Prospects for the development of bioenergy in the Russian Federation on the basis of agroindustrial complex wastes: Analysis of the regulatory framework and national support mechanisms

Authors:
Boris Reutov – Director General, OJSC « All-Russian Thermal Engineering Institute »
Anastasia Reutova – Specialist, NPP «Research Centre for the Advancement of Innovative Energy»
Minzalya Ishmuratova – Independent Expert

Head of Research:
Lesya Matiyuk – Agency for Renewable Resources

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Introduction

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The analysis was developed by the authors: B. Reutov, A. Reutova and M. Ishmuratova, under the scientific coordination of L. Matiyuk, referent for EU and International Cooperation at the Agency for Renewable Resources (FNR, Germany, www.fnr.de). The analysis was commissioned by the BIO-PROM Project Partner GFA Consulting Group (Germany, www.gfa-group.de).

The analytical work introduced in this edition does not reflect the opinion of the BIO-PROM partners. It solely reflects the opinion of the authors.

The study was delivered aiming:

- to provide relevant information about the development of the bioenergy branch in the Russian Federation for Western-European investors
- to describe the existing experience and achievements in this field as well as
- to analyse the barriers to the development of the branch making recommendations to overcome them.

Target audiences of the study include representatives of Western European companies / investors interested in cooperation in the field of bioenergy and in creating investment projects profitable for all participating parties.

The authors of the analysis will consider their mission to be accomplished if this publication shows the country's potential and encourages representatives of Western companies to establish mutually beneficial projects in the bioenergy sector.

In this paper, we used data from public sources, relevant for the description of the bioenergy branch (for example, program BIO 2020, BIOENERGETICS OF RUSSIA IN THE XXI CENTURY (REA study), RENEWABLE ENERGY FORUM - REENFOR 2013, etc.).
1. Preconditions for bioenergy development in the Russian Federation

The Russian Federation (Russia) is located in the Northern Hemisphere, in the North of Eurasia. It is washed by the Pacific and Arctic oceans, as well as the Baltic, Black, Azov seas of as well as the Caspian Sea, – and Russia has the longest shoreline in the world. The Ural Mountains and the Kuma-Manych hollow divide the country into the European and Asian parts. Russia borders on eighteen countries including two partially recognized countries which is the largest number of neighbouring countries in the world. It has land borderlines with Norway, Finland, Estonia, Latvia, Lithuania, Poland, Belarus, Ukraine, Abkhazia, Georgia, South Ossetia, Azerbaijan, Kazakhstan, China, Mongolia, and North Korea. Russia has sea borders with Japan and the United States.

The Administrative-territorial structure is represented by 85 subjects of the Federation, 46 of which are referred to as regions (oblast’ in Russian), 22 – as republics, 9 – as krai (Russian word with a close meaning to the word “area”), 3 - cities of federal importance, 4 –autonomous districts and 1 autonomous region. After the collapse of the Soviet Union in the late 1991, the Russian Federation has been recognized by the international community as the successor state of the USSR.

The population of Russia amounts to 143,666 931 people (status: 2014). The territory comprises 17,125,187 km², which is the largest in the world by area and the ninth biggest by population. The country is rich in various mineral resources (especially energy resources such as oil and natural gas). It also has significant bioenergy recourses such as wood, peat, agricultural residues and biogenic wastes. 10% of all productive arable land of the world as well as more than 50% of the world's black soil are located in Russia. However, more than 70% of the territory of Russia is a zone of risky agriculture (growing season lasts only for 2-4 months)¹.

Potential bioenergy opportunities in Russia reach far beyond the capacity of any country in the world which allows us to speak about a theoretical possibility for Russia to become a major exporter of various kinds of bioenergy raw materials.

Total annual energy consumption in Russia is 1600 Mt/year. However, the added value of the bioenergy development for the country does not only address its huge energy potential. It is more than that: It is a comprehensive solution that helps to overcome more complex challenges: social problems (high-skilled jobs), environmental problems (waste management), energy problems (production of all kinds of energy) and economic problems (obtaining of additional products).

The bioenergy potential of Russia is comprised in the following summary:

<table>
<thead>
<tr>
<th>Potential</th>
<th>Gross Millions of tons of oil equivalent/ per year</th>
<th>Technical Millions of tons of oil equivalent/year</th>
<th>Economic Millions tons of oil equivalent/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total potential of the biomass</td>
<td>467</td>
<td>129</td>
<td>69</td>
</tr>
<tr>
<td>Organic wastes of AIC</td>
<td>80</td>
<td>30</td>
<td>14</td>
</tr>
</tbody>
</table>

Source: compiled by the author

¹ http://russiafederation.ru
1.1 The potential of the country and of the selected regions

All the reasons why developed countries are working actively in the field of bioenergy can be applied to Russia. However, there is a specificity caused by the current state of the economy and society. The main characteristic is the fact that the development of bioenergy in Russia can lead to the solution of social problems: reducing unemployment, small business development, improving standards of living, education and culture. The development of bioenergy can reduce the environmental problems that exist in a number of cities. This result can be achieved by reducing harmful emissions of the common power plants. The solution is to use biomass for the biogenic fuel and energy production (both electrical and thermal power).

Another challenge is to provide decentralised energy supply in the remote areas which are not connected to the common national power grid system. Currently, the centralised energy supply systems cover only 1/3 of the country’s territory. Reliable energy supply in remote areas is a complicated and expensive task for the state: 8.6 million tons of liquid fuel (diesel, black oil) and 20-25 million tons of solid fuel (coal) are imported annually to the Far North, Siberia and Far East. Due to the increase of the transportation costs the price for the supplied fuels turns doubled. For example, in the Republic of Tuva, Altai Republic and Kamchatka it amounts to more than $ 350 per ton of oil equivalent.

The purposes for the bioenergy development in Russia are:

- Development of the bioenergy equipment production and marketing;
- Development of technologies for bioenergy utilisation as reliable autonomous clean renewable energy supply for consumers in the areas which are not connected to the centralised energy supply systems;
- Development of effective technologies for power grid systems and heat supply based on renewable energy;
- Increase of the production and utilisation capacities for new types of fuel based on various types of biomass.

The Russian Federation has the largest number of bioenergy resources in the world:

- 1180 million hectares of forest (22% of the world’s reserves) with the potential of production of 200 million m3 of low-value timber and timber waste
- 30.8 billion tons of peat (40% of the world’s resources), which is 10.7 billion tons of oil equivalent. Currently, only 1.2 million tons are actively used (75% for the energy sector and 25% for agriculture).
- 775 million tons of agro-industrial sector wastes (AIS), which can provide up to 70 billion m3 of biogas and more than 100 million tons of high quality fertilizer once current high-tech processing procedures and equipment are applied.

The country is theoretically capable to cover its own energy needs solely by using bioresources. Today in Russia there are more than 1,600 large animal production, pig and poultry farms. Every day they generate more than 450,000 tons of manure and other wastes. In addition, there is a huge amount of wastes from the meat processing plants, fisheries as well as crop and...
further residues (silage, beet and sunflower pulp), and wastewater. In fact, these are way too many biogenic raw materials which are not effectively used in the country. Recycling of these raw materials which are factually freely available allows producing electricity, heat and high-quality organic fertilizers as a by-product. The last is especially effective by recycling manure and plant materials.

Furthermore, more than 2 million hectares of land are currently occupied by the storage of agricultural residues in Russia. Returning these lands to normal agricultural use would bring a huge positive effect to the Russian economy. The production of biogas for energetic purposes seems to be the most promising field for rural areas of the country because most of the organic waste accounts for agriculture. The total estimated potential for the establishment of biogas plants in Russia amounts to 20 000 enterprises. The country could, thus, become the largest exporter of certain types of bioenergy if this sector of Russian energy industry was developed more intensively in the future.

Almost all federal districts of Russia have basic renewable energy sources (solar, wind, small hydro, biomass) and have the potential required to create integrated power plants for the production of thermal power, electricity and motor fuel to provide the population with all kinds of fuels and energy for both domestic and industrial demands. This can solve all the social problems of the rural population of any region of Russia. The mentioned sources make up about 30% of the total consumption of fuel and energy resources in Russia. They create favourable conditions for solving the energy, social and environmental problems in the future.

The assessment of the potential of various renewable energy sources in Russia is presented in the following table:

**Assessment of the potential of various renewable energy sources in Russia**

<table>
<thead>
<tr>
<th>Resource Type</th>
<th>Federal District</th>
<th>North-Western Federal District</th>
<th>Central Federal District</th>
<th>South</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar Energy (billion tons of oil equivalent)</td>
<td>178.2</td>
<td>84.9</td>
<td>100.7</td>
<td></td>
</tr>
<tr>
<td>Wind energy (billion tons of oil equivalent)</td>
<td>58.8</td>
<td>9.8</td>
<td>24.0</td>
<td></td>
</tr>
<tr>
<td>Small hydro energy (million tons of oil equivalent)</td>
<td>54.55</td>
<td>2.9</td>
<td>20.6</td>
<td></td>
</tr>
<tr>
<td>Energy of biomass</td>
<td>8.6</td>
<td>1.5</td>
<td>0.37</td>
<td></td>
</tr>
<tr>
<td>The reserves of thermal waters and steam hydrotherms Million gigacalories / year</td>
<td>1.7</td>
<td>14.5</td>
<td>24.8</td>
<td></td>
</tr>
<tr>
<td>WASTE</td>
<td>Domestic sector (million tons of oil equivalent)</td>
<td>1.095</td>
<td>3.22</td>
<td>1.956</td>
</tr>
<tr>
<td>Peat</td>
<td>Wood Processing Sector (million tons of oil equivalent)</td>
<td>2900.9</td>
<td>760.7</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>Agro industrial Sector (million tons of oil equivalent)</td>
<td></td>
<td></td>
<td>29.5</td>
</tr>
</tbody>
</table>
Promoting sustainable production and use of bioenergy in the Russian Federation and Ukraine

Uneven distribution of the renewable energy by regions allows creating energy clusters with different combinations of renewable energy sources.

The following table presents data on the qualitative composition of bioenergy raw materials quantitatively expressed in tons of oil equivalent. That allows determining not only the types of bioenergy technologies for the production of biofuel, but also the annual amount of its potential production in different regions⁴.

