Biofuels concept development in Kazakhstan: drivers and barriers

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Abstract
Kazakhstan has recently launched new programme in the agricultural sector to increase the competitiveness of the agricultural products in the world market and to diversify the economy that is dependent on the export of crude oil and gas and extraction of fossil fuels and natural resources. Sustainable development approach is being applied in different sectors of economy. Therefore, biofuels programme met the full governmental support as the way to address the economic, environmental and social challenges in the agricultural sector.

The thesis is devoted to the Biofuels Development Concept in Kazakhstan topic and to the analysis of the trends and dimensions of the emerging biofuels market in Kazakhstan focusing on the study of the main drivers and barriers in the biofuels policy of the country.

The thesis might be interesting for the wide range of stakeholders in biofuels area including policy-makers, industry representatives, research and consulting organizations, academia and students involved into the research on biofuels potential in Kazakhstan.
Executive Summary

Kazakhstan known for its vast oil and gas resources in the Caspian Sea region is one of the important fossil fuels based energy suppliers in the world. Besides, possessing enormous natural resources as minerals and metals the country’s economy relies upon the extraction and export of these resources.

Extractive industries are particularly vulnerable to the changes in the international markets and instability of the prices. Therefore, it is necessary to work out different stabilization measures to decrease the dependance of state budget on oil and gas export revenues and to reduce the gap in the incomes distribution as well as other supportive social programmes. This is possible if strategies are elaborated on the diversification of the economy, the intensification in the use of economic resources, the gradual change in the country specialization.

Agricultural sector used to be one of the most important economic sector in the country ranked ninth in the world by its territory and environmental conditions of which are favorable for the agricultural development. Both plant cultivation and livestock production have the significant potential due to the climatic and natural conditions.

Agriculture accounts for about 10% in GDP and provides incomes of around 40% of population. The sector has suffered the decline after the collapse of Soviet Union and the main problems at present are the lack of properly managed institutional structure, control and monitoring scheme, efficient technologies and the integrated approach which is important to establish the sustainable agricultural system on the consistent basis.

Biofuels concept development in Kazakhstan is studied in the thesis as the way to address some of the challenges agriculture faces today.

Biofuels are produced through biomass conversion and can be liquid, solid or gaseous. The application of biofuels is wide including automotive fuels, combined heat and power plants, electricity generation, district heating, etc.

The main drivers for the biofuels development in Kazakhstan are: rural development, regional development balance, energy efficiency and renewable sources of energy usage, boosting biotechnology research, reduction of air pollution in the cities and industrial centers of Kazakhstan due to the emissions from transport and energy sector, environmental improvements and better agricultural practices, and others.

The current situation in the biofuels production in the country shows that the process has been started and production capacities are not in place yet. However, the completion of the bioethanol plant construction in September 2006 showed benefits and barriers that may affect further development in the sector.

The Concept on Biofuels Market Development has defined the main objectives and targets for the biofuels industry until 2010. The concept indicated that the following biofuels are potentially feasible: bioethanol from wheat and biodiesel from rapeseed oil as defined in the priorities for the period 2007-2010. The draft law on biofuels is now under discussion and consideration in the Parliament. Its adoption is expected by the end of the year 2007. These document are supposed to sketch the policy framework that would allow to produce, transport and distribute biofuels to the domestic and export markets.

The main barriers that might hinder biofuels industry development are the lack of regulation at present, the scientific and economic uncertainty, potential replacement of current biofuels
with the second generation conversion technologies, high taxes, feedstock competition with food industry, environmental concerns.

It is important to introduce integrated approach and elaborate comprehensive policy that will take into account all the existing barriers and define the effective measures to overcome them. Preventative approach should also be applied to the first generation biofuels in order to catch up with the most advanced technologies and research.

Biofuels development in Kazakhstan is completely new area for agricultural sector; therefore, many discussions and further study are yet to come. The conclusions made in this study are preliminary and it is intended to show the main advantages and potentially problematic issues if biofuels are to take its stand in the economy of Kazakhstan.
Table of Contents

List of Figures
List of Tables

1 INTRODUCTION.......................................................................................................................................... 1
  1.1 BACKGROUND........................................................................................................................................ 1
  1.2 SCOPE AND LIMITATIONS...................................................................................................................... 4
  1.3 TARGETED AUDIENCE AND APPLICATION .......................................................................................... 6
  1.4 METHODOLOGY..................................................................................................................................... 6

2 BIOFUELS OVERVIEW .......................................................................................................................... 8
  2.1 TECHNOLOGIES, PRODUCTS AND APPLICATIONS ............................................................................... 8
  2.2 LIQUID BIOFUELS FOR TRANSPORT: BIOETHANOL AND BIODIESEL .............................................. 12
  2.3 WORLD BIOFUELS PRODUCTION TRENDS AND PROSPECTIVES .................................................. 15

3 AGRICULTURAL SECTOR OF KAZAKHSTAN: FEEDSTOCK POTENTIAL ............................................. 18
  3.1 AGRICULTURAL PROFILE OF THE COUNTRY ..................................................................................... 18
    3.1.1 Climate and geography..................................................................................................................... 18
    3.1.2 Agricultural specialization in different regions of the country ...................................................... 19
    3.1.3 Plant cultivation: main cultures, yields, mapping, capacities, problems ...................................... 21
    3.1.4 Livestock production .................................................................................................................... 25
    3.1.5 Environmental problems in the agricultural sector ........................................................................ 27
  3.2 BIOFUELS PRODUCTION IN KAZAKHSTAN ....................................................................................... 27
    3.2.1 Bioethanol feedstock and production ............................................................................................. 27
    3.2.2 Biodiesel feedstock and production prospects ............................................................................... 30
  3.3 AGRICULTURAL POLICY: BARRIERS AND DRIVERS FOR THE BIOFUELS PRODUCTION ............... 32

4 BIOFUELS POLICY ANALYSIS: DRIVERS AND BARRIERS ................................................................... 35
  4.1 POLICY FRAMEWORK .......................................................................................................................... 35
    4.1.1 Energy policy: key features and preparedness to accept biofuels ...................................................... 35
    4.1.2 Renewable energy policy .............................................................................................................. 38
    4.1.3 Biofuels market development concept ............................................................................................ 39
    4.1.4 Draft law on biofuels ..................................................................................................................... 42
  4.2 THE MAIN ACTORS IN THE BIOFUELS AREA: INVOLVEMENT AND PARTICIPATION .................. 43

5 BIOFUELS PRODUCTION: CASE STUDIES AND EXPORT POTENTIAL VS. DOMESTIC CONSUMPTION ................................................................................................................................. 46
  5.1 BIOETHANOL PROJECT: BIOHIM PLANT ON THE ADVANCED GRAIN PROCESSING ..................... 46
  5.2 ECOMUSEUM’S PILOT PROJECT ON BIOGAS INSTALLATIONS IN CENTRAL KAZAKHSTAN ............ 49
  5.3 EXPORT MARKETS VERSUS DOMESTIC CONSUMPTION .................................................................... 52

6 RECOMMENDATIONS AND CONCLUSIONS ......................................................................................... 55
  6.1 LESSONS AND RECOMMENDATIONS .................................................................................................. 55
  6.2 CONCLUSIONS ..................................................................................................................................... 59

BIBLIOGRAPHY ............................................................................................................................................. 60

ABBREVIATIONS ........................................................................................................................................... 64

APPENDIX 1 KAZAKHSTAN: AVERAGE RAINFALL, EVAPORATION AND TEMPERATURE ......................... 65

APPENDIX 2 SAMPLE INTERVIEW QUESTIONS .......................................................................................... 67
List of Figures

Figure 2-1 World fuel ethanol production, 1975-2005..........................................................13
Figure 2-2 World biodiesel production, 1991-2005..............................................................14
Figure 2-3 Crude oil prices vs. ethanol production, 1980-2004.............................................15
Figure 2-4 Main ethanol exporters......................................................................................16
Figure 2-5 World and Regional Biodiesel Capacity, 1991-2003 (million litres per year)..........17
Figure 3-1. Natural vegetation zones of Kazakhstan.............................................................18
Figure 3-2 Land use in Kazakhstan....................................................................................20
Figure 3-3. Areas of the plant cultivation in Kazakhstan......................................................22
Figure 3-4 Wheat cultivation areas.....................................................................................23
Figure 3-5 Regional distribution of oilseed crops cultivation.................................................24
Figure 3-6 Dynamics of oilseed crops cultivation.................................................................25
Figure 3-7 Livestock production development, 1995-2005....................................................26
Figure 3-8 Agricultural production shares............................................................................26
Figure 3-9. Dynamics of changes in oilseed crops cultivation in land use percentage.............31
Figure 3-10 The structure of agricultural policy-makers.......................................................33
Figure 4-1 Total primary energy sources.............................................................................35
Figure 4-2 The structure of stakeholders in biofuels development in Kazakhstan..................45
Figure 5-1 Biohim plant layout............................................................................................46
Figure 6-1 Proposed policy framework for the development of biofuels production in Kazakhstan..................................................57
List of Tables
Table 1-1 Collected information and inputs .................................................................7
Table 1-2 Biofuels: first and second generation technologies ....................................10
Table 2-1 Bioethanol: advantages and disadvantages ..............................................12
Table 3-1 Quality characteristics of soils .................................................................19
Table 3-2 Agricultural specialization by regions ......................................................20
Table 3-3 Bioethanol feedstock evaluation ..............................................................28
Table 3-4 Drivers and barriers for biofuels industry development from agricultural perspective ..................................................33
Table 5-1 Biohim plant production structure ...........................................................47
Table 5-2 Animal dung production .........................................................................51
Table 5-3 Estimations of bioethanol production amounts for the domestic consumption ..................................................53
1 Introduction

1.1 Background
Geographic location and environmental conditions play one of the most important roles in the economic and social development of the country affecting all aspects of the political life and economic concepts. The knowledge of a country’s natural and climatic conditions is especially important when it comes to the analysis of a new programme development linking several sectors of the economy and based on the socio-environmental reforms of the overall policy vision.

