DE GRUYTER OPEN
RIGA TECHNICAL UNIVERSITY

ISSN 2256-0394 (online)
ISSN 2256-0386 (print)
April 2017, *30*, 146–154
doi: 10.1515/eb-2017-0013
https://www.degruyter.com/view/j/eb

RENEWABLE ENERGY EFFICIENCY FOR REGIONAL DEVELOPMENT: CASE OF BELGOROD REGION

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Abstract. The article presents the results of an original research, conducted to evaluate the potential of renewable resources for increasing the sustainability of Belgorod region development. It is one of the most developed regions in Russia with diversified structure of economy. Significant feature of the region's economy is a lack of domestic energy production and dependence on energy supplies from neighbouring regions. To define the most suitable way to cover the lack of energy and to contribute to the solution of environmental problems, the potential of renewable energy resources, such as solar radiation, wind speed, and biomass energy was estimated. The research was conducted using a variety of sources, such as scientific articles, statistical data, reports of industrial companies and agricultural farms, cartographic materials, space images and materials of own field researches. The most effective way of regional development, which contributes to the decline of energy intensity and environment improvement, is agricultural waste recycling by biogas production. The conclusions on the efficiency of renewable energy sources were based on calculations of GRP energy intensity in cases of traditional and alternative energy systems.

Keywords*: Biogas, energy intensity, Gross Regional Product (GDP), renewable energy.*

INTRODUCTION

The key role of renewable energy in sustainable development of regions is globally recognized, however, its implementation in Russia is inhibited due to abundance of hydrocarbon resources. Dependence on hydrocarbon production slows down the innovative development of the Russian economy and provokes the deterioration of environmental situation (Bobylev & Zaharov, 2012). In this regard, studies on effectiveness of renewable energy are crucial in finding the solutions of environmental problems in Russia's regions and in promoting the principles of a green growth.

Today the level of energy intensity of national or regional economies is one of the most important indicators of sustainability. Over the last 15 years (from 2000) energy intensity has decreased for vast majority of countries, including Russia. The drop has been larger for China, Russia and India than, for example, for the United States, the European Union or Japan (Energy consumption..., 2014). The reasons explaining this decline are faster growth of GDP than energy demand, growing share of the services sector, and, of course, implementation of innovative technologies. At the same time there are two opposite trends in terms of energy

consumption per capita. For the countries with higher GDP/capita the indicator decreases due to higher share of services in GDP structure. The growth in GDP/capita in China, India and other emerging economies, has led to an increase in energy consumption.

The development of energy efficiency programs in Russia was based on institutional prerequisites that were created in the period after 2000. In comparison to 2005 the energy intensity of the Russian economy has decreased 6 times, but it is still 2 times higher than, for example, in China (Drujinin & Scherbak, 2015). In this regard, the study of possibilities to reduce energy consumption due to decoupling effect is still actual. We investigated the perspectives of renewable energy use through the case study of Belgorod region – one of the most developed regions of Russia. The study aimed to assess environmental and economical effectiveness of different kinds of renewable energy sources and also to identify their role in the strategic development of the region.

1. CURRENT STATE OF ECONOMY IN THE REGION

The world's best practices of implementation of principles of "green" economy demonstrate that energy efficiency is one of the key criteria on this way (Bezrukih, 2012; Pakina & Slipenchuk, 2014). Despite "green" growth proclaimed as the main trend in modernization of the Russia's economy, the institutional preconditions for such transition at the regional level are quite weak. However, there are a number of programs, dedicated to support activities for the improvement of energy efficiency in Belgorod region. The Federal Acts, such as Federal Laws "On Electrical Power Industry" (2003), "On Energy Saving and Increasing Energy Efficiency and on Amendments to Certain Legislative Acts of the Russian Federation" (2009) created the basis for regional acts in the same field. In Belgorod region they are: "The Concept of Bioenergy and Biotechnology Development in Belgorod Region in 2009–2012" and the Decree of the Government of Belgorod region of 19.07.2010 "On Approval of Temporary Rules of Calculation of Economically Justified Regulated Eco-tariffs for Electricity Produced at Electric Power Facilities Using Renewable Energy Sources". The listed documents create institutional preconditions for the development of renewable energy.

Regions of Russia are extremely different by their natural conditions, total area, density of population and level of economic development. That is why natural conditions along with the type of regional economic development often are the key drivers of renewable energy implementation. Belgorod region occupies only 0.2 % of the total area of the country, however, it ranks 26th in the list of 85 Russian regions. The main sectors of regional economy are mining industry developing from the resources of the world's richest Kursk magnetic anomaly, as well as agriculture based on extremely rich humus soils – "chernozem". GRP structure is shown in Fig. 1.

