The biomass conversion plant location substantiation

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Introduction

A goal of any agricultural enterprise, as a business entity, is to earn profit. One of the ways of raising income and introducing innovative approaches is using agricultural biomass for generating energy.

Biomass transportation expenses, due to its physical characteristics, make up a substantial part in the cost of generated energy. That is why, one of the ways of reducing the cost of introducing new technologies of the biomass processing is logistics. Such ways of biomass processing like baling, pelleting, pyrolysis or gasification, are used to reduce the logistic expenses. Besides, the investigations show that the effectiveness of the technology of biomass processing increases when the technological line productivity increases as well. That is, the higher volume of biomass is transformed into energy, the higher is the efficiency factor of the equipment which is a part of a technological line. Great amount of biomass is required in order to provide a continual operation of such lines. But small and medium-size agricultural enterprises can not provide sufficient volumes of biomass.

High cost of equipment for technological lines on biomass processing into fuel makes it necessary to combine efforts and resources (raw materials resources and financial ones) of the agricultural enterprises for effective biofuel production. Pooling of financial resources of the agricultural enterprises raises a possibility of purchasing a necessary technological line. Pooling of raw materials resources of the agricultural enterprises gives a chance to provide a technological line on biofuel production with a necessary amount of raw materials.

It is expedient to locate a technological line on biofuel production at a point (geographical) with the least traffic volume, that will considerably reduce logistics costs. It is necessary to take into consideration the distance from all enterprises (association –members) to this point as well as to estimate the potential of an available biomass and the seasonal patterns of receiving raw materials.

Methodology

When choosing a point for installing a technological line on biofuel production, it is necessary to minimize transportation, thus transportation costs and time consumption used on raw materials transportation will be minimal. The authors suggest to determine some reference points on the map of a chosen area (from which organic raw materials will be supplied) by applying the method of potential functions The above mentioned points determine the centers of organic raw materials potentials of the enterprises. They must be considered as the points of locating processing enterprises for processing organic raw materials into fuel. Herewith, it is expedient to make a cartogram of organic raw materials potentials on which a circle is drawn for each enterprise, and the center of this circle coincides with the coordinates of a given enterprise center, the area of a circle at scales μ equals the specified potential of organic raw materials:

$$r_i = \sqrt{\frac{P_i}{\pi\mu}}$$

where r_i – radius of a circle, which illustrates the biomass potential a_t the first enterprise, mm;

P_i – estimated organic raw materials potential at the first enterprise, t;

μ – coefficient of concordance, t/mm²

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Methodology

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P_i – estimated organic raw materials potential at the first enterprise, t;
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The coordinates of the center of raw material potentials are determined in a false grid system, which is marked in arbitrary style in nominal units of measure. The coordinates of the center of raw material potentials of a supply region can be calculated by a functional equation:

$$\sum_{i=1}^{n}\sum_{j=1}^{m} P_n\left[(x_i - x_{pj})^2 + (y_i - y_{pj})^2\right] \to \min \ ,$$

where x_{pj}, y_{pj} –the coordinates of a center of *j*- the option regarding the installation of a technological line on biofuel production, km;
x_i, y_i – coordinates of a center of *i*- enterprise, which supplies raw materials, km;
n – amount of enterprises which supply raw materials;
m – a number of options regarding the installation of a technological line.

For the option regarding the installation of one technological line of processing biomass into fuel ($m=1$) and taking into consideration the fact that grain crops productivity on the farm enterprises varies and the annual straw potential changes, the coordinates of the centers of organic raw material potentials should be determined with due regards to possible potential fluctuations. The coordinates of technological line installation x_p and y_p – must be presented as functions of time:

$$x_p(t) = \frac{\sum_{i=1}^{n} P_i(t)x_i}{\sum_{i=1}^{n} P_i(t)}, \quad y_p(t) = \frac{\sum_{i=1}^{n} P_i(t)y_i}{\sum_{i=1}^{n} P_i(t)}.$$

These functions describe a displacement of the center of potentials, whose coordinate values are sequenced in discrete moments of time and form a set of points, which fill some area which is called a dispersal zone of the center of potentials. That is why it is necessary to introduce an additional coordinates dissipation factor $\alpha_i(t)$, which represents raw materials potential ratio of the i- enterprise to a total potential of organic raw materials at the same period of time:

$$\alpha_p(t) = \frac{P_i(t)}{\sum_{i=1}^{n} P_i(t)}.$$

As $\alpha_i(t)$ have insignificant annual fluctuations *($\alpha_i(t)$-const)*, the equation system 3 which is used for the fixation of coordinates in which it will be expedient to locate an agricultural servicing cooperative, will look like:

$$x_C = \frac{\sum_{i=1}^{n} P_i x_i}{\sum_{i=1}^{n} P_i}, \quad y_C = \frac{\sum_{i=1}^{n} P_i y_i}{\sum_{i=1}^{n} P_i}.$$

where x_c, y_c – the coordinates where a technological line will be installed, km.