Kazakhstan may be considered as a country of transition between Western and Eastern worlds. The country is situated in the heart of Central Asian region neighboring with Russian Federation in the North and on the Caspian, China in the East, Kyrgyzstan, Uzbekistan and Turkmenistan in the South, and having sea borders with Azerbaijan, Turkey and Iran on the Caspian in the West. The area of the country is 2724.9 thousand square kilometers and this place the country by its territory as the ninth largest in the world (CIA World Factbook).

While there are still disputes around the status of the Caspian Sea whether it should be considered as sea or not the Caspian Sea is closed water body having no outlet to the global ocean system. Kazakhstan should be accounted the landlocked country. It is an important factor for the country possessing rich natural resources and involved into export and land transportation routes of different goods and services. Further, it is important to note that at present the export routes mainly pass through Russian territory on their way to Europe and important sea ports due to the historic and geographic factors. These factors are determined by the lengthy border with Russian Federation and the long-standing history of the relationship between two countries starting from imperial colonization in the eighteenth century till the collapse of Soviet Union and the consequent formation of newly independent states.

Natural and climatic conditions determine landscape diversity of the country generally characterized with low precipitation and prevalence of arid climate. However, in the northern part of the country the average rainfall is around 250-350 mm (see Appendix 1). Soil fertility has decreased over the past decades mainly due to the inefficient agricultural practices. Besides, arable lands in the country are located in the zone of high risk from the agricultural prospective (Tonkopiy, 2003).

Another important factor worth to mention is the demographic characteristics that may introduce reader to what the possible consumers are. According to the latest statistics of 2006, the population of Kazakhstan is 15.3 million people amongst which some 8.7 million people live in urban areas which makes 57% of total population, the rest of the population lives in rural areas. Unemployment rate is 8, 1%. Population density is 5.6 persons per square kilometer on average (Agency of Statistics RK, 2006) whereas in EU-25, for example, it is 115.7 people per square kilometer on average (Eurostat, 2003). As such, Kazakhstan is ranked among the least populated countries. In other words, the large area and relatively small amount of settlements determines the long distances from one inhabited area to another and complicated maintenance of communication between them.

Average income per capita per month is 20 531 tenge (around 128 euro). The lowest wage is in the agricultural sector counting for not more than 17 810 tenge per capita per month (around 111 euro) (Agency of Statistics RK, 2007). In recent years there is a trend of
population migration from rural areas to large cities, especially, in the southern regions with irrigated agricultural systems. In the Northern Kazakhstan the condition are the reverse. It is observed that agricultural sector is growing in the Northern Kazakhstan, mainly in the crops cultivation subsector (Nugmanov pers.comm.).

Kazakhstan is known for its vast oil and gas resources in the Caspian Sea region and is one of the important fossil fuels based energy suppliers in the world. The country is considered to be among the ten largest suppliers of oil and fifteenth leading supplier of gas in the world possessing around 1.6 billion tons of recoverable oil and 1 trillion cubic meters of recoverable gas (Shkolnik, 2005). Besides, being in possession of enormous natural resources as minerals and metals the country’s economy relies upon the extraction and export of these resources.

Resource-based economies are particularly vulnerable to the development challenges and changes in the world market (Sachs and Warner 1997). Indeed, some studies indicate that resource-rich economies perform worse than resource-poor economies as resources abundance serve as a disincentive for economic development (Ahrend, 2006; Wright and Czelusta, 2002). Inverse relationship between resources abundance and growth can be explained by the way extractive industries address sustainability challenges.

However, it has been argued that sustainable development is possible in extractive economies relying upon finite and non-renewable resources. Thus, re-orientation of economy towards other tradable sectors, e.g. manufacturing or agricultural sector, is being discussed as more sustainable options as it gives flexibility in economic activities and incentives for these sectors development (Ahrend 2006). However, the role of resources extraction and export in the growth of state revenues and overall development of a country cannot be denied and resources are there to stay for some time although limited by tens to hundreds years.

The analysis of recent changes and new trends in socio-economic life of Kazakhstan demonstrates the shift towards the development of different sectors of economy and introduction of different stabilization measures to decrease the dependance of state budget on oil and gas export revenues and to reduce the gap in the incomes distribution as well as other supportive social programmes. The most important strategic document has been adopted in 2003 and is called the Strategy of Industrial-Innovative development of the Republic of Kazakhstan for 2003-2015 focused on the diversification of the economy, the intensification in the use of economic resources and the gradual change in the country specialization.

Three major streams of the current state policy are important to take into account in the thesis: the first is related to the development and improvements in agricultural sector, the second is to deal with energy efficiency and renewable resources usage, and the third stream is related to the development of manufacturing sector and other tradable sectors.

Agricultural sector is of particular interest from the socio-economic and environmental prospective for the country. First of all, before the oil boom Kazakhstan had considerable agricultural potential in the crops cultivation and livestock production. Still Kazakhstan possesses a huge potential to develop these dimensions – although different opinions exist on what dimension – plant cultivation or livestock production – should be prioritized (Tassekeyev pers.comm.). Oil and gas sector is developing in two main regions of Western Kazakhstan – Atyrau and Mangistau. From the agricultural perspective, Northern, Eastern and, under particular conditions, Southern regions are considered to be the regions with the highest potential, hence, creating the incentives to develop other regions of the country.
Secondly, although agriculture accounts for about 10% in GDP the sector lacks properly managed institutional structure, monitoring scheme, efficient technologies and the integrated approach which is important to establish the sustainable agricultural system on the consistent basis.

The thesis is devoted to the topic of biofuels concept development in Kazakhstan as the way to address these three streams challenges.

In Kazakhstan biofuels have been seriously discussed since 2006 when the proposal on the first bioethanol plant construction was introduced. Biofuels have received the attention of state officials and, further on, the support on the national level after the plant has been constructed in September 2006 with the loan of the Development Bank of Kazakhstan, institution within the system of the Sustainable Fund “Kazyna” which main tasks are to elaborate and implement innovation projects to increase the competitiveness of the national products in the world market.

Biofuels are considered among the priority dimensions of innovative projects in the country. There was seven priority areas established for the investment portfolio of national development institutions, namely, the Development Bank of Kazakhstan. Biofuels have been included in the projects portfolio along with petrochemistry, metallurgy, forestry and other sectors development. Bioethanol produced from grain and rapeseed oil production for further conversion into biodiesel are the potential biofuels considered for the near future of biofuels development. But there are also other types of biofuels being discussed for the future development of biofuels sector.

The main drivers for the biofuels development in the country are:

- Considerable agricultural capacity and the creation of additional incentives for the rural development;
- Energy efficiency and renewable sources of energy usage;
- Boosting biotechnology research;
- High levels of air pollution in the cities of Kazakhstan due to the emissions from transport;
- A coming law on mandatory use of bio-additives in transport fuels;
- Existing infrastructure of petrochemical industry, alcohol production facilities;
- Export potential to Russia, China and Europe.

The first project on biofuels financed by the Bank of Development of Kazakhstan is the “Organisation of the Production of a High-Octane Ecological Fuel Bio-Additive” which is basically bioethanol production plant. This project was being implemented alone with the creation of the Working Group of the Ministry of Agriculture on Biofuels Market Development Concept that was approved in March 2007. The first draft law on biofuels has been initiated in the Parliament. The Working Group is created to develop the law and to include opinions of all interested parties.
Therefore, clear vision on biofuels promotion in the country is still under development and needs to be established. However, the preliminary analysis of available data allows us to assume that the potential for biofuels production in Kazakhstan is significant due to:

- The agricultural lands available;
- The feedstock availability;
- The need to improve agricultural business conditions through introduction of new industries and new opportunities for farmers;
- The need for economic diversification;
- The investing capacities of national development institutes;
- The high demand for innovative solutions

Biofuels development in Kazakhstan has also been driven by the recent trend in the country’s policy to promote and establish a strong technologic basis and science intensive industries. Biofuels can contribute to the increase in research activities and boost biotechnologies development in the country. Currently there are efforts to strengthen national biotechnology research capacities but from the market prospective there should be not only centralized institutions involved in technologic development but also business driven research to increase the competition between different enterprises and stimulate the development of new fields of industry competitive in the world market. Besides, scientific knowledge is needed to develop, prove and improve new products acceptable on the market. Therefore, emerging biofuels projects has attracted the attention of national and private stakeholders to the biotechnology and its applications.