<table>
<thead>
<tr>
<th>Region</th>
<th>Type of bioenergy raw material of Russia</th>
<th>Forest biomass/ millions of tons of oil equivalent/ year</th>
<th>Wood processing wastes/ thousands of tons/year</th>
<th>Agroindustrial sector waste/ thousands of tons/year</th>
<th>Peat/ millions of tons/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Federal District</td>
<td></td>
<td>13.6</td>
<td>881.0</td>
<td>17745.3</td>
<td>760.68</td>
</tr>
<tr>
<td>Belgorod region</td>
<td></td>
<td>0.0</td>
<td>15.5</td>
<td>1900.4</td>
<td>0.91</td>
</tr>
<tr>
<td>Bryansk region</td>
<td></td>
<td>0.8</td>
<td>63.0</td>
<td>747.6</td>
<td>62.76</td>
</tr>
<tr>
<td>Vladimir region</td>
<td></td>
<td>0.8</td>
<td>90.5</td>
<td>388.5</td>
<td>45.3</td>
</tr>
<tr>
<td>Voronezh region</td>
<td></td>
<td>0.1</td>
<td>22.0</td>
<td>2525.3</td>
<td>1.49</td>
</tr>
<tr>
<td>Ivanovo region</td>
<td></td>
<td>0.7</td>
<td>47.5</td>
<td>293.2</td>
<td>25.03</td>
</tr>
<tr>
<td>Kaluga region</td>
<td></td>
<td>0.8</td>
<td>37.0</td>
<td>364.0</td>
<td>8.51</td>
</tr>
<tr>
<td>Kostroma region</td>
<td></td>
<td>2.9</td>
<td>195.0</td>
<td>215.7</td>
<td>98.4</td>
</tr>
<tr>
<td>Kursk Region</td>
<td></td>
<td>0.1</td>
<td>14.0</td>
<td>1735.9</td>
<td>10.19</td>
</tr>
<tr>
<td>Lipetsk region</td>
<td></td>
<td>0.1</td>
<td>10.5</td>
<td>1508.0</td>
<td>2.53</td>
</tr>
<tr>
<td>Moscow Region and Moscow City</td>
<td></td>
<td>2.0</td>
<td>66.0</td>
<td>1242.3</td>
<td>63.87</td>
</tr>
<tr>
<td>Orel Region</td>
<td></td>
<td>0.1</td>
<td>10.5</td>
<td>1315.0</td>
<td>3.48</td>
</tr>
<tr>
<td>Ryazan region</td>
<td></td>
<td>0.8</td>
<td>25.5</td>
<td>1054.9</td>
<td>38.14</td>
</tr>
<tr>
<td>Smolensk region</td>
<td></td>
<td>0.9</td>
<td>33.5</td>
<td>487.5</td>
<td>108.94</td>
</tr>
<tr>
<td>Tambov Region</td>
<td></td>
<td>0.2</td>
<td>124.5</td>
<td>1247.1</td>
<td>6.5</td>
</tr>
<tr>
<td>Tver Region</td>
<td></td>
<td>2.0</td>
<td>150.0</td>
<td>463.1</td>
<td>228.95</td>
</tr>
<tr>
<td>Tula Region</td>
<td></td>
<td>0.3</td>
<td>17.5</td>
<td>922.8</td>
<td>0.11</td>
</tr>
</tbody>
</table>

Source: Russian Energy Agency: Bioenergy of Russia in XXI century, 2012

⁴ RUSSIAN ENERGY AGENCY: BIOENERGY OF RUSSIA IN THE XXI CENTURY, 2012
<table>
<thead>
<tr>
<th>Region</th>
<th>Biomass Production</th>
<th>Nitrates</th>
<th>Phosphates</th>
<th>Sulphates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yaroslavl Region</td>
<td>1.0</td>
<td>32.5</td>
<td>385.7</td>
<td>55.57</td>
</tr>
<tr>
<td>North-Western Federal District</td>
<td>46.3</td>
<td>3075.0</td>
<td>2852.1</td>
<td>2900.94</td>
</tr>
<tr>
<td>Republic of Karelia</td>
<td>4.5</td>
<td>519.0</td>
<td>113.6</td>
<td>216.67</td>
</tr>
<tr>
<td>Republic of Komi</td>
<td>15.9</td>
<td>445.0</td>
<td>167.8</td>
<td>230.49</td>
</tr>
<tr>
<td>Arkhangelsk Region and Nenets Autonomous District</td>
<td>11.3</td>
<td>1263.5</td>
<td>239.3</td>
<td>278.54</td>
</tr>
<tr>
<td>Vologda Region</td>
<td>7.5</td>
<td>273.5</td>
<td>456.5</td>
<td>1283.9</td>
</tr>
<tr>
<td>Kaliningrad Region</td>
<td>0.1</td>
<td>10.5</td>
<td>353.1</td>
<td>28.08</td>
</tr>
<tr>
<td>Leningrad Region and St. Petersburg</td>
<td>3.9</td>
<td>333.5</td>
<td>551.9</td>
<td>334.1</td>
</tr>
<tr>
<td>Murmansk Region</td>
<td>0.4</td>
<td>27.5</td>
<td>92.9</td>
<td>3.56</td>
</tr>
<tr>
<td>Novgorod Region</td>
<td>1.8</td>
<td>102.0</td>
<td>170.3</td>
<td>259.54</td>
</tr>
<tr>
<td>Southern Federal District</td>
<td>1.0</td>
<td>347.0</td>
<td>26861.0</td>
<td>0.32</td>
</tr>
<tr>
<td>Republic of Adygea</td>
<td>0.1</td>
<td>22.0</td>
<td>457.5</td>
<td></td>
</tr>
<tr>
<td>Republic of Dagestan</td>
<td>0.1</td>
<td>1.0</td>
<td>1417.8</td>
<td></td>
</tr>
<tr>
<td>Republic of Ingushetia</td>
<td>0.0</td>
<td>3.5</td>
<td>165.7</td>
<td></td>
</tr>
<tr>
<td>Kabardino-Balkaria Republic</td>
<td>0.0</td>
<td>3.0</td>
<td>607.3</td>
<td></td>
</tr>
<tr>
<td>Republic of Kalmyk</td>
<td>0.0</td>
<td>1.0</td>
<td>565.5</td>
<td></td>
</tr>
<tr>
<td>Karachay-Cherkessia Republic</td>
<td>0.3</td>
<td>5.0</td>
<td>145.0</td>
<td></td>
</tr>
<tr>
<td>Republic North Ossetia - Alanya</td>
<td>0.0</td>
<td>3.0</td>
<td>409.2</td>
<td></td>
</tr>
<tr>
<td>Republic of Chechnya</td>
<td>0.0</td>
<td>0.0</td>
<td>93.87</td>
<td></td>
</tr>
<tr>
<td>Krasnodarsky Krai</td>
<td>0.2</td>
<td>137.0</td>
<td>9177.8</td>
<td></td>
</tr>
<tr>
<td>Stavroposky Krai</td>
<td>0.0</td>
<td>34.5</td>
<td>4658.6</td>
<td></td>
</tr>
<tr>
<td>Astrakhan region</td>
<td>0.0</td>
<td>73.5</td>
<td>335.3</td>
<td></td>
</tr>
<tr>
<td>Volgograd Region</td>
<td>0.1</td>
<td>31.5</td>
<td>4054.4</td>
<td></td>
</tr>
<tr>
<td>Rostov Region</td>
<td>0.0</td>
<td>32.0</td>
<td>4772.8</td>
<td></td>
</tr>
<tr>
<td>Volga Federal District</td>
<td>24.1</td>
<td>1635.0</td>
<td>27533.6</td>
<td>413.84</td>
</tr>
<tr>
<td>Republic of Bashkortostan</td>
<td>5.1</td>
<td>158.0</td>
<td>3898.3</td>
<td>25.48</td>
</tr>
<tr>
<td>Republic of Mari-Al</td>
<td>0.8</td>
<td>77.5</td>
<td>374.2</td>
<td>40.27</td>
</tr>
<tr>
<td>Republic of Mordovia</td>
<td>0.2</td>
<td>18.5</td>
<td>747.9</td>
<td>2.91</td>
</tr>
<tr>
<td>Republic of Tatarstan</td>
<td>0.8</td>
<td>106.5</td>
<td>3819.7</td>
<td>8.21</td>
</tr>
<tr>
<td>Republic of Udmurtia</td>
<td>1.3</td>
<td>88.0</td>
<td>848.3</td>
<td>31.42</td>
</tr>
<tr>
<td>Republic of Chuvashia</td>
<td>0.5</td>
<td>22.5</td>
<td>849.6</td>
<td>1.91</td>
</tr>
<tr>
<td>Kirov Region</td>
<td>4.7</td>
<td>374.5</td>
<td>925.1</td>
<td>144.39</td>
</tr>
<tr>
<td>Nizhny Novgorod Region.</td>
<td>2.1</td>
<td>252.5</td>
<td>12373.9</td>
<td>67.28</td>
</tr>
<tr>
<td>Orenburg Region</td>
<td>0.2</td>
<td>17.5</td>
<td>2193.4</td>
<td>0.28</td>
</tr>
<tr>
<td>Penza Region</td>
<td>0.6</td>
<td>57.0</td>
<td>5657.8</td>
<td>3.92</td>
</tr>
<tr>
<td>Perm Region</td>
<td>6.7</td>
<td>569.5</td>
<td>945.3+78.29</td>
<td>49.54+30.39</td>
</tr>
<tr>
<td>Samara Region</td>
<td>0.3</td>
<td>24.0</td>
<td>1694.7</td>
<td>3.25</td>
</tr>
<tr>
<td>Saratov Region</td>
<td>0.1</td>
<td>26.0</td>
<td>3470.2</td>
<td>0.25</td>
</tr>
<tr>
<td>Ulyanovsk Region</td>
<td>0.7</td>
<td>43.0</td>
<td>792.9</td>
<td>4.34</td>
</tr>
<tr>
<td>Nizhny Novgorod Region.</td>
<td>2.1</td>
<td>252.5</td>
<td>12373.9</td>
<td>67.28</td>
</tr>
<tr>
<td>Ural Federal District</td>
<td>35.0</td>
<td>797.5</td>
<td>4400.8</td>
<td>2534.05</td>
</tr>
<tr>
<td>Kurgan Region</td>
<td>0.7</td>
<td>31.0</td>
<td>808.2</td>
<td>6.71</td>
</tr>
<tr>
<td>Sverdlovsk Region</td>
<td>7.9</td>
<td>470.5</td>
<td>1126.6</td>
<td>1148.03</td>
</tr>
<tr>
<td>Tyumen Region</td>
<td>24.7</td>
<td>225.0</td>
<td>1215.9</td>
<td>916.45+43</td>
</tr>
<tr>
<td>Chelyabinsk Region</td>
<td>1.7</td>
<td>71.0</td>
<td>1250.0</td>
<td>18.01</td>
</tr>
<tr>
<td>Siberian Federal District</td>
<td>151.6</td>
<td>2522.0</td>
<td>13315.9</td>
<td>3632.53</td>
</tr>
<tr>
<td>Republic of Altai</td>
<td>2.3</td>
<td>84.5</td>
<td>260.7</td>
<td></td>
</tr>
<tr>
<td>Republic of Buryatia</td>
<td>9.1</td>
<td>150.0</td>
<td>326.8</td>
<td>22.41</td>
</tr>
<tr>
<td>Republic of Tyva</td>
<td>5.1</td>
<td>12.5</td>
<td>157.3</td>
<td></td>
</tr>
<tr>
<td>Republic of Hakassia</td>
<td>2.1</td>
<td>0.0</td>
<td>274.7</td>
<td></td>
</tr>
</tbody>
</table>
The bioenergy development will bring the following key advantages for Russia:

- A new innovative bio-industry segment of economy
- An additional mechanism for economic growth through the production of high-quality added-value products
- The development of three major sectors of the economy: energy, agriculture and forestry
- Activation of scientific activity in creation of new technologies for processing of various types of biomass
- Widespread implementation of innovative technologies in the agriculture and industry
- The emergence of new competitive products, consumer market development
- Additional conditions for the successful development of regional economy
- A basis for the large-scale recycling helping to improve the environmental situation
- Local manufacturing of heat and electricity from biomass is supposed to develop various areas of power generation which is of particular importance for energy-deficient regions and regions of Russia, deprived of its own mineral fuel resources (oil, gas, and coal), sufficient gasification and adequate access to centralized power grids. According to experts, this energy-deficient regions make around 75% of the country’s territory, inhabited by more than 20 million people.

As for the field of biofuel production (e.g. biodiesel, bioalcohol, biogas, pellets), it is necessary to improve the ecology of cities and the entire environment by reducing emissions, increasing the profitability of agriculture, forestry, domestic sector and local transport through the use of locally produced biofuels, and on the other hand, to ensure a sufficient level of biofuel production to solve internal problems as well as to ensure export potential.

Energy and fuel production while recycling organic waste comprises both recycling and liquidation of emergency situations consequences in the energy sector through bioconversion
methods. It would both solve the pressing environmental problem and improve the economic efficiency of farms (“waste-into-income”).

Large-scale production of biomass as a raw material for bioenergy will solve the problem of creating new biological resources as the basis of bioenergy. Along with the traditional biomass sources there are some areas which are considered promising, such as fast-growing trees, microalgae, etc. Post-genomic technologies including cloning and methods of molecular and cellular engineering are widely used to solve the problems of this area: getting biomass sources with improved performance characteristics etc.

As for the bioenergy machinery, there is a problem of modern high-tech devices for the manufacturing of heat and electricity from a variety of biomass sources which requires to be solved in the near future. Particular attention shall be paid to energy efficiency, sustainability and economic efficiency of equipment and processes. This area of activities also includes the creation of biofuel cells and independent energy supply systems for industrial and domestic use.

The Program BIO 2020 (see section 2.1.3) sets quite ambitious targets for Russia in terms of product promotion, reduction of the biotechnology products import two times and increase of the export up to 25 times.

Targets for bioenergy sector under the program BIO2020:

- 10% of bio-energy in the fuel mix for the manufacturing of heat and electricity;
- 10% share of biofuel in the amount of motor fuel;
- 90% of water surface pollution cleaning performed by fuel and energy companies with the biodegradable sorbents;
- 30% of solid municipal waste and 90% of poultry waste being recycled for the energy needs;
- 20% share of the European solid biofuel market;
- 5% of the world motor biofuel and its components market.

The main question in this regard remains whether Russia is ready to provide competitive products for export to the world’s markets.

Currently, pellets and biodiesel are the only biotechnological products of all available and possible for production in Russia that are exported successfully. At the same time, even in the post-oil world, Russia has all the prerequisites to maintain its leading position as a supplier of renewable raw material and products derived from it⁵.

Given the fact that the bioenergy development is an integral part of the bioeconomy (food, green chemistry, biopharmaceuticals, bioenergy) market trends should be discussed within the general biotechnology paradigm. The experts’ assessment shows that by 2030 certain shares of the following markets will be based on biotechnology:

- 35% of chemical products (green chemistry);
- 80% of pharmaceutical products (biopharmaceuticals);
- 50% of agricultural products.

⁵ Source http://биотех2030.рф/интервью-о-в-фомичева
Bioeconomy Development Programs for the developed countries (OECD) predict that up to 3% of GDP in these countries will be based on "green technologies." To date, the European bioproducts market has already reached the volume of 250 billion EUR and employs over 22 million people.

Unfortunately, Russia is losing in this new technological revolution "race". In 1980 Russia was the 2nd in the world (after the U.S.) in terms of manufacturing of biotechnological products, then by 2008 it fell back to position 70, significantly yielding the EU, India, China.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>TOTAL AMOUNT OF BIOPRODUCTS IN THE WORLD (BILLION USD)</th>
<th>RUSSIA (BILLION USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>30</td>
<td>1.5</td>
</tr>
<tr>
<td>1990</td>
<td>95</td>
<td>3.2</td>
</tr>
<tr>
<td>2000</td>
<td>150</td>
<td>0.4</td>
</tr>
<tr>
<td>2010</td>
<td>250</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Source: http://www.biorosinfo.ru

As the demand for biotechnology products increases while relevant domestic production is sharply reduced, Russia is forced to import up to 90% of biotechnology products from abroad.

<table>
<thead>
<tr>
<th>Type of Products</th>
<th>Share of import</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biopharmaceuticals</td>
<td>89 %</td>
</tr>
<tr>
<td>Agricultural Biotechnologoes</td>
<td>93 %</td>
</tr>
<tr>
<td>Ferments</td>
<td>89 %</td>
</tr>
<tr>
<td>Live cultures</td>
<td>88 %</td>
</tr>
<tr>
<td>Ecological Biotechnologies</td>
<td>82 %</td>
</tr>
</tbody>
</table>

Source: http://www.biorosinfo.ru
In the recent years (2012 - 2013) the Russian Federation has taken steps to develop the bio-economy sector in the country. The "Comprehensive program of biotechnology development in the Russian Federation for the period up to 2020" (BIO-2020) was developed on the initiative of technological platforms (TP "Bioenergy" TP "Medicine of the Future," TP "Biotech 2030"). The program was approved by the Prime Minister of the Russian Federation Vladimir Putin.


**The Target of the Program:** to create a hi-tech bioeconomy sector in The Russian Federation which as well as nanotechnologies and IT should become a basis for development of the post-industrial economy in the country.

The program sets ambitious targets: increasing biotechnological products consumption 8.3 times, manufacturing - up to 33 times, import reduction by 50% and increasing the share of exports in manufacturing of biotechnological products more than 25 times. Overall, the program should result in increasing the share of biotechnological production up to 1% of GDP by 2020 and in creating the preconditions for achieving 3% of GDP by 2030.

According to the information given above the main trends of bioenergy development in Russia are:

- A widespread transfer of modern "know-how" and technology for the development of the national segment of the bioenergy;
- Export of bioenergy (solid and liquid biofuels) with a tendency to 20% of the European market for solid biofuels (pellets) and 5% of the liquid ones (bioethanol and biodiesel);
The development of the national bioenergy market: bioenergy products should make no less than 10% of energy consumption, especially for isolated, energy-deficient regions and objects of the industrial agriculture (for example - Belgorod region).

1.2 The experience of Russia in the field of bioenergy

According to the materials of the Russian Energy Agency (BIOENERGY OF RUSSIA IN THE XXI CENTURY), Russia has a serious industrial experience in manufacturing biofuels from biomass. The Soviet Union was the first country in the world that has mastered large-scale industrial production of biofuels (biobutanol, bioethanol bioacetone, biohydrogen and biogas) from biomass (molasses which is the waste of manufacturing sugar from sugar beet).

Just a few examples: in the USSR until the late 1980s there were four acetone-butyl plants: in Grozny, Nalchik, Talitsa (Sverdlovsk region) and Efremov (Tula region.). Daily production at Efremov plant at full load was up to 50 tons of solvents (butanol, acetone, ethanol in a weight ratio of 13: 4: 1) and 29 thousand m3 of hydrogen, or 15000 tones of solvents and to 8.7 million m3 of hydrogen a year. Grozny plant produced to 74 tons of solvent and 43 thousand m3 of hydrogen a day or 22 000 tones of solvents and up to 13 million m3 of hydrogen per year. In 1967 the Efremov and in 1969 the Grozny plants were commissioned for manufacturing fodder vitamin B-12 which is also called barda (3000 m3/day) using the method of thermophilic methane fermentation of waste. Except for vitamin B-12 each workshop produced up to 30 thousand m3 of biogas per day, which was used entirely to produce heat energy for the entire production cycle.

By the 1970s, for the first time in the world Russia had established a large-scale industrial production of biofuels from biomass: biohydrogen, biomethane, biobutanol bioacetone bioethanol. The successful industrial development of biogas technology, large-scale production of biogas at acetone-butyl plants and "aeration" stations for wastewater cleaning had allowed Moscow to set the task of wide deployment of these technologies in the agricultural complex of the USSR by the end of the 1970s.

Bioenergy recycling plants processing the waste of domestic livestock and poultry production called "Cobos" and BEU-301 operated in Russia and the former USSR in 1980 – 1990.

In the early 1980s the leading place in the use of biomass for energy purposes, in addition to the gasification of wood and lignocellulosic materials, belonged to the development of biogas technology for the manufacturing of biogas, heat and electricity from organic waste of agriculture, food industry and light industry, as well as the utilities sector waste and solid municipal waste. Tangible practical results have been achieved in this area.

Research and Production Centre "Ekoros" developed and implemented a highly profitable biogas technology and equipment (biogas plants IBUGU-1), designed for use at small farms with a payback period of 1-1.5 years, the plants can operate efficiently in any climatic region of Russia. In the period from 1992 till 2004 more than 80 units of this type were produced and implemented.

