capacity and significant number of facilities be avid for autonomous energy supplying. The source of bioenergy can serve such as waste grains and oilseeds, watermelons.

Kostanay region has reserves of organic raw materials, number of cattle is more than 500 thousand heads, pigs up to 300-400 thousand heads, the volume of the potential amount of biogas, produced per year, will be about 5 million tons of reference fuel (Fig.1)[7].

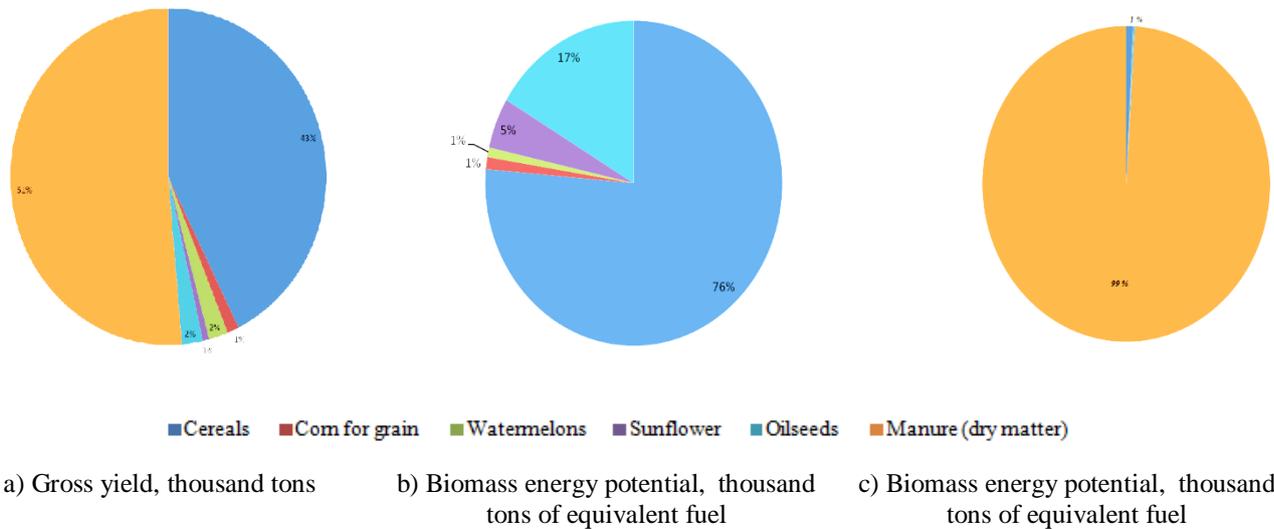


Fig. 1. Biomass Energy Potential

Using of organic waste has a triple positive effect: it gives energy, reduces the amount of waste, contributes to the preservation of the environment.

After all, waste-free and low-waste "almost closed" technology in industry, transport and urban economy will give an increasing positive effect, reducing the pollution of the biosphere.

Besides the fact that bio-energy resources are very significant, they are also renewable, because only the energy of chemical compounds (transformed solar energy) is takes from the raw material, and the waste of anaerobic digestion is high-quality organic fertilizers. This is due to the fact that

in the conditions of methane fermentation (the depth of decomposition of organic substances to 30-40%), the amount of phosphorus and potassium practically does not change, and the amount of nitrogen in the ammonia form increases to 30-40%. The increase in the share of ammonia nitrogen makes organic fertilizers more effective than with ordinary, aerobic fermentation. In this form, it is most well absorbes by plants [3].

Consequently, we have structure of closed energy cycle with self-regenerating soil fertility (Fig. 2).[7]