Comprehensive strategies to develop new technologies should take into account all the impacts associated with the technology, all affected parties and learning process to facilitate this development (Johansson et al., 2003). In biofuels sector it becomes even more critical as biofuels market worldwide is in the emerging stage and needs further research and proper management to avoid certain negative effects of biomass extraction for the biofuels production. Kazakhstan has good chances to catch up with the most recent developments in the area. As such, it can be considered that a careful and wise approach should be applied to introduce biofuels products on the domestic and international market on the competitive basis.

1.2 Scope and limitations

The main purpose of the thesis is to analyze the trends and dimensions of the emerging biofuels market in Kazakhstan focusing on the study of the main drivers and barriers in the biofuels policy of the country. Biofuels sector has been recognized one of the priority area in the agricultural sector. However, at present there are certain knowledge gaps due to the lack of the relevant information and competence. The experience in the biofuels production and development in the country is rather low. It will take a while for the process of learning and developing to be set in.

The research question that has been raised from the thesis purpose and formed a roadmap for conducting this study is:
How does the strategic vision for biofuels in Kazakhstan define and constrain the likely future development in biofuels sector?

Research objectives of the thesis are:

- To delineate the current prerequisites for the biofuels development in the economic, energy and agricultural policy of the country
- To identify the potential actors and participants of the process of biofuels penetration into the domestic and export markets
- To study advantages and disadvantages of biofuels development in the country from the sustainable development prospective

To address this research question and fulfill the objectives, the following tasks for the thesis are introduced:

- General overview of the biofuels market and technologies and the study of the potential niche for Kazakhstan’s biofuel products;
- policy and legal framework and recent developments in this area in Kazakhstan;
- domestic and export market potentials;
- elaboration of the recommendations for targeted groups of stakeholders

The scope of the thesis covers the analysis of the potential production of two main biofuels - bioethanol and biodiesel. Both of these are so-called “first generation” biofuels. Biogas and second generation biofuels are considered in terms of the analysis of possible scenarios on bioenergy development in the country but these types of biofuels were not included into the analysis of the current production and feedstock potential as there are no existing organizations or entities dealing with the involvement of these types of biofuels. Moreover, biogas has not been included into the Concept of biofuels market development and is not taken into account as tradable product.

There were several limitations during the thesis research:

The analysis and recommendations were developed from the observations, data and personal opinions of experts and participating organizations. It was difficult to find the literature and research papers on the estimates or quantitative evaluation of biofuels potential in Kazakhstan as there were no publications yet in this thematic area.

Some interviews important for making conclusions were not conducted due to the time constraints and unavailability of people during the research period. One of the interview with the expert who was participating in the elaboration of Biofuels Concept did not take place as expert has not replied my request about the meeting. A second interview was planned to take place in the Food Contract Corporation, the main grain exporter. But there was no answer from them either. Therefore, the conclusions on their possible attitude and participation potential in the biofuels market penetration were made based upon conducted interviews and meetings and standpoints of experts and specialists.
Bioethanol production expediency and drawbacks was assessed based upon observation of the only plant existing in Kazakhstan. Furthermore, the plant is not yet working with its full capacity; therefore, conclusions on the effectiveness of its operations are not final. There is no biodiesel plant in Kazakhstan. Biodiesel production potential assessment was limited to the evaluation of the feedstock potential. Biogas production potential was not evaluated as there should be separate research done in this area due to the feedstock specifics.

1.3 Targeted audience and application

The thesis is intended to be relevant to the wide range of stakeholders in biofuels area including policy-makers, industry representatives, research and consulting organizations, academia and students involved into the research on biofuels potential in Kazakhstan.

It can also serve as a starting point for the future deeper research in the area as well as an overview for those who is interested to get an information about Kazakhstan’s activities in the biofuels production sector – for international experts studying different markets and policies, for potential investors.

1.4 Methodology

The following methods were used to write and present the thesis: primary and secondary data collection, literature review, field visits and case studies.

Personal communications and field visits were the primary sources of information. The data was collected through 17 interviews, 4 study visits and the study of laws and regulations related to the biofuels development. Interviews were conducted in the semi-structured form and divided into three types by the set of the questions addressed: public officials (The Ministry of Agriculture, Sustainable Fund “Kazyna”, etc.), project implementators (Ecomuseum, Biohim plant, etc.) and researchers (Tassekeyev, Nekrasov and others). The typical questions are presented in the Appendix 2.

Special attention was devoted to the study visit to Biohim, the only existing bioethanol plant in the northern part of Kazakhstan. This visit has formed a basis for an internal case study. The other case study is related to the pilot project on biogas installations of Ecomuseum, NGO in Central Kazakhstan. The aim of presenting case studies is to introduce the existing activities in the biofuels area and drawing conclusions on further development potential, lessons that must be taken into account and the recommendations of the people and organizations directly involved into the process.

Secondary data includes international publications available from sources such as the International Energy Agency, European Commission, World Bank, National Research Council, Network of Excellence, and others; research activities data available from the Sustainable Fund “Kazyna”, the Ministry of Agriculture, Ecomuseum, individual researchers M. Tassekeyev, V. Nekrasov and G. Samenova.

The Table 1-1 below presents the inputs of collected information in the relevant parts of the thesis.
### Table 1-1 Collected information and inputs

<table>
<thead>
<tr>
<th>Primary data</th>
<th>Personal communications</th>
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<tr>
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<td>Background, 3.2. Biofuels production in Kazakhstan, 3.3. Agricultural policy, 4.1.3. Biofuels Market Development Concept, 4.1.4. Draft Law on Biofuels; 4.3. The main actors in the biofuels area</td>
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<tr>
<td>Study visits</td>
<td>3.2. Biofuels production in Kazakhstan, 3.3. Agricultural policy, 4.3. The main actors in the biofuels area, 5.1. Bioethanol project, 5.3. Biogas pilot projects</td>
</tr>
<tr>
<td>Secondary data</td>
<td>Literature review</td>
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2 Biofuels Overview

2.1 Technologies, products and applications

Nowadays one of the major problems on the global scale is associated with climate change and its consequences for socio-environmental well-being of the world population. Countries are looking for different policies and technologies to reduce or, at least, stabilize greenhouse gases concentration in the air.

Most of the measures are based on the changes in the energy policy and improvements in the patterns of energy usage on the supply and demand side. Replacement of fossil fuels, efficient and clean technologies of extraction, diversification of energy sources are considered to take the largest part on the supply side. Energy efficiency and energy savings programmes are the measures related to the demand side. In addition, in the light of increasing oil prices, the limited amount of available sources of fossil fuels and the uneven distribution around the world it is considered by many actors as the right time to introduce cost-effective and environmentally sound alternatives to conventional fuels (IEA 2004, Worldwatch Institute 2006).

However, these driving factors behind energy related discussions are not as important and relevant for developing countries (with minor exceptions) as they are on the top priority agenda for the industrialized countries. In fact, rising oil prices and increased greenhouse gases concentration in the atmosphere are among other many items in the list of environmental problems in the developing countries and countries in transition. Agricultural degradation, deforestation, water shortages and water quality, soil erosion, waste issues, desertification, and droughts – this is just a part of the problems of these countries. Kazakhstan is not an exception taking into account the country faces all the range of consequences of environmental mismanagement of previous years. That is why there might be different driving forces behind the strategy idem.

This case is applicable to bioenergy. Bioenergy has attracted significant attention as the substantial potential to replace conventional sources of energy. However, importantly, bioenergy is also considered to be one of the most promising ways to create favorable conditions for the development of agricultural and forestry business as well as to boost the development of new industries and clusters (Tassekeyev pers.comm., Sutyaginskiy pers.comm.).

According to the report of International Energy Agency bioenergy is defined “as material which is directly or indirectly produced by photosynthesis and which is utilised as a feedstock in the manufacture of fuels and substitutes for petrochemical and other energy intensive products” (IEA 2005).

Biofuels are used as bioenergy carriers in solid, liquid and gaseous forms. There are many definitions for biofuels and its main characteristics. Here some of them are listed:

- “Biofuels” is a term used to describe raw biomass processed into a more convenient form to be used as a fuel (EIA 2004);
- “...the term biofuels is defined according to the Swedish standard as solid, liquid, and gaseous fuels based on biomass” (McCormick and Kaberger 2005);
• “A fuel produced from dry organic matter or combustible oils produced by plants. Examples of biofuel include alcohol (from fermented sugar), black liquor from the paper manufacturing process, wood and soybean oil.” (IPCC 2001).