The distance L from the center of organic raw material potentials to the enterprises-suppliers must strive to a minimal value:

$$L = \sqrt{(x_i - x_c)^2 + (y_i - y_c)^2} \to \min$$

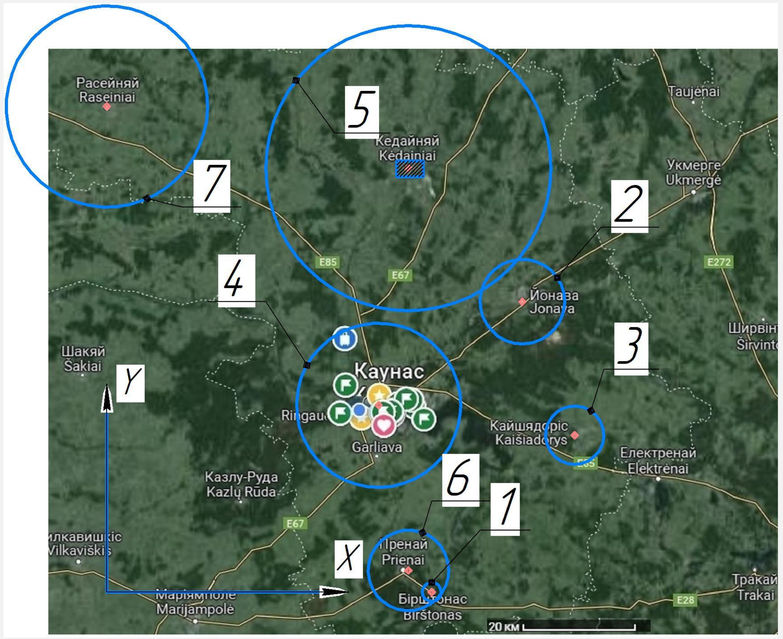
The coordinates where the technological line must be installed, must provide minimal value for L.

Results

Table. Data necessary for determining the location coordinates of installing the technological line on biofuel production

Name of the region	Available amount of biomass for manufacturing biofuels (Pi), t on average for за 2019-2023рр	No. on the map	Location coordinates of the agricultural enterprise, km		Total transportation volume with respect to the axis, t/km		Radius of circles which characterise the available straw potential, mm*
			x_i	y_i	$P_i x_i$	$P_i x_i$	r_i
Birštono sav	4574	1	62	0	283024	0	2
Jonavos r.sav	36643	2	78	55	2876100	2010229	15
Kaišiadorių r.sav	26618	3	88	30	2352261	788701	11
Kauno r.sav	75103	4	51	35	3855035	2649633	31
Kėdainių r.sav	132402	5	57	80	7542953	10602768	55
Prienų r.sav	37851	6	57	4	2155624	154054	16
Raseinių r.sav	90339	7	0	92	0	8285912	38
Sum	*403530.522*				*19064998.68*	*24491297*	
* coefficient of concordance 0,24t/mm2							

Results



A cartogram of biomass potentials available for its processing into fuel (marks are given in Table)

Main conclusions

1.High cost of equipment for technological lines on biomass processing into fuel makes it necessary to combine efforts and resources (raw material resources and financial ones) of the agricultural enterprises for effective biofuel production. Pooling financial resources of agricultural enterprises makes it possible to purchase a required technological line. Pooling raw material resources of agricultural enterprises makes it possible to provide a technological line on biofuel production with necessary amount of raw materials.

2.When choosing a point for installing a technological line on biofuel production it is necessary to minimize transportation that will result in lower transportation expences and time consumption. With this in mind, it is necessary to determine the center of biomass potential of the enterprises of the biomass supply area. This center must be considered as the point of location of the technological line on biomass processing into fuel.

3.The location of technological line on biomass processing into fuel at a point with determined coordinates (center of biomass potentials) will make it posible to have minimal volume of transportation and to reduce logistic expences. It will enable the enterprises to win fresh market segments, to introduce close productive cycles as well as to increase a profit level.

4. We suggest to install a technological line at Kėdainių, herewith,the transportation cost will minimum. Herewith, the expenses on a technological line installation will be much lower due to using the available infrastructure.