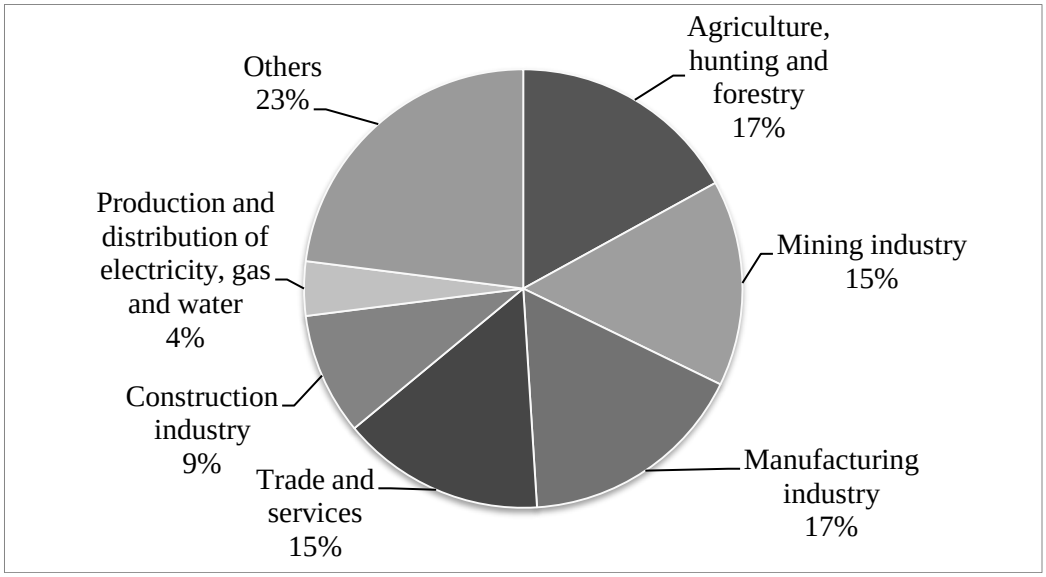

Fig. 1. GRP of Belgorod region.

The analysis of GRP dynamics shows that the total share of the primary sector in regional economy is reducing during the last years due to the increasing share of the services sector. At the same time the decline is typical mostly for the mining and metallurgical industries, while agriculture has shown the tendency to increase. The role of agriculture in the economic structure of the region has significantly increased over the last 15 years (Territorial body, 2015). For the period from 2000 to 2014 the agricultural output has significantly increased, both in livestock and crop production (Fig. 2).

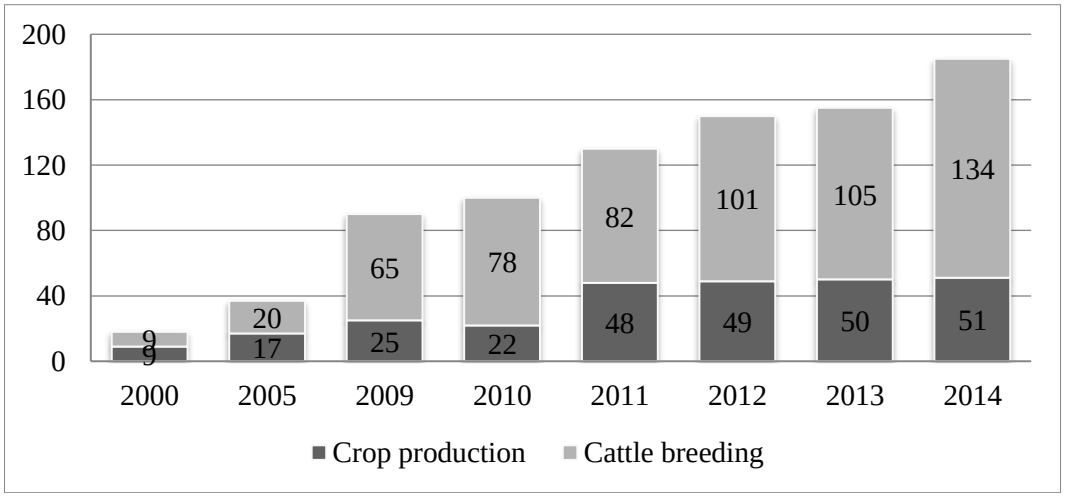

Fig. 2. Dynamics of agricultural production in Belgorod region.