It is clear from the definitions that biofuels production is based on the biomass conversion where biomass is defined as all organic materials including plants, trees and crops, organic waste, agricultural and forestry residues (Vessia, 2005). Traditional biomass is being used for long time still in use in many developing countries of the world. Indeed, it is estimated that 2.5 billion people rely on the energy derived from biomass (Hirst, 2007). However, only 10 per cent of biomass goes to the energy production, the rest is used for food, feed or fiber production (WWF, 2006). But the new era of biofuels commercialized and introduced into the world market has been started in 1980s with the production of bioethanol from sugar cane in Brazil to increase the energy efficiency, product usability and feedstock availability (UNEP, 1991).

According to IEA (2004) studies biofuels development is driven by several factors amongst which the most important are:

• energy security and energy sources diversification;
• reduction of greenhouse gases emissions;
• agricultural development;
• environmental considerations (vehicle performance, pollution reduction, biodegradability, etc.);
• existing knowledge and technology.

It is important, however, to distinguish biofuels by their feedstock and production chains, by the final product type and by their application. Generally, biomass is the principal feedstock for the biofuels production but there are many forms of biomass available for the conversion into biofuels. Correspondingly, there is a diversity of conversion routes to transform different types of biomass into usable form of biofuels. Sustainability issues are another parameter that defines optimal biofuels production route that has to be well-managed to prevent negative effects of bioenergy use such as biodiversity loss, replacement of food crops on the dedicated lands, soil erosion, etc (WWF, 2006).

By the feedstock and production chains biofuels can be divided into two groups – the first and the second generation biofuels. First generation biofuels are widely introduced in the world market representing bioethanol from energy crops like sugar cane, grain and other crops, biodiesel produced from oilseeds like rapeseed, biogas or landfill gas.

The first generation biofuels are generally considered as biofuels derived from crops such as grain, corn, sugar cane, sugar beet or oilseed crops (IEA 2004). The technologies to produce first generation biofuels are already in place and commercialized.

One of the touchiest issues for the production of the first generation biofuels is the significant input of fossil fuels into the process both in the feedstock preparation and production of the final product. In some instances, the amount of fossil fuels needed to produce the certain amount of biofuels does not seem sustainable and promising to speak about the solution of climate change problem or any other environmental problem. For example, according to
European Biomass Industry Association, bioethanol production cost is 0.32-0.53 euro per litre which is more than those to produce gasoline if we take into account the taxes, except for bioethanol produced from sugar cane in Brazil. Fossil energy balance that accounts for feedstock production input as well as the final product process is not really advantageous for the biofuels production. That is why many countries introduce different policies aiming at support and promotion of biofuels. The drawbacks of the first generation biofuels – high production cost in comparison with energy derived from fossil fuels, competition with food industry, environmental concerns – encourage policy makers as well as researchers to look at another options of biofuels with greater potential and less costs to replace conventional sources of energy (Worldwatch Institute, 2006).

The second generation biofuels are considered mostly as advanced biofuel production systems. Here typically, experts are referring to the production of biofuels from lignocellulose that allows the use of a wider range of feedstock than for the production of the first generation biofuels. Such production systems for biofuels utilise highly efficient conversion processes in comparison to the first generation technologies. They are also regarded as carbon-neutral biofuels (IEA 2004). The production can be based upon low value agricultural crops, perennial grasses, organic waste (agricultural and forestry residues as well as solid municipal waste). Despite such promise, treatment technologies are still in the development phase and have not yet been commercialized. However, in recent years a lot of research efforts were made to introduce cost-effective technologies of the conversion of lignocellulosic biomass into fuel.

The simplified description of existing and potential biofuels is outlined in the Table 1-2 below. It is just an overview of the technologies and products that are currently available on the market and that are potentially available from technical and economic perspective.

*Table 2-2 Biofuels: first and second generation technologies*

<table>
<thead>
<tr>
<th>Biofuels</th>
<th>Feedstock</th>
<th>Process</th>
<th>Form</th>
<th>Application</th>
<th>Production cost estimations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioethanol</td>
<td>Energy crops, sugar cane, sugar beet - plants rich in starch and sugar</td>
<td>Fermentation and distillation</td>
<td>Liquid</td>
<td>Heat, power, CHP, automotive fuels</td>
<td>0.32-0.53 euro per litre</td>
</tr>
<tr>
<td>Biodiesel</td>
<td>Oilseeds and oil rich plants – rapeseeds, sunflower seeds, palm oil, etc.</td>
<td>Estherification</td>
<td>Liquid</td>
<td>Heat, power, CHP, automotive fuels</td>
<td>0.50 euro per litre</td>
</tr>
</tbody>
</table>
Biofuels concept development in Kazakhstan: drivers and barriers

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### Biogas

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Process*</th>
<th>Sub-process</th>
<th>Product</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural and forestry residues, organic municipal solid waste, wastewater treatment organic effluents</td>
<td>Digestion</td>
<td>Gaseous</td>
<td>Heat, power, CHP, automotive fuels</td>
<td>Depends on the feedstock and operation</td>
</tr>
</tbody>
</table>

### Pellets

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Process*</th>
<th>Sub-process</th>
<th>Product</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Woody biomass</td>
<td>Combustion/Burning</td>
<td>Solid</td>
<td>Heat, Power, CHP</td>
<td>60-110 euro per ton</td>
</tr>
</tbody>
</table>

### Second generation biofuels:

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Process*</th>
<th>Sub-process</th>
<th>Product</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lignocellulosic biomass – crops, grass, timber, etc.</td>
<td>Hydrolysis</td>
<td>Fermentation</td>
<td>Ethanol</td>
<td>Energy use: Heat, power, CHP, automotive fuels</td>
</tr>
<tr>
<td></td>
<td>Pyrolysis</td>
<td>Refining</td>
<td>Diesel, RME</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gasification</td>
<td>See – Gasification route</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gasification</td>
<td>Synthesis</td>
<td>Fischer-Tropsch liquids, Methanol, Hydrogen</td>
<td>Non-energy use: chemicals, materials</td>
</tr>
</tbody>
</table>

*there are hybrid technologies involved into the processes as well, e.g. pyrolysis plus gasification.

**Source:** Adapted from Vessia 2005, Larson 2006, EUBLA

Second generation biofuels are capable of overcoming a number of important barriers for wider bioenergy promotion:

1) they do not compete with food crops; in fact, all kind of biomass may be suitable if conversion technologies are available on feasible basis (competition for land may be an issue but the technologies are looking at the options to use lands not suitable for food crops);

2) lower feedstock costs;

3) they provide more GHG reductions in comparison with the first generation biofuels;

4) energy yields are more efficient;

5) Development of “biorefinery” concept – production of wide range of products at one site for energy and non-energy use.

It is difficult, however, to predict the future pathway for biofuels production. For the sustainable development of biofuels there should be consistent policy on national and international policies, advanced technologies to increase efficiency and cost-effectiveness, strong market incentives and instrument so the sector might be self-regulated and less
vulnerable to macro-economic changes (UNCTAD, 2006, IEA, 2004). Conversion technologies for the second generation biofuels are still under development and not cheaper than production costs for the first generation biofuels which are not competitive with the production costs of conventional fuels except cost of ethanol production from sugar cane in Brazil (IEA 2004).

2.2 Liquid biofuels for transport: bioethanol and biodiesel

In the thesis the main focus is made on the liquid biofuels for transport, namely, bioethanol and biodiesel, because the national strategy of the country has defined these types of biofuels as the potential area for market penetration. It is worth to stress that in this paper bioethanol and biodiesel are considered to be produced with the first generation technologies available on the market.

Transport is considered to be the major consumer of fossil fuels like petrol and diesel. Therefore, it is particularly important to find optimal and cost-effective alternative in the transport sector. These alternatives include electricity, compressed or liquified natural gas, bioethanol, biodiesel and biogas. However, most options are not viable due to the high capital investment, significant engine modifications and provision of completely new infrastructure for the production, distribution and use of these fuels. Therefore, bioethanol and biodiesel are considered to be the most preferred options due to the flexibility in the use and mature technologies.

Bioethanol is the biofuel derived mostly from crops rich in sugar and starch - wheat, corn, sugar cane. It is produced through process of starch fermentation by yeast. The technology is well established and has been used for many years. Bioethanol can be blended with the petrol at different ratios or can be used in its pure form, however, with certain modification of vehicle engines. There are specifics that limit the use of bioethanol in most of the countries. The most important barriers are production costs that are up higher than for gasoline production, except Brazil case, and certain physico-chemical characteristics that may be incompatible with existing engines (IEA 2004). First of all, the energy content of bioethanol is lower that in conventional petrol, therefore larger handling volumes are needed (IEA 2004). Secondly, bioethanol can be easily separated from petrol with water presence. Thirdly, ethanol is considered as an agressive fuels with corrosive characteristics that need to be handled in specifically designed storage conditions. Besides, there are many factors influencing the attractiveness of bioethanol. The Table 2-1 presents the comparison of positive and negative effects of bioethanol production and use as bio-additive to the petrol is presented below.