The All-Russian Institute for Electrification of Agriculture (Moscow) developed a highly-efficient experimental plant, based on the principle of fast pyrolysis of biomass, converting up to 70% of solids into a liquid or gaseous fuel with calorific value of 5,000 kcal / kg. It includes diesel
generator, converted for the co-combustion of produced gas and diesel fuel, while saving up to 50% of diesel fuel. The uniqueness of the biogas technologies based on thermophilic methane-generation modes is explained by the fact that the methanogenic consortium simultaneously creates biogas containing no hydrogen sulfide (which is important in the operation of equipment made of carbon steel) and a unique and versatile high-performance and eco-friendly organic fertilizers. These fertilizers greatly increase the productivity of various crops and increase the resistance of plants to environmental stress which was proved by twenty years of research in the leading eco-soil Centres of Russia and wide application in a number of regions of the country. Modern Russian bioenergy offers a variety of high-tech biogas technologies developed earlier in the USSR:

(1) The technology of incoming raw material vertical substitution in the methane tank - "classical technique" (1961) (Efremov, Grozny, Andrushevsk and Daugavpils plants producing fodder concentrate of methane fermentation; Kuryanovskaya and Lyuberetskaya aeration stations, Moscow). Developers: Bach Research Institute of The Academy of Sciences of the USSR, Grozny Institute of fermentation industry, Research institute Vodokanal).


(3)The recycling technology which reduces the fermentation time up to 8 times and increases the biogas output up to 8 times for the raw material with 96-98% moisture content (1965) (Grozny Acetone-Butyl plant). Developers: Grozny Institute of Automation, Bach Research Institute of The Academy of Sciences of the USSR, Grozny Acetone-Biochemical Plant.


(5)The three-stage Methane – Generation Technology for all kinds of raw materials with a moisture content not exceeding 85%. The technology reduces the fermentation time up to 1.5 times, increases the output of biogas and methane up to 2 times, increases the degree of decomposition of the starting substrate up to 1.8 times (1986) Developers: Institute of Microbiology of the Armenian Academy, Bach Research institute of The Academy of Sciences of the USSR, JSC Centre "ECOROS."

(6)The technology for processing livestock-production and pig-farming waste with moisture component of 97-98% based on preliminary separation of phases of raw materials. The technology reduces the time of fermentation and the workload of methane tank bioreactors, increases the output of biogas. (1989, Bioenergy station at the "Bolshevik" pig farm. The crimean region, USSR). Developers: Soviet Research Institute of Agriculture, under the state program “Biotechnology”.

(7)The technology of solid-state methane-generation for processing of concentrated sewage sludge with a moisture content of 60-80%. (1992) Developers: Bach Research Institute at the USSR Academy of Sciences, the Academy of Municipal Economy named after K. Pamfilov.
(8) The express thermophilic methane-generation solid-state recycling technology for municipal solid waste and agricultural solid waste. (1986). This technology allows to create a stationary, non-polluting and non-waste solid waste processing plants able to eliminate landfills in 15-20 days instead of 30-60 years and produce ferrous and nonferrous metals, building materials, cardboard, glass, gaseous fuels - biomethane and biofertilizers. Technology can be applied for the processing of solid agricultural wastes (straw, corn and sunflower stalks etc.). (The technology was tested at JSC Centre "ECOROS") Developers: Bach Research Institute at USSR Academy of Sciences, JSC Centre "ECOROS".

(9) The «upslow» methane-generation technology for super-liquid (liquid component no less than 98-99%) animal farming waste, food industry waste, canning industry waste, dairy industry waste, paper industry waste. Several times increases the output of biogas and methane. (Pig farm in the Vologda region). Developers: MSU University and Research institute “Vodokanal”

Successful industrial implementation of the biogas technologies mentioned above and their optimization requires testing them on the model methane tanks of the stations of technological testing. Unfortunately, the experience of bioenergy technologies development in the Soviet Union acquired during the period between 1970 and 1990 was almost lost during the 90s and today we can say that Russia practically has no national bioenergy sector.

A huge scientific potential still remains undiscovered to restore and develop the high-level bioenergy sector. However, this is possible only with broad international cooperation and considerable political and the financial support from the state.

2. Bioenergy manufacturing based on agricultural waste

Biomass refers to all kinds of substances of plant and animal origin, and the organic waste formed in the manufacturing or consumption process and on various stages of technological cycle of waste.

There are three main categories of biomass:

- An agricultural waste of plant origin (husk, straw, cane etc.), waste of animal farming, waste of timber industry; municipal waste, sewage waste etc.
- Agricultural crops (including specially grown energy crops).
- Woody biomass.

The main areas for the development of domestic bioenergy in Russia are:

- The generation of thermal power and electricity from biomass.
- Manufacturing of biofuels (biodiesel, bio alcohol, biogas, pellets, etc.).
- Recycling of organic waste for energy and fuel production including waste management.
- Large-scale manufacturing of biomass as raw material for bioenergy.
- The development of bioenergetic machinery.
- Organic biomass of plant and animal origin and different types of recyclable waste make the basis of raw materials for bioenergy in Russia.
The assessment of the total amount of organic waste of agricultural sector and of timber industry performed by the Institute of Energy Strategy allowed to find out that the following types of biofuel are universal for all the regions of Russia: pellets (pellets and briquettes) and biogas.

**Allocation of agricultural waste by federal districts**

![Map of Russia showing agricultural waste distribution](image)

*Source: Autonomous Non-Profit Organization “Information and analytics centre”*

**Opportunities for biogas manufacturing in various regions of Russia**

![Map of Russia showing biogas potential](image)

*Source: Autonomous Non-Profit Organization “Information and analytics centre”*
The potential of biogas generated from wastes in the agro-industrial complex: According to estimation based on available statistical data, about 450 million tons of animal wastes (58 million tons of dry substance) are annually produced in Russia. The recycling of this amount with anaerobic fermentation will allow to generate about 33, 5 billion m3 of biogas (55% CH4) a year.

<table>
<thead>
<tr>
<th>Type of animals</th>
<th>Livestock, millions</th>
<th>Amount of wastes, tons /year (moisture content, %)</th>
<th>Total amount of wastes, million tons/year (organic solid substance)</th>
<th>Potential for biogas production, billion m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pigs</td>
<td>13,5</td>
<td>3,5 (87)</td>
<td>47,25 (6,14)</td>
<td>2,14</td>
</tr>
<tr>
<td>Cattle</td>
<td>21,4</td>
<td>15,5 (88)</td>
<td>331,7 (39,8)</td>
<td>12,26</td>
</tr>
<tr>
<td>Small Cattle</td>
<td>18,2</td>
<td>2 (85)</td>
<td>36,4 (5,5)</td>
<td>2,48</td>
</tr>
<tr>
<td>Poultry</td>
<td>360,8</td>
<td>0,075 (75)</td>
<td>27,1 (6,77)</td>
<td>3,39</td>
</tr>
<tr>
<td>TOTAL:</td>
<td></td>
<td></td>
<td>442,45 (58,21)</td>
<td>20,27</td>
</tr>
</tbody>
</table>

Source: http://www.bioges.ru

The processing industry and crop raising can also provide additional raw material for biogas production.

<table>
<thead>
<tr>
<th>Type of wastes</th>
<th>Total amount of waste, million tons /year</th>
<th>Solid Substance, million tons/year</th>
<th>Potential for biogas production, billion m³</th>
<th>Fertilizer production (85% of organic solid substance), million tons/year.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal farming wastes</td>
<td>442,5</td>
<td>58,2</td>
<td>20,3</td>
<td>31,5</td>
</tr>
<tr>
<td>Crop raising wastes</td>
<td>222,2</td>
<td>147</td>
<td>36,8</td>
<td>86,5</td>
</tr>
<tr>
<td>Processing industry wastes</td>
<td>29,2</td>
<td>14</td>
<td>5,6</td>
<td>3,3</td>
</tr>
<tr>
<td>TOTAL:</td>
<td>693,9</td>
<td>219,2</td>
<td>62,7</td>
<td>121,3</td>
</tr>
</tbody>
</table>

Source: http://www.bioges.ru

Thus, the use of anaerobic fermentation for agro-industrial complex waste recycling makes it possible to get 63 billion m3 of biogas and 120 million tons of high-quality organic fertilizers annually.
63 billion m3 of biogas is equivalent to 35 million tons of gasoline / diesel fuel. Using biogas for cogeneration* makes it possible to get 144,000 GW/h of electricity and at least 1 billion GJ of thermal power\(^7\).

For comparison, Russia's agriculture consumes 2.0 million tons of gasoline, 4.8 million tons of diesel and 70,000 GW/h of electricity. Thus, applying an anaerobic processing of its waste, the agricultural complex of Russia can become energetically autonomous. Moreover, the excess heat and electricity can be supplied to all rural population of Russia (38 million people consuming about 43,000 GW/h of electricity).

However, in the short term, a 100% waste utilisation for energy production is practically not realistic. Even in the developed countries such as Germany where the share of biogas derived from wastes, currently amounts to 15% and is estimated to reach 30% of waste utilisation for energy production in the long term.

Thus, a realistic production of electricity from agro-industrial wastes in Russia could reach 50,000 GW/h of electricity, or 11.7 million tons of gasoline / diesel fuel.

The by-products of anaerobic digestion – the organic fertilizers – can replace a significant amount of mineral fertilizers used in agriculture, also used as a bio-fuel for boiler plants.

* Conversion efficiency in electricity is 38%.

**2.1 The legal framework**

The state authorities in Russia understand the value of bioenergy for the country and are aware of its potentials as well as economic benefits in case of further development of the sector. Information on the relevant legislative documents is available in section 2.1.2 of this analysis. The key players responsible for the establishment of the legal framework at the federal level are listed in section 2.1.1.

**2.1.1 Key Players**

At the federal level, the bioenergy related issues are under competence of several ministries:

**The Ministry of Energy of the Russian Federation** (http://www.minenergo.gov.ru) is a federal executive body, responsible for drafting and implementing national policy and legal regulation in the energy complex (including the renewable energy sources), as well as for providing various state services and state property management in the sphere of energy manufacturing and use if different energy sources.

**The Ministry of Economic Development of the Russian Federation** (http://www.economy.gov.ru) is a federal executive authority responsible for the creation and implementation of public policy and legal regulation in the field of analysis and forecasting of socio-economic development, entrepreneurship, including small and medium businesses. The ministry is also responsible for the protection of the rights of legal entities and individual

\(^7\) Source: The web site of BioGasEnergoStroy Corporation http://www.bioges.ru
entrepreneurs, for the implementation of state and municipal control (supervision), licensing, accreditation of certification bodies and testing laboratories (centers), for the implementation and development of interstate and federal programs of socio-economic development and for creation of the special economic zones in the Russian Federation. Also the Ministry performs its functions in the sphere of energy efficiency while performing the procurement for state needs, also the Ministry ensures the energy conservation and energy efficiency of the state and municipal institutions and organizations.

The Ministry of Agriculture of the Russian Federation (http://www.mcx.ru) is a federal executive authority responsible for public policy and legal regulation in the field of agriculture, land issues, various state services, sustainable development of the rural areas, state property management. It coordinates and controls the activities of the Federal Service for Veterinary Supervision, the Federal Agency for Fishery.