The share of agriculture in GRP in recent years (2011–2014) also increased steadily, providing up to 17 % of GRP and occupying the second position after industrial production (mining and manufacturing industries together). In 2015, the

share of Belgorod region in Russia's total agricultural production amounted to 4.5 % (Federal state, 2015), which brought the region to the leading position in Russia (the second place in the national economy after the Krasnodar region). An important indicator is the fact that the region plans to increase these volumes in future.

One of the key features of the region's economy is lack of domestic energy production: the region produces only 6.3 % of the required volume, and the rest comes from the neighbouring regions where two Nuclear Power Plants (Kurskaya and Novovoronejskaya) are located. Domestic energy production is provided by local thermal power plants (TPP) and associated with attendant environmental impacts. The current regional development has caused several environmental problems, such as air pollution from TPP and transport in industrial cities (Stary Oskol and Gubkin cities), contamination of local rivers by agricultural waste, etc. Together with shortage of energy they form main challenges for further development of the region.

2. PRECONDITIONS FOR ALTERNATIVE ENERGY IMPLEMENTATION

As it is shown in a number of recent scientific works – both theoretical and applied – renewable energy use can be considered from the point of view of not only environmental effectiveness, but also economical one (*A Guidebook*, 2013; Chernova, Korobkova & Kiselyova, 2010). To evaluate the perspectives of renewable energy development in Belgorod region we have analyzed its natural prerequisites, such as the wind speed and the amount of solar energy, and compared GRP energy intensity in the cases of traditional and alternative energy systems.

The area has sufficient resources to generate energy through local renewable sources: the amount of solar radiation within its boundaries varies from 1140 to 1200 kWh/m² per year, which is comparable with the southern regions of Russia, where such stations are widely used. Wind resources are less promising, but also available to produce energy: the average value of wind speed is about 5.2 m/s (NASA, 2016). The comparison of the potential of renewable energy sources in Belgorod region and one of the European leaders in the field – Germany – showed that these variables are quite similar (Table 1).

Table 1. Natural Potential of Renewable Energy in the Belgorod Region and Germany

Type of natural renewable resources	Belgorod region		Germany	
	Geographic coordinates	Amount	Geographic coordinates	Amount
Solar radiation, kWh /m2 per day	53.5 N 34.07 E	2.7	53.8 N 7.2 E	2.7
	48.5 N 41.07 E	3.39	47.8 N 9.2 E	3.37
Wind speed, m/s	53.5 N 34.07 E	4.01	53.8 N 7.2 E	8.01
	48.5 N 36.07 E	5.87	47.8 N 9.2 E	4.57

Considering the possibility of increasing energy efficiency of the region's economy, we first appealed to the most energy-intensive industries that are represented in the region by mining and metallurgical industries. The largest of them – Lebedinsky and Stoilensky mining complexes and Oskol electrometallurgical complex – are part of the largest world known Russian manufacturers Holding Company Metalloinvest and Novolipetsk Metallurgical Plant. According to annual reports of these companies, they pay great attention to the improvement of energy efficiency: their profitability and investment policies are directly related to modernization efforts.

Several studies (Shagaev, 2012; Pakina & Turlybekova, 2013) on the prospects of renewable energy implementation, especially solar and wind energy, estimate their potential to cover the needs of large plants. The potential of wind energy basically is insufficient to cover their needs, so more attention is usually given to solar energy. As it was mentioned above, the amount of incoming solar radiation is sufficient to develop this type of energy in Belgorod region. However, practical implementation of solar plants in the region is also inefficient: their installation in industrial North of the region, where the main production is concentrated, will face the problem of dusting due to open-pit ore mining. In addition, to meet the needs of the plants significant amount of energy – more than 5 billion kWh per year – is required. Solar power plants are not suitable for producing energy for two reasons: the area reserved for panels that traps solar radiation is comparable to the area occupied by carrier and tailing, and the cost of such facilities will amount to hundreds of billions rubles, which exceeds profitable investment.

The next step was the analysis of statistical data (Territorial body, 2015) to calculate the volume of organic waste biomass generated in agricultural sector (Table 2). Biomass resources in Belgorod region are represented mainly by livestock waste; crop production gives waste mostly from grain and beet processing (straw and sugar beet pulp), which are used in animal husbandry as bedding and feed.