Table 2-1 Bioethanol: advantages and disadvantages

<table>
<thead>
<tr>
<th>Effects of bioethanol production and use</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Positive</strong></td>
</tr>
<tr>
<td>Promoting agricultural development and to improve rural economics</td>
</tr>
<tr>
<td>Reduction of greenhouse gases</td>
</tr>
<tr>
<td>Reduction of emissions of sulfur, carbon monoxide, particles</td>
</tr>
</tbody>
</table>
Better performance of a vehicle due to higher octane number of ethanol
Reduction of the amount of petrol to be used; energy supply security
Social benefits – employment, rural development
International trade development

<table>
<thead>
<tr>
<th>Modifications of engines with higher blending ratios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental concerns – soil erosion, water supply for irrigation purpose, biodiversity loss</td>
</tr>
</tbody>
</table>

Source: EIA, 2004; Puppan, 2001

So far, bioethanol use in the transportation sector is growing as it is shown in Figure 2-1 mainly due to the policies in EU, US and other countries requiring certain blending ratios with bio-ethanol and biodiesel.

![Figure 2-1 World fuel ethanol production, 1975-2005](source: Worldwatch Institute 2006)

Bioethanol production has also another advantage of additional profit created by by-products. By-products of bioethanol production include gluten used to improve flour and fodder quality, CO2 that is often liquified and sold to the companies producing beverages and fodder that is highly demanded in the livestock production sector. Therefore, bioethanol production becomes more profitable with these by-products improving the whole sector and creating opportunities for new businesses.

Biodiesel is biofuel derived from oilseed crops through esterification. It can also be produced from spent cooking oil or waste fats; however, due to the complexity of composition of these feedstocks production of fuel is limited. The different titles exist to mark biodiesel production specifics, e.g. FAME meaning Fatty Acid Methyl Ester or RME – rapeseed methyl ester. It has similar characteristics with conventional diesel, therefore, can be used as an additive to the diesel as well as pure fuel without engine modifications. Biodiesel is biodegradable and improve environmental performance of vehicles (IEA, 2004).
By-products that are of commercial interest in the process of production are animal feed and glicerin used in cosmetics, chemistry, etc.

Storage and transportation issues are not so complicated for biodiesel as oils and esters have mature handling technology that might be applied to biodiesel production and use system (IEA, 1999). Biodiesel production rate is relatively small in comparison with bioethanol production, however, the stable trend of increase in production is observed as we can see from Figure 2-2.

![Figure 2-2 World biodiesel production, 1991-2005](image)

*Source: Worldwatch Institute 2006*

Liquid biofuels for transport has a great potential to replace significant amount of conventional gasoline and diesel. There are certain drawbacks and barriers to the wider use of automotive biofuels that can be overcome by the appropriate policies aiming at obligatory use of biofuels in transport sector, certain standards to regulate the quality of fuels, certification schemes that will encourage fuel producers to strive for larger use of bio-additives to fuels, subsidies to agricultural sector to reduce production costs mainly driven by the feedstock costs, tax regulations. Subsidies for biofuels production are becoming the more and more disputable issue in the global biofuels market. Subsidies may cause negative impact on the agricultural and food sector withdrawing farmers from food crops production which some considered should be prevented or avoided (Worldwatch Institute, 2006, IEA 2004).

Another important factor is that technologies to produce biofuels from biomass are improving and developing creating new opportunities for biofuels that are efficient, cost-effective and environmentally sound. These so-called second generation biofuels derived from lignocellulosic biomass may replace existing first generation biofuels as the production costs for the advanced technologies are predicted to be lower than “older” technologies and competitive with those for conventional fuels production. Moreover it is anticipated that the environmental “footprint” of second generation will be less than first generation (Vessia, 2005).
To sum up, there is a need for the balanced policy that should be comprehensive. The use of biofuels for transport is certainly increasing. To manage the process it is necessary to promote sustainable approach in the existing production as well as R&D activities to hasten the second generation biofuels introduction to the market. And last but not least there should be measures to influence the demand side of fuels consumption, in other words, transportation sector should generally use less energy to reduce overall environmental burden.

2.3 World biofuels production trends and prospectives

As it was noted previously biofuels market today is represented only by the first generation biofuels. Bioethanol and biodiesel has the largest share in the biofuels production in the developed world, and biomass combustion and burning is an important energy source in the developing world. Biogas production generally remains the option of small-scale, local production.

It has been estimated that bioenergy provides more than 35% of the energy needs in developing countries on average. This number can vary from one region to another. For example, in Africa more than 90% of energy needs are covered by bioenergy (Risø Energy Report, 2003). More than 2 billion people rely on the energy derived from biomass.

However, there should be clear distinguishing of traditional biomass use and novel bioenergy use. Traditionally, biomass is combusted or burnt for heating and power purposes. Nowadays, biomass is used on more efficient basis using technologies and processes that can convert biomass into usable forms of biofuels with high efficiency ratio and with less harm to human health and environment. These biofuels production is now taking place in the industrialized countries facing increasing issues such as high oil prices, energy security concerns and obligatory targets under Kyoto Protocol. Bioethanol, biodiesel, biogas, combustion of wood pellets in the combined heat and power plants are biofuels and conversion processes that are highly exploited today. From the Figure 2-3 it can be seen that bioethanol production is heavily driven by the increasing oil prices.

![Figure 2-3 Crude oil prices vs. ethanol production, 1980-2004](source: Vessia 2005)
The recent trends in bioethanol and biodiesel market development clearly show the tendency to increase the production and export of biofuels by the main producers as well as emerging markets in the developing countries (UNCTAD, 2006). In the bioethanol international market the largest producers are Brazil, US, China, South Africa and EU with the largest share of Brazil as it is shown in Figure 2-4. Brazil managed to achieve competitive with fossil petroleum production cost for bioethanol from sugar cane. So far, it is the only fuel competitive with petrol on the international market taking into account that crude oil price will not fall under $30 per barrel (UNCTAD, 2006). In total bioethanol production is around 3 billion liters which is just 0.32% of crude oil international trade (UNCTAD, 2006).

![Figure 2-4 Main ethanol exporters](source: UNCTAD, 2006)

Ethyl Tertiary Butyl Ether, also known as ETBE, is being used as well, mainly in Europe as an additive to petrol. ETBE is an octane enhancer and usually produced from ethanol adding isobutylene. ETBE was introduced as an alternative to MTBE, methyl tertiary butyl ether produced from methanol, as MTBE is being now phasing out due to uncertainty and possible impact on the groundwater pollution (Vessia, 2005). With high octane number and less volatility than ethanol ETBE is considered as optimal additive to petrol but in the nature it is just partially renewable using chemicals to further convert bioethanol into final product (IEA, 2004).

There is a need to expand the international bioethanol market with the introduction of new producers to develop and strengthen the role of bioethanol in the energy sector and to create additional incentives for the producers. The biofuels market is mainly driven by governmental policies as the production costs are not competitive with the crude oil production costs (IEA, 2004). But the more mature market in the area the more opportunities for the market instruments to penetrate the production of biofuels and to be self-regulating.

In the biodiesel market the leadership in the production belongs to the European Union deriving biodiesel from palm oil imported from South East Asia though production capacities are much smaller than those of bioethanol production (UNCTAD, 2006). The total production of biodiesel is hard to estimate due to the fact that feedstock for biodiesel
production – rapeseed oil, palm oil, sunflower oil, etc. – is traded also for human and animal consumption and cosmetics.

The biodiesel market is steadily growing, especially in Europe. The main biodiesel producers are Germany, France and Italy. It is sold either as blends with diesel or in its pure form. It is expected that the demand for the feedstock production will increase. European Union is already in short supply of oil for the biodiesel production. Germany, the leading biodiesel producer, is importing rapeseed oil mainly from Canada, and with existing capacities will have to increase rapeseed oil import (Zimmermann, pers.comm.). Figure 2-5 demonstrates biodiesel production capacities in the world. EU has produced about two thirds of its capacities in 2003 (IEA, 2004).

Second generation biofuels may appear on the international market within 5 to 15 years, the predictions vary between studies. It is estimated that due to better characteristics, performance and wider application second generation biofuels have higher potential to replace petrol on the market. So far, the international biofuels trade is in the beginning that is why it is hard to analyze international market trends due to the lack of data and lack of strict differentiation of feedstock trade and final products trade.
3 Agricultural Sector of Kazakhstan: Feedstock Potential

3.1 Agricultural profile of the country
Possessing the large territory and variety of environmental conditions Kazakhstan has historically been agricultural country specializing both in livestock production and plant cultivation. To introduce the agricultural profile of the country for the better understanding of further considerations on biofuels feedstock availability and options several parameters are briefly described:

3.1.1 Climate and geography
The country is located in the heart of Eurasian mainland having no outlet to the sea. This factor predetermines continental climate with cold winters, hot summers and high evaporation rates. The average temperature in January and July varies from north to south. In the northern part of the country the average temperature in January is about -18°C in January and +19°C in July. In the southern part the average temperature in January is -3°C and +30°C in July (AQUASTAT, 1998).