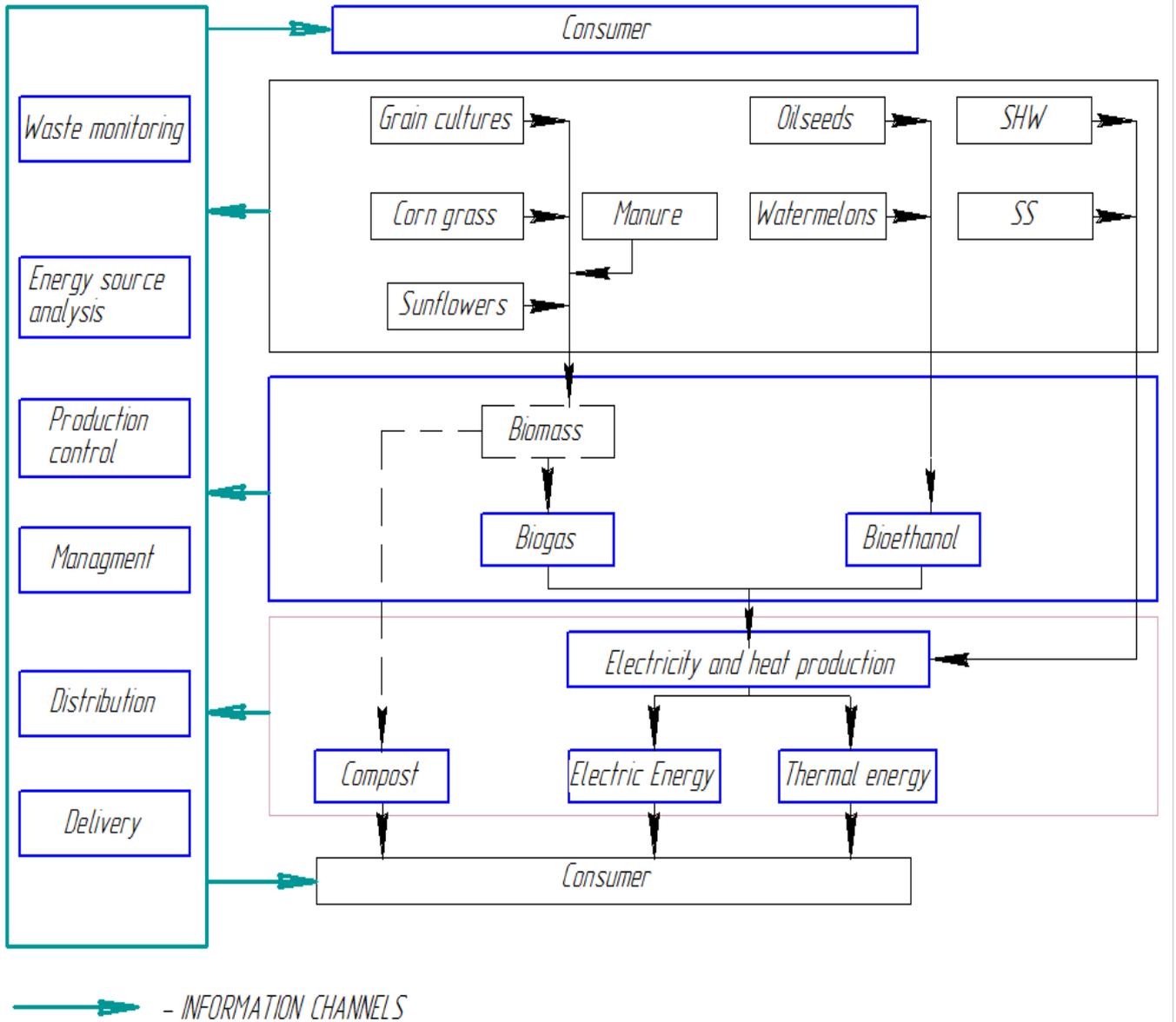


Fig. 2. Block diagram of energy production with a self-regenerating process.

Studies conducted by a number of authors [4,5,6,7], noted increase yield gain by 15-20% (grains), up to 26% (herbs), up to 10-20% (potatoes, corn).

Especially promising is the use of organic fertilizer obtained by anaerobic digestion for greenhouse crops, since with the same doses of nitrogen, it gives the same yield when using mineral fertilizers, and the nitrate nitrogen content is 5 times less [8]. As a result of such use, it is possible to obtain environmentally friendly food.[7]

A few years ago, most consumers expected that with the growth of liquefied natural gas production, it would become global commodity as oil. There occur predictions about structural changes in gas markets, but the experience of countries that are not provided with natural gas, such as China, shows that backcountry district should be gasified with the help of small bio-plants operating on organic waste.