Table 2. Accumulation of Organic Waste from Livestock in Agricultural Farms of Belgorod Region

Type of livestock	Number	Mass of excrements, kg/head/day	Total mass, tons/day
Pigs	3 977 100	4.5	17 897
Poultry	51 320 200	0.3	15 396
Cows	93 100	35	3 258
Other cattle	133 600	21	2 806

Reducing energy intensity of the regional economy is one of the main criteria of energy efficiency on the way towards sustainability. During the research we considered the possibility to produce energy by bio-waste recycling at individual farms. Taking into account the region's share in pork production (currently exceeding 28 % of total production), it could be a suitable decision to increase energy efficiency and to reduce traditional fuel consumption.

The total amount of waste from farms in Belgorod region is about 12.5 mln tons of high-calorie mass per year. Taking into account different moisture, this volume is enough for biogas production in the amount of about 250 thousand m³ per year. The recycling of all livestock waste at the biogas stations in Belgorod region would allow to produce about 2 bln kWh per year. Even if 25 to 50 % of this energy goes to cover the demand of the plant, the total output of electricity will be about 1 bln kWh per year which is enough to cover the electricity needs of all farms of the region (721.1 mln kWh).

Being an agricultural region, Belgorod area has a great potential for use and recycling of agricultural production wastes, especially livestock, for energy purposes, and such facilities are already in operation in some farms of the region. Taking into consideration that renewable energy in general and biomass energy in particular is most often local by its nature (Ryden, 2012), we concluded that biomass resources have the greatest potential as a renewable energy source in the researched area.

3. ENVIRONMENTAL AND ECONOMIC EFFICIENCY OF BIOMASS UTILIZATION

The effectiveness of environmental management is one of the most significant and complicated issues in modern environmental policy at national and regional levels. Economic policies at the regional level must be aimed at providing not only economic growth but also at achieving environmental and social effects. Experience of some developed countries shows that the attempts to reduce ecological impact while maintaining economic growth – for example, by reducing GHG emissions in absolute terms within their territories – have not been completely successful. Unfortunately, life cycle emissions of final consumption, in fact, in many cases increased; production of emission-intensive goods has simply moved elsewhere (Tukker et al., 2014). That is why the key issue in this field is transferring of focus from production or consumption parameters to evaluation of efficiency. This idea fully corresponds with the principles of "green" economy, which is a low-carbon, resource efficient and socially inclusive economy. In the case of Belgorod region main attention must be given to the development of innovative technological and management approaches. Such innovations can be considered as the most important benefit of environmentally oriented policy.

Energy efficiency in the agricultural sector of the economy of Belgorod region is a very actual issue, since agriculture dominates in the territorial structure of land use (77 % of total area of the land fund), and most of the population (18.7 %) is employed in agriculture.

We evaluated that energy intensity of the regional economy is as follows:

$$E_{GRP} = \frac{EC}{GRP}, \quad (1)$$

where E_{GDP} is energy intensity (kWh /RR), EC is energy consumption (kWh), *GRP* is Gross Regional Product (RR).

The evaluation of current energy intensity of the region's economy showed that total amount in the area is 24 kWh/1000 RR. The difference between economy sectors is quite substantial: in agriculture – 6 kWh/1000 RR, and in mining industry – 57 kWh/1000 RR. Reduction of energy intensity in industrial production is the most urgent task, however, it can be solved through its modernization. To achieve lower energy intensity in agriculture is more realistic, since there already is such experience, and implementation of biogas stations is effective at the level of individual farms. Bio-waste utilization will result both in covering the needs of agriculture for energy and in decline in total energy intensity of the region's economy. The total energy consumption of GRP, while maintaining the volume of production, will decline by 4.2 % (24 to 23 kWh for 1000 rubles).

Changes in the structure of regional economy are always related to new projects, requiring careful consideration of all consequences. This especially concerns changes in environmental and social spheres (Pakina, 2014). In the case of developing new facilities for bio-waste recycling at individual farms the proposed changes are mainly connected with construction and operation, and will cause an increase in employment of local population. Employees with different skills in various industries – from economists and engineers to unskilled workers – will be needed in the process of construction and further operation of facilities. During operation the staff of about 8 people will be needed at each biogas station. In addition, the small business sector (building materials from local suppliers, transport services, etc.) will be engaged during the construction period. Thus, each station will create new work places with different skills, which is extremely important for rural areas.

CONCLUSION

The assessment of the potential of biogas production and its comparison with other renewable energy resources in Belgorod region has showed that it can be considered as an effective way to reduce the consumption of fossil fuels and to meet energy demand. Despite the effect of biogas production, first of all, in e agricultural sector, the consequences for regional economy will be tangible due to the decline in GRP energy intensity. Along with economic effect biogas production will also result in the solution of environmental problems through increasing resource efficiency and waste recycling. The development of renewable energy will also contribute to the improvement of standard of living of local population.

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