Kazakhstan is predominantly flat country with the gradual change of landscapes from north to south consisting mostly of steppes and deserts. The more detailed look at the natural zones of the country is introduced in the Figure 3-1.

![Figure 3-1. Natural vegetation zones of Kazakhstan](source: Wild Natures 2003)
Soils characteristics and productivity also vary between natural zones but mostly represented by chernozems and chestnuts. High evaporation rate, small amount of precipitation, dry weather and strong winds are the typical characterizing factor for the climate of Kazakhstan implying certain impact on soils. The main specific of soils in the country is their high vulnerability to wind erosion. 80% of grain is cultivated on chernozems and dark chestnut soils but these types of soils lost from 20 to 25% of humus due to the wind erosion and intensive ploughing (Tonkopiy, 2003). Soils productivity due to the low content of organic matter and humus is considerably low. Estimated quality parameters of soils are shown in the Table 3-1 below:

Table 3-1 Quality characteristics of soils

<table>
<thead>
<tr>
<th>Lands, %</th>
<th>Humus matter, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>4,7</td>
<td>More than 6</td>
</tr>
<tr>
<td>23,9</td>
<td>4-6</td>
</tr>
<tr>
<td>46,5</td>
<td>2-4</td>
</tr>
<tr>
<td>24,9</td>
<td>Less than 2</td>
</tr>
</tbody>
</table>

Source: Tonkopiy 2003

Annual rainfall in the country is around 300-340 mm though with high disparity between natural zones: from 100-120 mm in the deserts and 700-750 mm in the mountainous areas (AQUASTAT, 1998). Deficient amount of precipitation in the central and southern parts of the country during cropping period implies water pressure due to the irrigation demand.

3.1.2 Agricultural specialization in different regions of the country

Agriculture in Kazakhstan is typically divided into two forms of activities: plant cultivation and livestock production. Climatic conditions and local practices predetermine regional specialization in the country. Agriculture provides around 10% of GDP from which 52% comes from plant cultivation, and 48% come from livestock breeding (Ministry of Agriculture, 2005).

Land use patterns can be illustrated in the following way (Figure 3-2):
Based on the type of the soil and annual precipitation certain types of agriculture are introduced in the country. Northern Kazakhstan and some parts of Central and Eastern Kazakhstan practices mainly dry agriculture specializing in grain cultivation. Irrigated agriculture is applied in the rest of the regions. The outline of agricultural specializations is indicated in the Table 3-2.

**Table 3-2 Agricultural specialization by regions**

<table>
<thead>
<tr>
<th>Zone</th>
<th>Precipitation, mm/year</th>
<th>Type of soil</th>
<th>Regions</th>
<th>Agricultural specialization</th>
<th>Farmland</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>N-Kazakhstan, northern districts of Akmola, Kostanai, and Pavlodar regions</td>
<td>dry agriculture</td>
<td>2,1</td>
</tr>
<tr>
<td>Forest-steppe</td>
<td>320-340</td>
<td>black and leached chernozems</td>
<td></td>
<td></td>
<td>9,3</td>
</tr>
<tr>
<td>Steppe</td>
<td>270-310</td>
<td>ordinary and southern chernozems</td>
<td>N-Kazakhstan, northern districts of Akmola, Karagandy, Kostanai, and Pavlodar regions</td>
<td>predominantly dry agriculture</td>
<td>10,2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>44,7</td>
</tr>
<tr>
<td>Dry steppe</td>
<td>230-250</td>
<td>dark chestnuts</td>
<td>Akmola, Aktobe, Kostanai, E-Kazakhstan, Pavlodar, and small eastern part of N-Kazakhstan</td>
<td>instable dry agriculture and livestock breeding</td>
<td>6,5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>28,5</td>
</tr>
<tr>
<td>Semi-desert</td>
<td>200-230</td>
<td>light chestnuts</td>
<td>Akmola, Aktobe, Kostanai, E-Kazakhstan, Pavlodar, and small eastern part of N-Kazakhstan</td>
<td>livestock breeding, pastures, local oases and</td>
<td>0,5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2,2</td>
</tr>
</tbody>
</table>
### Plant cultivation: main cultures, yields, mapping, capacities, problems

Plant cultivation is introduced by the crops, oilseed crops, vegetables and cotton; small scale rice cultivation, melons and gourds and sugar-beet growing exist mostly in southern parts of the country. The shares of land use for different types of plants are shown in Figure 3-3.

<table>
<thead>
<tr>
<th>Desert</th>
<th>120-150</th>
<th>Central Kazakhstan uplands, E- and W-Kazakhstan, Atyrau, southern part of Aktobe, northern parts of Almaty, Zhambyl, Kyzyl-Orda, and S-Kazakhstan</th>
<th>Livestock breeding, pastures, irrigated agriculture</th>
<th>0.4 1.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foothill desert-steppe</td>
<td>200-300</td>
<td>Almaty, E-Kazakhstan, Zhambyl, and S-Kazakhstan</td>
<td>Irrigated and dry agriculture, livestock breeding and pastures</td>
<td>1.4 6.1</td>
</tr>
<tr>
<td>Foothill steppe</td>
<td>120-170</td>
<td>Almaty, E-Kazakhstan, Zhambyl, and S-Kazakhstan</td>
<td>Livestock breeding, pastures, and areas with irrigated crop growing</td>
<td>0.8 3.5</td>
</tr>
<tr>
<td>Mountainous steppe</td>
<td>300-400</td>
<td>Almaty, E-Kazakhstan, Zhambyl, and S-Kazakhstan</td>
<td>Irrigated agriculture, horticulture, pastures and weeds</td>
<td>0.9 3.9</td>
</tr>
<tr>
<td>Mountains</td>
<td>730-750</td>
<td>Almaty, E-Kazakhstan, Zhambyl, and S-Kazakhstan</td>
<td>Pastures and grasses in lower areas</td>
<td></td>
</tr>
<tr>
<td>Total Kazakhstan</td>
<td>277-322</td>
<td></td>
<td></td>
<td>22.8 100</td>
</tr>
</tbody>
</table>

Plant cultivation in the regional context might be divided into 3 groups:

1) Cereals, oilseed crops, forage crops, potatoes – North Kazakhstan and neighboring regions of West Kazakhstan, Central Kazakhstan;

2) Cotton, rice, sugar beet, corn, vegetables, melons and gourds, tobacco – South and South-East Kazakhstan

3) Potatoes, sunflower, vegetables, horticulture – foothills in South-East and East Kazakhstan

It is seen from agricultural practices that cereals are the main cultivable crops in the country on the large-scale production. Other plants due to the climatic conditions are the subject to small-scale region-attached production (Tassekeyev pers. comm., Tonkopiy, 2003).

The main arable lands are concentrated in the northern regions of Kazakhstan. Soil and climatic conditions are suitable for dry agriculture, cereals planting. Northern regions together with Aktyubinsk and Uralsg regions of West Kazakhstan provide more than 50% of all the plant cultivation production and around 80% of grain production (Agency of Statistics of RK, 2006). Due to the weather conditions and amount of fertilizers used high fluctuations in yields occur that make it difficult to predict future trends in crops production.

Wheat remains the major cultivated crop in Kazakhstan occupying around 12.5 million hectares, or 68% of all cultivated area (Ministry of Agriculture of RK, 2006). Three northern regions – Kostanai, Akmola and North-Kazakhstan region provides more than 70% of the total wheat output in the country (USDA, 2003). Figure 3-4 shows wheat cultivation areas in Kazakhstan.
Northern regions are mainly focused on the cultivation of spring wheat while winter wheat is cultivated in the southern region. Total wheat production is around 15 million tons (Ministry of Agriculture, 2006). The average yield is 1-1.2 tons per hectare that is relatively low indication of lands productivity whereas in Europe the yield is around 3 tons per hectare (Tonkopiy, 2003).

Use of fertilizers is significantly lower than it should be taking into account the climatic conditions and soils specifics. According to the statistical data in the year 2005 37.5 thousand tons of fertilizers were used in the plant cultivation, 34.4 thousand tons were used for the grain cultivation that amounts to approximately 2 kilograms of fertilizers used per 1 hectare while the average amount of fertilizers are defined to be 20-25 kilograms per hectare (Agency of Statistics, 2005, Kashevkin pers.comm). In Canada, for example, with similar climatic conditions around 50-55 kilograms of fertilizers are used. This fact can be explained by the high cost of fertilizers being more than 180 euro per ton (Kashevkin pers.comm.).