The Ministry of Industry and Trade of the Russian Federation (http://www.minpromtorg.gov.ru) is a federal authority responsible for public policy and legal regulation in the sphere of industrial and military-industrial complex. Also the Ministry performs the function of technical supervision and ensures the unity of measurements and regulation of the foreign trade.

The Ministry of Finance of the Russian Federation (http://www.minfin.ru) is a federal executive authority responsible for public policy and legal regulation in the sphere of budget, tax, insurance, banking, credit cooperation and customs payments, determination of the goods customs value.

The Ministry of Natural Resources and Ecology of the Russian Federation (http://www.mnr.gov.ru) is a federal executive authority responsible for public policy and legal regulation in the field of study, use, reproduction and protection of natural resources, including minerals, water sources, forests, fauna objects and their habitat, land issues, the environment, including issues related to waste production and consumption, state environmental supervision of protected areas and state expertise.

The Ministry of Science and Education of the Russian Federation (http://www.minobrnauki.rf) is a federal executive authority responsible for public policy and legal regulation in the sphere of education, science, scientific, technological and innovation activities, nanotechnologies, intellectual property.

2.1.2 The main documents regulating the development of the bioenergy sector

The laws on renewable energy sources builds up the basis necessary for the legal framework to ensure the establishment and development of innovative industries, however, in fact, insufficient attention is paid to the bioenergy in the today’s Russia.

The background documents are:
Promoting sustainable production and use of bioenergy in the Russian Federation and Ukraine

www.bio-prom.net

- Federal Law of March 26, 2003 № 35-FZ "On Electric Power Industry", since the adoption endured 22 editions (by August 23, 2012),


- Bioenergy is one of the prioritized sections of the state coordinating programs for biotechnology development in the Russian Federation until 2020 (The "BIO 2020" program) approved the Russian Government 04/24/2012. Bioenergy issues also make a significant part of the regional programs of biotechnologies development.

Sergey Chernin (currently the president of "GazEnergoStroy" Group of Companies and the chairman of NPP "Bioenergy") comments on the situation in the bioenergy field: "Today in Russia there is a paradoxical situation: the biogas plants market exists, the first plants are built, the farmers and regional authorities are interested in the technology. However biogas legislation simply does not exist. Basic regulations governing the energy sector don’t contain even a single mention of this method of heat and electricity manufacturing, although our country has all the prerequisites for the large-scale development of bioenergy. This gap in legislation should be eliminated as soon as possible". On February 4, 2014 the meeting of the Presidential Council for Russia's economic modernization and innovative development, took place in Belgorod under the chairmanship of Prime Minister Dmitry Medvedev. As a result of this meeting The Ministry of Energy, The Ministry of the Natural Resources, The Ministry of Agriculture and NPP "Technical platform Bioenergy" should prepare a draft of legislative amendments that will incorporate the term" biogas" and definitions of the various types of biofuel into the Russian legislation up to May 21, 2014. The decree was signed by the relevant ministries and the Deputy Prime Minister Arkady Dvorkovich. Also on the instruction of Arkady Dvorkovich the technical platform "Bioenergy" in collaboration with interested government authorities is recommended to provide a Working Group on the development of biotechnology under the Government of the Russian Federation, a list of pilot projects in the field of bioenergy, including the production of energy from organic raw materials, also defining the necessary mechanisms to support these projects.

- Federal Law of March 26, 2003 № 35-FZ "On Electric Power Industry", since the adoption endured 22 editions (by August 23, 2012),

In Section 8 "Renewable energy and local fuels" of The "Energy Strategy of Russia until 2020", there are no reports on bioenergy, although the priority of this sphere is noted.

The section 7 of the "Energy Strategy of Russia until 2030" which was approved in 2009 (the section is called "Innovation, scientific and technical policy in the energy sector") already referred to the "expansion of manufacturing and use of new fuels derived from various types of biomass." /http://www.minenergo.gov.ru/activity/energostrategy/

The decree of the government of the Russian Federation from 01/08/ 2009 number 1-P "The main directions of the state policy in the of sphere energy efficiency of electric power industry based on using the renewable energy sources for the period up to 2020" recommends local authorities to include the use of biomass in their development plans.

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8 Detailed comments at http://gis-vie.ru
9 The decree based on the results of the meeting http://www.i- russia.ru/all/docs/22556/
10 Source: http://www.perfectagro.ru/novosti/05_03_14/gazen
The "Comprehensive program for biotechnology development in Russia until 2020" was approved in 2012. The program BIO-2020 pays a lot of attention to bioenergy and introduces a number of performance indicators of its development up to 2020.

An interdepartmental work group was established to supervise the implementation of the program and to monitor the result. The group established is headed by Deputy Prime Minister Arkady Dvorkovich.

2.1.3 National mechanisms for support and stimulation of the bioenergy development

The following main tools for the biotechnology development support are currently available:

- Support of the advanced technological base implementation and development
- Development and support of eco-friendly agriculture
- Creating the following incentives for the industry development:
  - Attracting core investors
  - Improving the methods of financial support for participants
  - Developing mechanisms for the rational allocation of budgets
- Financing of innovative projects
- Development and implementation of the mechanisms for trading emission reduction units (ERUs) attracting players from Russia and CIS to this market
- Monitoring and dissemination of information on domestic and international renewable energy markets
- Assistance in the preparation of research papers and studies, the introduction of advanced international experience
- Fostering of professionals in the industrial sectors concerned
- Development of management and improvement recommendations for enhancing environmental and energy efficiency of production
- Promotion of bio-energy and renewable energy in Russia and CIS
- Support of the environmental safety and energy efficiency of the industries.

2.1.4 Federal / regional support programs

The State Programs of the Russian Federation are the main instruments for the state support on innovative technologies and applications:

(1) The Russian Government approved the Comprehensive Program for biotechnology development in Russia up to 2020 on 04.24.2012, the estimated cost of bioenergy sector development is 367 billion rubles. The Target of the Program is to create a hi-tech bioeconomy sector in The Russian Federation which as well as nanotechnologies and IT should become a basis for development of the post-industrial economy in the country.

The structure of the program BIO 2020 comprises:

- Medical Biotechnology
- Industrial Biotechnology
The activities of the "BIO 2020" program are:

- "Industrial manufacturing of non-food biomass for obtaining fuel and energy resources, including technologies of selection and bioengineering techniques"
- "The production of biofuel and biomass components with specified chemmotology properties"
- "Production of electricity and heat from biomass"
- "Energy waste management"
- "Absorption (recycling) of greenhouse gas emissions formed in energy production cycles, industrial and municipal wastewater for non-food biomass production intensification"
- "Prevention and mitigation of harmful anthropogenic environmental impact of the energy sector with bioconversion methods"
- "Bioenergy Machinery".

The budget structure for BIO – 2020 is build upon the following components:

<table>
<thead>
<tr>
<th>Indicator of the program’s targets achievement</th>
<th>Unit</th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Integral Indicators</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The consumption of biotech products in Russia</td>
<td>billion RUR</td>
<td>120</td>
<td>400</td>
<td>1 000</td>
</tr>
<tr>
<td>The amount of biotechnological products manufacturing in Russia</td>
<td>billion RUR</td>
<td>24</td>
<td>200</td>
<td>800</td>
</tr>
<tr>
<td>The share of imports in consumption</td>
<td>%</td>
<td>80</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>The share of exports in consumption</td>
<td>%</td>
<td>&lt; 1</td>
<td>20</td>
<td>25</td>
</tr>
</tbody>
</table>

**Indicators of the bioenergy in the program**

<table>
<thead>
<tr>
<th></th>
<th>%</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bio-additives for motor fuels</td>
<td></td>
<td>0</td>
<td>5-10</td>
</tr>
<tr>
<td>Biogas</td>
<td>%</td>
<td>0.01</td>
<td>1.5</td>
</tr>
<tr>
<td>Pellets</td>
<td>million tones</td>
<td>1.1</td>
<td>10.0</td>
</tr>
</tbody>
</table>

Source: http://www.biorosinfo.ru

2) The State Program of the Russian Federation “Energy efficiency and energy development” (Sub 6. "Development of renewable energy sources (RES)."

The program includes a package of measures to stimulate the production of electric power generating facilities that operate through the use of renewable energy.

The key results include:

- The development of the best available technologies and mechanisms for regulating the use of renewable energy sources in the regional economy (territorial units).
- Identifying areas and development priorities for the use of renewable energy sources on the territorial level (depending on the targets)
- Reducing the technology gap between the Russian Federation and the industrialized countries in the field of renewable energy.
- Achieving natural competitiveness for most of the types of renewable energy compared with fossil fuels up to 2020 (without government support).
- Creating conditions for the organization of industrial manufacturing of the equipment using renewable energy sources
- Increasing industrial and export potential.


The result of the program will be the creation of an effective system of state administration in the field of environmental protection, stimulation of the companies engaged in the program of ecological modernization of the industries as well as the environmental rehabilitation of the territories. In addition, the program creates conditions for the development and implementation of innovative eco-efficient technologies to reduce emissions and discharges of harmful substances (pollutants), and to stimulate the development of the market for eco-friendly goods and services.


One of the most important tasks of the program is to ensure the technological development of the industry through the creation and implementation of breakthrough, resource-saving, environmentally friendly industrial technologies for the production of competitive high-tech products.

5) **The State Program for the development of Agriculture and Regulation of the market of agricultural products, raw materials and food** for the years 2013 - 2020 years Subprogram "Technical and technological modernization, innovations development» (23, 7 bln. RUR).

The areas of the program linked to biotechnology comprise:

- The development of biotechnology;
- Promoting innovation and innovative development of agroindustrial sector;
- Supporting economically significant agricultural development programs of the Russian Federation.

### 2.1.5 Barriers and trends of the legal framework

There is a number of unresolved problems and deficiencies in the legislative regulation of the bioenergy segment. A complex solution of a number of topical issues is linked to the necessity of immediate removal of regulatory barriers which hinder the development of bioenergy technologies.

In the opinion of the authors of this analysis, the complex solution should include:
- Legislation and regulations, a system of technical regulations and standards in the field of an environmental law, energy law, international law necessary for the formation and development of the bioenergy sector.
- The introduction of new legal standards should be based on transparency and validity of their application which will require the involvement of business, science and public authorities in a reasonable, coherent and long-term program for the development of the legal regulation of this sphere of the economic activity.
- It is necessary to provide measures for the energy waste-recycling. For that Russia should adopt legislative and regulatory legal acts which include incremental implementation of restrictive measures on the use of non-full utilization technologies and manufacturing in agriculture utilities sector, forestry, food industries and other economic activities which are sources of biological waste.
- It is necessary to adopt bioenergy programs of federal agencies (Department of Defense, Justice, Interior and CHS), which provide for the use of bioenergy technologies for the energy supply the relevant objects.
- The support for manufacturing of bioenergy, bio motor fuels and their components is necessary to adopt legislative and regulatory legal providing the following:
  - A complete denaturation of industrial alcohol,
  - The abolition of excises on manufacturing and sale of dehydrated denatured ethyl alcohol,
- The support for exports of biofuels and their components.
- Licensing the manufacturing of biofuels and their components.
- The reduction of the excise tax on motor fuel containing components of renewable raw materials.