Thus, the introduction of 2 million units would provide about 2 billion m<sup>3</sup> of biogas per year, which is equivalent to 13 billion kW.h energy and would provide family estates with organic fertilizer in the amount of 10 million tons per year.

Many years of practical experience in many countries shows that biogas production is the most promising direction of biomass energy using for the Kostanay region

In addition, potential sources, besides the mentioned: urban municipal sewage installation (systems), organic waste of some industrial sectors, municipal solid waste landfills (landfills).

The population of cities and towns in the region shows in table 1.

Norms of formation of municipal solid waste are accepted (SDW- Solid Domestic Waste)[1, 2]:

– for urban residents-1.2 kg / person · hour with humidity 50%;

– for rural residents-0.52 kg / person · hour (it is assumed that in rural areas food waste is used for feed of domestic animals and poultry and is not part of the waste).

Calorific value (SMW) is taken to be 0.2thousands tons of reference fuel (oil equivalent) per ton of dry matter (SMW). Domestic waste is considered dry waste at 50% humidity.

When calculating energy potential of sewage sludge (SS), the amount formed (SS) per day for person should be taken equal to 0,26 kg at a humidity of 75%[3].

The economic potential of SMW and SS in the region for the year presented in table 1.

TABLE I. ECONOMIC POTENTIAL SMW AND SS

District	Population	Economic Potential (SMW)	Gross Energy Potential (SMW)	Gross potential of sewage sludge (SS)	Calorific value (SS)	Total potential of SMW and SS
	<i>persons</i>	<i>tons per year</i>	<i>thousands tons of reference fuel</i>	<i>tons per year</i>	<i>thousands tons of reference fuel</i>	<i>thousands tons of reference fuel</i>
Altynsarinsky district	14114	2678,837	535,77	1339,42	95,98	631,74
Amangeldy district	16673	3164,535	632,91	1582,27	113,38	746,28
Auliekol district	42991	8159,692	1631,94	4079,85	292,34	1924,28
Denisov district	18824	3572,795	714,56	1786,40	128,00	842,56
Dzhangeldy district	12550	2381,99	476,40	1191,00	85,34	561,74
Zhitikarinsky district	48755	9253,699	1850,74	4626,85	331,53	2182,27
Kamystinsky district	12764	2422,607	484,52	1211,30	86,80	571,32
Karabalyk district	27966	5307,947	1061,59	2653,97	190,17	1251,76
Karasu district	25834	4903,293	980,66	2451,65	175,67	1156,33
Kostanay district	70468	13374,83	2674,97	6687,41	479,18	3154,15
Mendykarynsky district	27841	5284,222	1056,84	2642,11	189,32	1246,16
Naurzum district	11080	2102,984	420,60	1051,49	75,34	495,94
Sarykol district	20976	3981,245	796,25	1990,62	142,64	938,89
Taranovsky district	25432	4826,994	965,40	2413,50	172,94	1138,34
Uzunkol District	21479	4076,714	815,34	2038,36	146,06	961,40
Fedorovsky district	25953	4925,879	985,18	2462,94	176,48	1161,66
Arkalyk, town	41354	18113,05	3622,61	3924,49	281,21	3903,82
Kostanay, town	239652	104967,6	20993,52	22742,97	1629,63	22623,15
Lisakovsk, town	40842	17888,8	3577,76	3875,91	277,73	3855,48
Rudny, town	130068	56969,78	11393,96	12343,45	884,46	12278,42

## V. CONCLUSIONS

Calculations show that human settlements can meet the needs of the region for energy sources in whole or in part. If we consider that about a million tons of fuel burned in the Kostanay station during the year, using of waste will fully provide city with fuel.

In addition to saving energy resources, such a source forms a culture of waste processing, creates conditions for energy independence from centralized suppliers of electricity and heat.

The proposed structural scheme (figure 2) is a closed cycle of energy transfer from one type to another, satisfying human needs and at the same time aimed at the most careful attitude to nature.

As can be seen from the above, obtained the structure of closed energy cycle with self-regenerating soil fertility[7].

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