Despite the decline in overall agricultural production during the first decade of independence, the recent trends in plant cultivation are positive mainly due to the increase of grain yields because of favourable weather conditions. Kazakhstan is ranked among ten world exporters of wheat and wheat products taking the third place in wheat flour export and the sixth place in wheat export (USDA, 2007). Exported wheat is characterized as the wheat of high quality and with the high content of protein (Samenova, 2006).

Kazakhstan produced 15 million tons of wheat in 2006 out of which 5.5 million tons were exported and 4.5 millions tons were used for the domestic consumption. The wheat of low quality is around 1-1.5 million tons (Ministry of Agriculture, 2006; USDA, 2007). The year 2006 was extremely favorable for the plant cultivation in Kazakhstan due to the good weather conditions and wheat yields were comparatively higher than in previous years. Average wheat production in the country is estimated to be around 11-12 million tons based on the data from previous years under existing conditions.

Another point of interest from the plant cultivation prospective is oilplants production which is considerably smaller in comparison to the grain cultivation. Total oilseed crops cultivation
area is around 760 thousand hectares, sunflower plantations take around 500 thousand hectares (Ministry of agriculture, 2006). It can be seen in the Figure 3-5 that eastern regions are leading on the cultivated area under oilseed crops, especially, in sunflower production.

![Figure 3-5 Regional distribution of oilseed crops cultivation](Image)

*Source: Evniev 2003*

In Figure 3-6 the main parameters of oilseed crops cultivation are shown. The increase in 1999-2000 may be explained by relatively low prices on grain, especially, wheat. Oilseed crops were more profitable to sow and to sell oilseeds to oil producing companies (Samenova pers.comm.).
Oilseed crops cultivated in the country include mainly sunflower (70-80% on average from total oilseed crops production) and safflower (10-15% from total production). Other oilseed crops cultivated are soy, rapeseed, mustard, flax, cottonseed. The rapeseed cultivation area is steadily increasing. If in the 1990-2002 the average share of rapeseed area has been around 3-4% of total oilseed crop production in 2004-2006 the situation has changed in favour of rapese cultivation, especially, canola production that has grown up to 8-9% share with the highest figure in 2006 – 16% (Agency of Statistics of RK, 2006). Vegetable oil market demand is growing; therefore, further increase in oilseed crops cultivation might be expected. Domestic consumption of vegetable oil has increased significantly in recent years. The country is now focusing on the expansion of the area under oilseed crops to cover domestic consumption needs (Samenova pers.comm).

The changes in agricultural policy and improvements in plant cultivation practices may result in yields increase and better grains quality that is the topic of discussion in the subchapter 3.3.

### 3.1.4 Livestock production

Kazakhstan historically was the country of the agriculture based on the animal breeding due to the availability of pastures and nomadic traditions of grazing. The situation changed during the Soviet Union period, especially with the promotion of “Tselina” campaign aimed at the developing of virgin lands with the highly productive soils in the northern regions of the country. Plant cultivation was becoming more and more important priority area in the country.

In recent years the situation in the livestock production has been improved and the steady growth can be observed in this sector as it can be seen from the Figure 3-7.
The main point to rise about livestock production from the perspective of the thesis is that livestock production has significantly high potential to develop. World Bank studies (2004) indicate several reasons contributing to this assumption:

- the total pastures area is around 68% of all agricultural area available; large pastures area provides one of the major prerequisites for high production capacities;

- improved world market prices;

- livestock production in the country is especially important for small and medium agricultural enterprises
3.1.5 Environmental problems in the agricultural sector

Agricultural sector in Kazakhstan has a number of environmental problems of both natural and human-caused character. The inclement climatic conditions, soil specifics, water shortages create high vulnerability of agricultural activities to the changes in weather conditions and other natural factors. Subsequently, crops yields suffer high fluctuations from year to year.

However, with proper agricultural management in place, water regulation and efficient use policies, sufficient amount of fertilizers used to preserve soils and the use of best available techniques can effectively overcome these problems and to positively affect agricultural performance of the country. Yet, the agricultural practices are far away from wishful mainly due to the legacy of the past (Tonkopiy, 2003).

According to the existing world land reserves estimates Kazakhstan possesses rich land resources. But most of the lands are in the arid zone where average annual rainfall is less than 300 mm. Farming is of high-risk or impossible on these lands (Tonkopiy, 2003).

The developing of virgin lands became remarkable event in the history of the extensive farming in Kazakhstan. It allowed the country became one of the largest exporters of grain. But these lands lost from one forth to one third of organic matter in that period. The consequences of the “Tselina campaign” were irreversible for the agriculture of Kazakhstan. Intensive and unsystematic use of the high quality pastures led to the significant decrease of their yields and deterioration in the species composition of plants. The main consequences of the agricultural policy of that period are: degradation and losses of agricultural lands due to erosion, salinization, waterlogging, heavy machinery, reduction of natural yields, water pollution by chemical products and manure, increase of hazardous pollutants content in agricultural products (UNECE, 2000).

Another negative side from the livestock production prospective was that the use of non-arable lands for the plant cultivation led to the degradation of lands and soil erosion that made them unsuitable for the animal breeding.

For the intensive agriculture the nitrous, phosphorous and potassium content is an important factor. At present, soils have poor content of phosphorous that is preventing from high yields. That is why chemical fertilizers are critical for the plant growing. Unfortunately, the level of the application of fertilizers is not sufficient (Tonkopiy, 2003).

In recent years there also has been not much attention to the environmental problems in the agricultural sector. The collapse of Soviet Union and the following decline in all the sectors of economy made the public focus on social problems rather than environment. Therefore, the progress on the effective environmental policy-making is slow and has just been started. The main point for consideration here is that agricultural policy approach should be shifted from extensive use and developing of new areas to more environmentally friendly practices and overall efficiency of the agricultural development (Tassekeyev pers.comm; Tonkopiy, 2003).

3.2 Biofuels production in Kazakhstan

3.2.1 Bioethanol feedstock and production

First generation bioethanol which is one of the biofuel options in Kazakhstan studied in this paper is the type of biofuel derived from crops rich in sugar and starch. The possible feedstocks for bioethanol production based upon local and conditions are: wheat, barley, corn,
sugar beet (Tassekeyev pers.comm.). Though winter rye can be considered a relevant feedstock for bioethanol production the cultivation of this crop is quite small amounting for about 24 000 tonnes in 2005 (Agency of Statistics of RK, 2006). Rice and potatoes were also excluded due to the specific harvesting techniques that make them incompetent as it involves significant human labour cost.

The discussion on different types of possible feedstock led to the Table 3-3 briefly introducing main pros and cons of these crops as bioethanol feedstock in Kazakhstan.

**Table 3-3 Bioethanol feedstock evaluation**

<table>
<thead>
<tr>
<th>Biofuel type</th>
<th>Yield, t/ha</th>
<th>Production, t/year (average)</th>
<th>Use</th>
<th>Bioethanol feedstock potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>wheat</td>
<td>1.0</td>
<td>11000</td>
<td>Food, seeds, forage, alcohol production</td>
<td>Yield, l/tonne</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>350</td>
<td>Availability: wheat is cultivated on vast area that allows to allocate certain amount of it, especially, low-quality and surplus, to bioethanol production</td>
</tr>
</tbody>
</table>

Good practices: bioethanol production from wheat may create demand on grain market that will make farmers to apply efficient techniques to increase yields and to improve soil productivity

Uncertainty in technologies: as R&D is continuing there are more and more technologies available on the market to be highly competitive with the current technology of conversion of the first generation biofuels

Diversified wheat purchasers: bioethanol plants will diversify current wheat market players which is good for farmers as they will have additional Extensiveness: increase in the demand on wheat market may lead to the developing of fallow lands that might be not suitable for wheat cultivation;
## Biofuels concept development in Kazakhstan: drivers and barriers

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Yield per tonne</th>
<th>Percentage of crops cultivated</th>
<th>Bioethanol yield per hectar</th>
<th>Processing equipment specificities</th>
<th>Other related factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>1.0</td>
<td>Food, brewing, forage</td>
<td>275</td>
<td>Distract attention from environmental problems on existing sown lands</td>
<td>Increased domestic consumption and export needs: food and brewing needs are not met in the domestic market, further increase in crop area is planned to meet these needs</td>
</tr>
<tr>
<td>Corn</td>
<td>4.0</td>
<td>Forage, seeds</td>
<td>350</td>
<td>Highly abrasive</td>
<td>Water supply issue: Corn is cultivated on the irrigated lands that are very limited in the country</td>
</tr>
<tr>
<td>Sugar beet</td>
<td>20.0</td>
<td>Sugar</td>
<td>90</td>
<td></td>
<td>Corn production is decreasing mainly due to the decrease in yields</td>
</tr>
</tbody>
</table>

### Note
- Wheat is not the most advantageous feedstock for bioethanol production in comparison to sugar cane and corn – bioethanol yield per tonne and per hectar is lower for wheat.
- They have the highest bioethanol yield after sugar cane.
- Water supply issue: Corn is cultivated on the irrigated lands that are very limited in the country.
- Processing equipment is wearing out faster because of barley’s specifics – it is highly abrasive.
among other feedstocks in the country sugar beet does not exist in the country, therefore, domestic seed supply is limiting factor

Sugar beet is cultivated in the southern parts of the country that practice irrigated agriculture

The demand for sugar beet production is decreasing mainly due to the replacement of sugar beet by the cane raw sugar for the sugar production

Overall assessment of the available feedstocks allows picking out wheat and corn as the most likely feedstock for the bioethanol production in Kazakhstan. Despite some shortcomings, these crops may help to boost agricultural development and introduce environmentally sound and efficient techniques.