In the energy sector it is required to use standards supporting full bio-recycling of the energy production and accidents waste, as well as preventing harmful human impact on the environment through the use of biodegradable sorbents and other biological means of pollution control.

The economic potential of biogas industry can also be greatly increase under the following conditions:
- If the owner of a biogas plant is allowed to supply surplus electricity to the grid,
- In particular, if the order of the federal tariff services is approved, and the methodology for calculating tariffs for "green" electricity purchased at retail markets is available
- If the green tariff is used to compensate losses in power grids.

The improvement of the legal regulation in the field of bioenergy will be a motivating factor for the development of a large-scale production of biogenic products as well as the establishment of a stable consumer demand.

2.2 Economic performance and financial conditions for the production of biogas

The biogas production is the renewable energy segment in Russia operating a huge volume of agriculture, food industry and municipal wastes and residues. Potentially, it is the most attractive bioenergy sector for (inter)national investors. However, only a comprehensive approach can
provide fast growth of the industry. Such an approach should include the implementation of projects mandatory respecting environmental issues, getting profits from the disposal of organic wastes and the sale of organic fertilizers.

The production of biogas is also a priority for the development of bioenergy in the remote autonomous regions of Russia. This sector is provided with the resource base and domestic technological solutions, it creates conditions for effective growth of rural areas and agro-enterprises, solves complex social and environmental problems.

The development of biogas segment turns out to be the most promising one because it does not require large-scale investments in the organization of manufacturing.

2.2.1 The current situation on the market

In Russia, the interest in biofuels has been growing since 2006. However, the market for biofuel products is still at the stage of formation. Its development started by the manufacturing of solid biofuels (fuel pellets, briquettes, etc.) due to the availability of resources and woodworking technologies in Russia. The industry is mostly export-oriented and has a tendency to dynamic growth. Another priority for the Russian bioenergy development is the development and application of biomass gasification technology based on the processing of biogas from different types of waste: wood, agricultural and municipal solid.

The main sources of energy biomass in the Russian Federation are forest biomass, agricultural and organic wastes, energy plant cultures and residual oil. In this regard, agriculture is becoming an important element in the formation of the biofuel market in Russia\textsuperscript{11}.

There are two promising directions in the biogas production in Russia: the construction of industrial plants and implementation of modular installations of factory production.

From the standpoint of technological solutions the production of biogas reactors is also developing in two directions: The first kind of biogas installation is a modular horizontal reactor of a cylindrical shape with agitators of mass production and delivered as a finished product. The second constructive type comprises vertical methane tanks, which are usually assembled on site\textsuperscript{12}.

Among the major manufacturers of biogas plants in Russia the following companies should be named:


Products of the Corporation "BioGazEnergoStroy are quite competitive in the world’s market today. Russian stations are constructed and operated in the Baltic Region, Israel, Belorussia. Technologies of the Corporation "BioGazEnergoStroy" are adapted to operate at an ambient temperature of +40 to -40 degrees Celsius.

\textsuperscript{11} Source: an article “Perspective fuel” by T. Pantsyrnaya published in “Forest Industry Magazine” in April, 2014

\textsuperscript{12} \url{http://www.biogaz-russia.ru}
Currently, the "BioGazEnergoStroy" Corporation is implementing a comprehensive project on the introduction of biogas technologies in the Russian regions and CIS countries. Protocols and agreements are signed by the leaders of 27 regions of Russia, including: Belgorod, Nizhny Novgorod, Novosibirsk, Tambov region, Stavropol region, Voronezh, Orel, Rostov and other subjects of the Russian Federation. These agreements provide the construction of more than 50 bioenergy power plants working on raw materials of livestock and crop production. In addition, the agreements provide the construction of a bio energy power plant on the basis of sewage facilities (Belgorod). The planned installed capacity of each station will be from 350 kW to 10 MW. The power stations will exceed 120 MW in total. They are approved by all necessary certificates and licenses, both Russian and international ones.

Practically, the farm owning a biogas plant often uses no more than 15% of produced energy for own purposes. The rest of the produced power goes on sale. To stimulate producers of energy from biogas, the Ministry of Energy of the Russian Federation is developing a set of supporting measures: It is supposed to establish a premium to the wholesale price for electricity and to offset the costs for connecting to the power grids.

The production of high-quality biofuels, as well as their efficient combustion requires the introduction of new technologies. At the current moment, the problems of creation and large-scale production of devices for use in bioenergy abroad are solved on the latest scientific and technical level. The high-quality systems for cold-pressing oils in the production of biodiesel are developed. The production of installations for the biodiesel fuel of BioDieselPlant type with an annual capacity - 450, 900, 1800 and 3600 is launched.

This foreign experience in the field cannot always be transferred to Russia without adaptation, and the high cost of imported equipment often makes Russian bioenergy projects unprofitable.

Demand creates offer, and now Russia has already a cluster of industrial, consulting, engineering companies which carry out the development of domestic bioenergy technologies and produce appropriate equipment. Today, it is possible to equip any factory producing fuel pellets or briquettes solely with Russian components and units. High-quality boilers that effectively burn pellets and briquettes are produced in the Russian Federation. Recently, very original domestic developments concerning technologies for the preparation of raw materials, transportation of biomass, biofuel production technologies have appeared on market. For example, TehEkspress ltd. offers mini-factories for the production of biodiesel from rapeseed at the capacity of 100 tons of rapeseeds per year. The oil output is no less than 340 liters of 1 ton of rapeseed. The structure of a mini-plant consists of a press and a chamber filter, through which ready canola oil can be poured into the fuel tank after filtration. The costs of the biodiesel production produced on the farm will be much lower than the costs of diesel fuel, which is used in the agricultural machinery.

A separate problem is the creation of enterprises for the production of bioethanol.

A large-scale construction of such plants in Russia is not yet underway. Although there are long-term projects in the Republic of Tatarstan, Volgograd, Lipetsk, Rostov, Omsk, Tomsk and other regions.

As for biogas plants, it should be noted that there is no special program to stimulate the construction of biogas plants in Russia. Serial production of biogas plants, even small ones, is still not established, with the exception of "BioGazEnergoStroy" using a modified German
technology. However, there still are several models of small biogas plants on the domestic market made for use in personal subsidiary and farms.

Among these plants the products of the following companies should be mentioned: JSC "Centre EcoRos" Company "Greentek", JSC "Volga Diesel " Company "Melkompinzhinering", LLC "Siberian Institute of Applied Research", JSC "Energy-biogas" " KONATEM Company", JSC "VNIIKOMZH", etc.

Since January 1, 2009 the first national standard for bioenergy GOST R 52808-2007 "Innovative technology. Energy biowastes. Terms and definitions" came into force on the territory of Russia. The purpose of the standard is to establish general requirements for biogas plants of various capacities and purposes in accordance with the specifications of the latest Russian developments. The challenges of the bioenergy machinery are still primarily related to the high costs and shortage of investment resources so necessary for the adequate amount of R&D, financing the development and operations of productive capacities. In addition, the industry is experiencing a shortage of qualified engineers. Experience in managing finances, marketing and promotion of products on the market is urgently required.

2.2.2 Factors determining the economic attractiveness of projects

The inefficiency of the centralised power supply and gas industry, rates growth, problems with connecting to grids contribute to the rapid development of decentralised energy systems, including energy based on biogas.

Over the past decade, the price of electricity in Russia has risen 4 - 4.5 times, and it is up to 50% higher than the rate of inflation. A very sharp price increase took place after the liberalization of the electricity market in 2011. At that time the costs of 1 kWh for small consumers (power up to 5-10 MW) connected to the low voltage grids exceeded 3-4 rubles, in some regions of the central and southern Russia it reached 6 - 6.5 rubles.

Thus, electricity rates for a large number of Russian consumers today are comparable or higher than the ones in the U.S. and Eastern Europe. As a consequence of price jump, there is a growing interest of consumers in partial or complete refusal to use the centralised energy services and turn to their own generating plants instead.

Under these conditions and in comparison with other types of alternative energy sources, biogas has several advantages for the Russian environment:

1. Biogas is the only type of renewable energy that can provide acceptable reliability and continuity of the autonomous power system. Its most important feature, which makes it similar to the traditional types, is the constancy of energy production and maximal utilization of installed capacity.

2. Availability of raw materials to operate the plant which leads to the total absence of fuel costs in the structure of operating expenses. This defines the territorial flexibility: Biogas installations can be placed in any area and do not require the construction of expensive pipelines and network infrastructure, as well as allow the new company to save on the cost of connecting to grids.
3. Using of biogas makes it possible to simultaneously obtain several types of energy resources - gas, motor fuel, heat and electricity.

2.2.3 Project Funding

One of the major problems hindering the development of bioenergy in Russia is the lack of investment resources. Providing investment attractiveness for bioenergy projects is an important task because:

- on the one hand, - it will facilitate the inflow of funds in the sphere of science, technology and production, and,
- on the other hand, - it will facilitate the creation of jobs in agriculture.

In peripheral and rural areas, the problem of investment resources for the development of bioenergy infrastructure is unsolvable without the support of the federal and regional budgets. Both municipal energy suppliers and local manufacturing companies suffer from the lack of investments. Therefore, the current challenge for the authorities is to create mechanisms of resources concentrated and available on the regional level.

Financing projects in the Russian Federation are usually carried out through government programs and special purpose funds. The programs can be subdivided into the following types:

(1) State programs (described in detail in section 2.1.4 of this analysis)
(2) Institutions and development funds (e.g. Vneshekonombank, RUSNANO, RVC\(^{13}\), Skolkovo)
(3) Public or state corporations
(4) International programs
(5) Technology platforms.

The specifics of these types of financial support for investment projects in the Russian Federation are:

(1) **State target programs** (described in detail in section (2.1.4)

(2) **Institutions and Development Funds** (Vneshekonombank, RUSNANO, RVC (Russian Venture Company), Skolkovo, etc.).

Let’s take a closer look at the "RVC“ example. JSC "RVC" was established in accordance with the order of the Federal Government from June 7, 2006 № 838-p. The main objectives of JSC "RVC" are stimulating the creation of the Russian venture capital industry and achieving a significant increase in the financial resources of venture capital funds. The company takes the role of the public fund for venture capital funds, through which the government stimulates venture capital and financial support for high-tech sector in general. Also RVC performs the role of the State Institute for Development of venture investment industry in the Russian Federation. The priority areas for venture investment funds were formed with the participation of "RVC“ and

\(^{13}\) "RVC“ – Russian Venture Company
defined in accordance with the list of critical technologies approved by the President of the Russian Federation, which includes:

- Security and counter-terrorism;
- The living systems (understood as biotechnology, medical technology and medical equipment);
- The nano-systems and materials;
- The information and telecommunication systems;
- Environmental management;
- Transport, aviation and space systems;
- Energy and energy efficiency.

"RVC" invests through venture funds established together with private investors. The total number of funds established by "RVC", reached fifteen (including two funds under a foreign jurisdiction), their total size is 25.23 billion rubles. The share of "RVC" is more than 15.7 billion rubles. The number of innovative companies financed by RVC funds totaled 148 in 2014. A total amount of invested assets is 13.65 billion rubles. RVC signed 32 agreements on cooperation with the Russian regions. RVC is developing its international activities with the aim of importing advanced technologies, the acquisition of knowledge and know-how of technological entrepreneurship, as well as to support the entry of Russian high-tech companies to global markets.

The following cooperation can be shown as an example:

The national Union on Bioenergy, Renewable Energy and Ecology NSBE and the German Union Biogasrat signed a cooperation agreement. NSBE and Biogasrat intend to represent the interests of each other in both countries. The main areas of cooperation: the attraction of investments and financing, supply of equipment and materials, research and development, assistance in negotiations with federal, regional and local authorities of both countries. The purpose of cooperation is the establishment of the biogas industry in the Russian Federation. This includes: financing and constructing biogas plants; the use of produced biogas at power plants and other units of electric and thermal energy production, and also as a fuel. The important area of cooperation will be the implementation of projects aimed at the production of biomethane (purified biogas). The enterprises which are parts of Biogasrat, have all the technologies and a long-term experience in biomethane manufacturing. In Russia purification of biogas is not performed. However, in the future the parties intend to provide not only the production but also the procurement to the gas-transport system for further supply to consumers in Russia and EU.

(3) Public or state Corporations.

One of the projects implemented by OJSC "Biotechnologies Corporation", (a subsidiary of the state Corporation "Russian technologies") is a full-scale industrial production of biobutanol at the East Siberian biotechnology plant, located in Tulun (Irkutsk region). It’s planned to produce 30 thousand tons of biobutanol, 59 thousand tons of fuel pellets, 15 thousand tons of fodder yeast and 3 thousand tons of acetone per year there. In addition, the company will obtain glucose and dextrose that will allow organizing the production of antibiotics in Russia which was

14 http://www.rusventure.ru
stopped two years ago due to the monopoly position of China in the industry. The enterprise at Tulun will develop technology and technical regulations for other plants.

"Corporation Biotechnologies" plans to create enterprises on the base of Biryusinsk plant based in Irkutsk and hydrolytic plant based in Ziminsk district of Irkutsk region.

(4) **International programs**

One of the most important international activities in the field of bioenergy is participation of the Russian Federation in the International Energy Agency (IEA) programs through the membership of “Bioenergy” Technical Program in the operating agreement (Implementing Agreement) “Bioenergy” of the IEA.

In addition, an Agreement on cooperation between the Russian Technology platform "Bioenergy", and the International energy Agency (IEA) was signed.

(5) **Technology platforms** ("Bioteh2030", "Bioenergy", "Medicine of the Future")

The diagram below shows the structure of investments in the bioenergy industry. Basically the most significant investments are aimed at the production of pellets (55%) and transition of boiler rooms to use of wood chips (31%). For all other areas it’s less than 15%.

![Structure of investments into bioenergy in Russia](image)

*Source: ROSROBIONCONSULTING*  

2.3 **Potential projects in the field of bioenergy**

Due to the current electricity tariffs and increased environmental expenditures in Russia, there are several hundred companies interested in at least partial transition to independent power supply. They are potentially interested to become pioneers implementing highly profitable biogas projects in the country. These projects do not require a subsidy in the form of "green tariffs" and other measures, legislative support and can be implemented in the near future.

Biogas installations become a priority for the following companies:  

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15 **RUSSIAN ENERGY AGENCY: BIOENERGY OF RUSSIA IN THE XXI CENTURY, 2012**
- Pig farms with livestock from 70,000 heads
- Complexes with livestock cattle from 8000 heads
- Poultries with more than 1 million heads of livestock
- Meat processing enterprises with slaughterhouse waste from 80 tons per day
- Distilleries with waste from 130 tons per day
- Sugar factories with waste from 220 tons per day
- Breweries with waste from 150 tons per day
- Urban water utilities, serving a population of no less 400,000 people, with no less 150 tons of waste from sewage sludge per day
- Enterprises with grain waste from 30 tons per day

However, only a comprehensive approach can provide fast growth of the industry, the approach should include the implementation of projects with mandatory environmental issues, getting profits from the disposal of organic waste and the sale of organic fertilizers.

### 2.3.1 Optimal model projects

There are certain criteria and conditions for the success of projects which are able to achieve a positive result.

Positive cash flow of the company that builds and implements a biogas installation is formed by:

- Selling electricity to the enterprises which are sources of waste or to network companies
- Selling heat to the enterprises which are waste sources
- Selling motor fuel (compressed methane) on the open market
- Selling bio-fertilizers in the open market
- Selling carbon offsets
- Waste recycling.

The operator builds and operates a biogas plant himself getting wastes at zero costs, processing them as a treatment plant. Produced energy is delivered to the wastes’ owner. By-products and excess energy are sold on the open retail market.

The required characteristics for promising successful projects are:

- The payback period - no more than 5 years from the commencement of operation
- The installed electric capacity of 1MW
- The current energy costs for the waste owning enterprise from 3.5 p. per kWh
- The guaranteed consumption of the entire electricity produced at biogas installation by the enterprise (usually this refers to e.g. water utilities, food industry, poultry farms)
- The guaranteed free and uninterrupted supply of raw materials for biogas installation.

Recommended characteristics are:

- Need for the allocation of installed capacity at the enterprise
- Environmental problems (high emission charges or disposal costs, a significant amount of waste)
- Guarantee of thermal energy consumption

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16 Source: presentation of I. Egorov (head of biogas projects at AEnergy) http://www.myshared.ru
Availability of the most profitable types of waste at the enterprise: sewage, grease, organic waste, grain waste, food industry waste.

According to our recommendations, the payback not exceeding 5 years from the start of operation being very attractive for investors can be achieved by a project with following characteristics:

**Eligible biogas plant investment project with a power of 1, 5 MW, replacing the existing grid electricity at the cost from 3 rubles. per kWh, having the guarantee of consumption of the entire electricity produced in biogas installation and the guarantee of free and uninterrupted supply of raw materials.**

Another model for the development of biomass energy projects in Russia is
to create new chains of production of bioenergy raw materials based on agroindustrial clusters including farm animals, crop farms and enterprises processing biological waste into electricity, heat, and organic fertilizers.

A striking example is the PARK project in the Omsk region, where all the 4 clusters are implemented,( detailed information is provided in Part 2.3.2).

### 2.3.2 Overview of current projects (successful and negative examples)

Obviously, not all potential sites meet the criteria described above.

Prior to the adoption of the relevant documents, autonomous grid projects ranging from 1.5 to 5 MW have the greatest prospects for development. One way to solve the problem is suggested, for example, by OJSC Agro-Biotech. The company suggests implementation of projects by an energy and ecological company which rises the funds and builds a biogas plant on its own. Enterprises which are sources of waste are proposed to sign a long-term contract for the supply and disposal of these wastes and the purchase of heat and electricity at prices linked to the market prices with discount.

This scheme solves the problem of waste disposal and reduces energy costs without investment made by the company and allows it to release funds for modernization and development. Russia has a chance to study the experience of biogas energy in other countries in order not to repeat the mistakes made. Attention to the environmental component of biogas projects should be the basis of measures of the country’s state support. It is advisable to put biogas plants on the list of the best technologies available for agribusiness companies, the food industry and water utilities. A series of measures should be implemented to tighten control over emissions of organic waste made by companies, collectability of environmental charges.

Despite all difficulties of biogas projects, and considering the importance of energy and environmental issue, the possibility of the construction of biogas plants with financed by corporation is considered. More than a dozen facilities are chosen for long-term investment and construction of biogas plants as replicable projects. For example, it is agreed to invest 3.4 billion

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17 Source: the materials of RENEWABLE ENERGY FORUM — REENFOR 2013
18 Source: an article “Perspective fuel” by T. Pantsynaya published in “Forest Industry Magazine” in April, 2014
19 Source: the materials of RENEWABLE ENERGY FORUM — REENFOR 2013
rubles into the projects of biogas plants in Belgorod region. Total planned construction includes at least 20 bio power stations in the next two years. Belgorod Institute of alternative energy and the German company Weltec Biopower GmbH, which is one of the leaders of the biogas industry in Germany, signed a cooperation agreement. Under the agreement, a biogas plant that produces electrical energy, thermal energy and bio-fertilizer from chicken manure and sugar beet pulp region will be built in the Belgorod region.

Russia's first bioreactor was launched in 2009 in the village Doshino in Kaluga region. Later in the Belgorod region the biogas plants “Luchki” and "Bayntsur" were launched. They’re based on the pig farm. In 2014, it is planned to launch a large biogas plant in the village of Romadanovsky, Republic of Mordovia.

Belgorod region remains a leader in the production of biogas in the coming years remains: it’s already planned to build three new stations, and in the longer term, there will be located more than 100 bioenergy complexes. The regional authorities submit their calculations according to which 10% of Russia’s electricity soon will be produced by Belgorod bioreactors. Also the Volga, Siberian and the Southern Federal Districts have the greatest potential for the development of bioenergy technologies. These regions have determined the success of projects in the region:

1) There a concept and a program of support for the industry were adopted:

2009 - The Concept of bioenergy and biotechnology development was adopted in the Belgorod region in 2009 - 2012. Start pilot projects realization.

2010 - a long-term target program “Energy saving and energy efficiency of the Belgorod region in 2010-2015 and targets for the period up to 2020” was adopted. Start pilot projects realization.

2012 - A Council for the development of bioenergy and biotechnology in the Belgorod region chaired by the Governor of Belgorod region was formed as well as the Council of the Governor of Belgorod region for the development of small-scale power. A long-term target program “Development of renewable energy sources in the Belgorod region for 2013-2015 and targets for the period up to 2020” was adopted. 2 biogas plants were commissioned.

2) There the mechanism of state and private partnerships was used, providing state support measures:

- In the form of incentives to pay property tax and corporate profit tax (law of Belgorod region from November 27, 2003 № 104 "On Property Tax of organizations," the law of the Belgorod region on September 18, 2007 № 142 "On the benefits of tax profit of organizations")

- In the form of subsidizing the interest rate on bank loans at the expense of the regional budget in 2013-2015 of $ 2.0 million annually. In the years 2016-2020 the amount and forms of state support will be determined annually by the law (from the local regional budget for the next financial year.

Examples of successful investment projects of the participants of the Technology Platform "Bioenergy" also include:

- Transition of agricultural enterprises on bioenergetic processing energy supply (Moscow, Belgorod, Ulyanovsk region, Altai, Stavropol region, etc.)
- The transition of municipalities energy supply on bofuels (Krasnoyarsk region, Kirov region, etc.)

- The creation of new producing facilities for pellets with a capacity of 300 thousand tons (Kirov Region, Komi Republic, Krasnoyarsk Krai, etc.)

- The creation of biogas power plants with a capacity of 30 MW (Republic of Mordovia, Bashkortostan, Penza region, etc.)

- Bioenergy cluster "Park" producing bio components for motor fuels (Omsk region).

As international experience shows, the most efficient way of manufacturing organization which really ensures economic growth is a cluster system. Clustering is crucial for the transfer of the domestic economy to the way of innovative development. Clusters are the driving force of a social development and long-term sources of economic growth.

A cluster organization of the economy has the following advantages:

- First, it is dynamic, able to expand, deepen, constantly include to new elements.
- Second, the enterprises in one cluster support each other, thus creating synergies and providing a continuous progressive development.

In Russia, regional cluster projects are well represented in the cities of Omsk, Krasnoyarsk, Krasnodar, Stavropol region, Belgorod region, Tatarstan, Chuvashia.

An example of Omsk cluster:20

The non-profit Partnership "Innovation Center" is the coordinator of the industrialized agricultural innovation cluster "PARK". Mission of the Park is to improve the living standards of the citizens of the Russian Federation through the development of biotechnology, industry and agriculture, the promotion of Russia's transition to an innovative non-oil economy based on the deep processing of raw materials and production of products with high added value. The goal is the creation, commissioning and effective management of an integrated network of innovative processing industries. The task is to create favourable conditions for the development of scientific, technological, industrial, infrastructure, social, interdisciplinary, international cooperation

The structure of the park project includes 4 clusters: agriculture, petrochemical, silicon and timber. They are based on the technology of deep and waste-free processing of raw materials, crops, biomass and wastes into products with high added value.

The complex combines 4 clusters: agriculture, petrochemical, timber and silicon, which are closely interrelated in terms of supply of raw materials and products, as well as in the optimal energy balance.

The agriculture cluster is a complex of deep processing of crops and related production, where businesses (including livestock) provide each other with raw materials and products.

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20 Information on project implementation is presented in the annual report: http://www.center-inno.ru/park/reports.
The petrochemical cluster is a complex of petrochemical plants and high-tech enterprises where the use the "green" technologies are used and the programs in the field of gas-chemistry and deep processing of hydrocarbon raw materials are widely implemented.

The silicon cluster is a silicon industry chain, producing raw materials for solar energy, microelectronics and high-precision optics

The timber cluster is a timber processing complex providing deep processing of wood (including non-wood) to ensure rational forest use and production of a wide range of valuable products from biofuel to timber and organic products.

Two basic principles are considered

(1) Presence of natural geographic advantages

This is the main condition for the formation of clusters. Omsk region, the South of Russia and border regions are traditionally known for their lands. The Omsk region has significant natural advantages - renewable sources of raw materials, the competitiveness of finished products.

(2) The integrated food and energy system

It is based on growing foodstuff and fuel solely on the basis of renewable raw materials. Thanks to this system of production, not only foodstuff security is created but also the economic and environmental security, and, of course, energy.

The Park complexes and their products provide bioenergy in three areas:

- Biogas production from different biomass of plant origin, and from the wastes of animal farming.
- Solid biofuel production based on grain-producing and grain-processing waste, and also on the waste of the enterprises of the timber industry cluster.

All companies included in the clusters are tightly interconnected with each other in terms of the product and raw materials supply and create together an optimal energy balance. Thanks to these advantages the production costs and the impact on the environment become lower which creates the competitiveness of finished products which is unique not only for Russia but for the international markets.

Forecast of socio-economic effect of the project:

- The development of regional infrastructure.
- Opening of new opportunities for small and medium business in industry and agriculture.
- Increasing the share of the middle class in the social structure of the regions.
- The replenishment of the Federal and regional budgets at the expense of income taxes, property taxes, VAT and other contributions of Park.
- Creation of new jobs.
- The creation of a comfortable environment for living.
- The reduction of the residents outflow from rural to urban areas.
- Full use of agricultural resources.

21 http://www.center-inno.ru
- The gradual import-substitution for strategically important goods.
- Increasing the share of products of deep processing in the Russian export.
- The involvement in the economic turnover the unused lands and lands.
- Energy conservation and energy efficiency.

2.3.3 Barriers to achieving the profitability of investment projects

Despite the conditions for the start of a rapid growth of the industry formed in the recent 2-3 years and currently implemented projects, further measures and framework improvement is required considering the capacity of the country.

The main difficulty for the biogas energy is a relatively narrow range of projects’ profitability. The cost of 1 kW of installed electric capacity of the biogas plant typically ranges from 2 up to 5 thousand Euro, depending on the size of the station (the smaller the more expensive) and raw materials type. A higher power installations (10 MW), working on the most profitable types of waste (for example, sugar beet pulp or food industry waste with high content of fats) are cheaper - 2 thousand Euro per 1 kW. Small plants (less than 1 MW), as well as stations that use non-profitable types of waste (for example, a cattle manure) can cost more than 6-7 thousand Euro per kW. Thus, a plant with a capacity of less than 1-1.5 MW is economically inefficient in the Russian conditions because of the high unit costs.

There is an upper limit for the optimal installed capacity of biogas projects. Not all power objects exceeding 4-5 MW have sufficient amounts of raw materials at their disposal. Here the problem of guaranteed sales of produced electricity arises. When there is no possibility of its sale through a network at retail tariffs the list of cost-effective biogas projects is limited to only those ones that have a continuous cycle of work and a constant level of energy consumption which obviously exceeds the capacity of the biogas plant.

And the second problem arising – biogas technologies do not solve the problem of waste from the production of bioenergy/biogas. The content of ammonium in the substrate increases during the fermentation process, leading to the formation of nitrates and nitrites. In the end, the application of traditional biogas technologies leads to the fact that by processing one type of waste we get another type of waste which is even more dangerous for the environment. The suppliers of classic biogas plants suggest calling this product a bio-fertilizer and storing it in the lagoons, and it should be taken out to the field. This approach is partly applicable at small stations which are common in Europe, but in Russian conditions, yet only large-scale projects are cost-effective. The application of traditional biogas technologies at such facilities requires huge investments in storage and disposal of waste, and the solution of environmental problems is rather disputable. It makes the arguments of some participants of Russian biogas market in favour of subsidizing projects through the "green tariff" under the pretext of solving environmental problems rather surprising. The technology of full processing of fertilized mass after a biogas plant allows ensuring the absence of waste and reduces the payback period up to at least two times. Often the amount of revenue collected by payments for utilization exceeds the revenue from the sale of energy. In this case, a comparison of biogas plants with other renewable energy facilities by the cost of one kilowatt of installed capacity has no meaning, because the installation is a recycling facility, which pays off because of the environmental component and provides other sources of revenue as a "bonus". Much of the investment in bioenergy is not returned.
Among the main reasons of the project failures is their lack of preparedness, including errors in business planning and management, errors in evaluation of the resource base and markets, errors in technology choices, technical and logistical solutions and other

### 2.3.4 Barriers and opportunities for further development of the bioenergy sector

Barriers and shortcomings which stand on the way of a successful development of the bioenergy sector are:

- Insufficient industrial base for the development of the bioenergy segment.
- The domestic consumers market for the bioenergy products is undeveloped.
- Week legislation: No tax preferences for the segment of bioenergy.
- A historical focus on production and sale of the traditional energy sources.
- Poorly developed infrastructure for production and sale of motor biofuels.
- Lacking state support for the innovative business and entrepreneurship, especially of the "start-ups".
- Undeveloped system of effective linkages between research teams and technology, on the one hand, and business which has the need for emerging technologies, on the other hand.
- Poorly developed domestic scientific environment: The lack of effective communication and information resource for the professional and scientific community.
- Lack of integration of Russian scientists into the international bioenergy programs.
- High demand for investments and sources of financing.
- Lacking awareness of manufacturers for the economic feasibility of production of bio-products capable to provide high added value.

Another difficulty of the biogas market in Russia is a certain scepticism and mistrust to these new technologies on the part of potential consumers. Biogas seems too complex and capital-intensive for Russian customers. The operation of the plant will require knowledge, specialists,
mechanisms of financing, which the Russian enterprises simply do not have. The owners of the waste cannot, and sometimes are even afraid to borrow money for acquiring such installations.

Conclusion

Despite all the barriers mentioned above, the opportunities for the development of the industry in Russia are unique in their potential, namely:

- The existence of a significant resource potential for biomass;
- Rapid growth of energy consumption, the growing need for autonomous power and heating supply for the remote and rural areas;
- Necessity of formation of the new markets for innovative products;
- High added value in the production of biofuels from renewable raw materials;
- The possibility of innovation industry segment development which will provide new jobs (also in the rural areas); intensification of the regional economy;
- A good scientific base practically in all basic areas of the bioenergy development
- The development and implementation of new technologies; a system of highly qualified personnel training already established;
- The need for large-scale recycling of industrial, municipal and agricultural wastes;
- The need for environmental protection and reduction of harmful environmental effects.

While planning a business in Russia investors should consider the following:

(1) The technology transfer from abroad is very important for Russia (it is actually taking place, since up to 90 % of the equipment working in Russia is foreign). However, Western technologies and equipment require serious adaptation to Russian conditions (geographical, climatic and technological).

(2) Investments in bioenergy sector are profitable, considering the main aspects:

- Bioenergy is becoming an important regional segment of the economy, and good contacts and support from the regional administration can be guaranteed.
- The raw materials segment of bioenergy should be developed, but with a well defined consumer market in Europe.
- Careful choice of the Russian partners with competencies and references in the field of bioenergy is strongly recommended.