However, wheat promotion may hinder diversification of crop cultivation in the northern regions, therefore, bioethanol feedstocks should be studied and selected taking into account all the barriers and alternatives for existing crops production. Wheat as a feedstock for bioethanol production may be used under the combination of certain conditions that will prevent using of wheat at the expense of food industry needs:

- first of all, low quality wheat not suitable for export or flour production may be used to produce bioethanol;
- secondly, wheat for bioethanol production might be cultivated on lands that are available (meaning not used for food crops and not deteriorated);
- thirdly, strict control and monitoring should be applied to prevent excessive land use for energy crops.

### 3.2.2 Biodiesel feedstock and production prospectives

The feedstock for biodiesel is more difficult to analyze. Oilseed crops together with industrial and forage crops were just recently promoted as the means to diversify monoculture planting in the country (Ministry of Agriculture, 2006). Grain cultivation having 80% share in the plant production was the priority for the agricultural policy until the end of 90s. That is why total crops area for oilseed crops is not impressive and have to be increased if the country is planning to implement biofuels projects not limited to the bioethanol production. At present, there is a need to increase production of oilseed even to supply domestic consumption of vegetable oil (Samenova, 2006). Another difficulty with the assessment of biodiesel production is the market potential which will be discussed further.
Biodiesel feedstocks may include sunflower, safflower, rapeseed, soybean, mustard seed
cottonseed, hemp and cole-seed oil (Sustainable Fund Kazyna, 2007, Tassekeyev pers.comm.).
The first five oilseed crops amount for more than 99% leaving just 0.7% share for other
oilseed crops cultivation as we can see from the Figure 3-9. Sunflower is dominating over
other cultures but the increasing trend can be observed in canola production.

![Figure 3-9. Dynamics of changes in oilseed crops cultivation in land use percentage](image)

Source: Samenova, 2006

There are other alternatives for biodiesel feedstocks not as promoted as rapeseed oil. For
example, there are large areas, in total, around 3 million hectares, under hemp plantations
which are better known for their illegal use for drug production. Tassekeyev (2007) assumes
that these plantations may be controlled in sustainable way to convert them into biodiesel
feedstock production. Hempseeds may be extracted to produce oil. The main advantage of
hemp that it does not need any specific growing techniques and can be planted on marginal
lands (Tassekeyev, 2007). Besides, hemp cultivation may be potential area for the second
generation biofuels research, hemp straw is considered to be a good source of lignocellulosic
biomass for bioethanol production (Castleman, 2001).

Rapeseed oil known as the major feedstock for biodiesel production has not been produced in
the country in large amounts. However, recently the agricultural policy turned to the oilseed
crops and industrial crops made farmers think about most optimal and profitable crops to
cultivate. Rapeseeds can be grown in the northern part of the country and improve soil
characteristics as well as overall land quality (Samenova pers.comm).

Rapeseed species that is mostly cultivated in the country is canola type. It can be cultivated in
the harsh climatic conditions of the north. Another advantage is that canola cultivation uses
the same machinery as wheat cultivation and the planting period is similar for both crops (Zimmermann pers.comm). Overall canola yields have been increased significantly in recent years and steady growth in canola cultivation is expected due to the subsidies and support for crops diversification (Samenova pers.comm). Canola receives state subsidies in amount as twice as much of those for wheat cultivation (Ministry of Agriculture, 2007). However, there is no seed development inside the country. Seeds are mostly imported from Russia, Canada, and Europe. Canadian seeds being the most productive have the higher prices in comparison to the seeds from Russia, for example, and farmers are reluctant to buy these seeds though the productivity and quality of Canadian seeds are better.

Other oilseed crops such as sunflower, safflower and soybean are not expected to increase in production as the market demand for these crops is comparatively lower than for others. Besides, soybean, cotton and sunflower are regionally limited to the southern and south-eastern regions where the irrigated agriculture takes place. Safflower has a good potential to replace sunflower because of less vulnerability to climate conditions. However, sunflower, safflower, soybean and cole-seed are cultivated mainly for the food market and are not expected to provide biofuels market.

3.3 Agricultural policy: barriers and drivers for the biofuels production

Agriculture is one of the largest economic sectors in Kazakhstan employing around 40% of population and providing rural incomes (Ministry of Agriculture, 2005). The framework of agricultural policy in the country is defined by several factors:

- to sustain and to improve the strong agricultural potential of the country;
- to diversify the economy and to make agricultural products competitive;
- to improve quality and to merge business and farming;
- to build new agricultural sectors and stimulate rural development;
- to decrease regional development inequality.

Agricultural policy of the country today is administered by the Ministry of Agriculture which is also responsible for the biofuels development concept. Ministry of Environmental Protection, Ministry of Industry and Trade and Food Contract Corporation are other participating institutions in the sector. In general, agricultural development management and administrative work are concentrated in the Ministry of Agriculture. The structure of agricultural policy participants is presented in Figure 3-10.

Recently the government created a new body called National Holding “KazAgro” that is responsible for the implementation of national agricultural policies through the formation of project portfolio which should ease the financing flows into the agricultural sector. This holding is functioning under the auspices of the Ministry of Agriculture and consists of seven national companies including Food Contract Corporation. The main objective for the holding is the stimulation of agricultural business and increase of agricultural competitiveness.
If we take into account the factors that drive agricultural development in the country it can be understood why biofuels are considered as one of the potential areas to invest and to develop. One of the most recent strategic approaches added to the country’s strategic instruments arsenal is cluster development. Cluster is the territorial production complex that integrates several industries to produce certain categories of products. Biofuels are believed one of the self-sufficient production cycles that may develop out of existing capacities helping to boost the development in other agricultural sectors (Tassekeyev pers.comm).

But the limiting factor for biofuels development in the country is that this dimension is considered from the agricultural perspective without inputs from energy and petrochemistry sector.

The comparative Table 3-4 on drivers and barriers to biofuels development within agricultural policy framework may be divided into three pillars in conformity with triple-bottom framework of sustainable development: economic, environmental and social.

**Table 3-4 Drivers and barriers for biofuels industry development from agricultural perspective**

<table>
<thead>
<tr>
<th>Sustainable development pillars</th>
<th>Drivers</th>
<th>Barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Economic</strong></td>
<td>Diversification</td>
<td>Tax policy</td>
</tr>
<tr>
<td></td>
<td>New and innovative businesses</td>
<td>Oil and gas sector reluctance</td>
</tr>
<tr>
<td></td>
<td>Investments</td>
<td>Uncertainty on the world market prices for fossil fuels and biofuels</td>
</tr>
<tr>
<td>Balanced development</td>
<td>Regional development</td>
<td>Capital investment costs</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Value-added to the agricultural production</td>
<td>Availability of export markets</td>
<td></td>
</tr>
</tbody>
</table>

**Social**

<table>
<thead>
<tr>
<th>Rural development and income generation</th>
<th>Infrastructure and communications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access to the essential needs</td>
<td>Lack of prepared and trained specialists</td>
</tr>
<tr>
<td>Health care improvements</td>
<td>Mentality issues</td>
</tr>
<tr>
<td>Job availability</td>
<td></td>
</tr>
</tbody>
</table>

**Environmental**

<table>
<thead>
<tr>
<th>Renewable energy sources</th>
<th>Scientific uncertainty; 1st vs. 2nd generation biofuels</th>
</tr>
</thead>
<tbody>
<tr>
<td>New environmentally friendly and efficient technologies</td>
<td>Expansion of sown areas to provide feedstock</td>
</tr>
<tr>
<td>Protective measures for land and soil fertility</td>
<td>Existing agricultural practices</td>
</tr>
<tr>
<td>Reductions of air pollution and greenhouse gases emissions</td>
<td></td>
</tr>
<tr>
<td>Better vehicle performance</td>
<td></td>
</tr>
</tbody>
</table>

*Source: Ospanov pers.comm, Sntyaginskiy pers.comm, Tassekeyev pers.comm*
4 Biofuels Policy Analysis: Drivers and Barriers

4.1 Policy framework

4.1.1 Energy policy: key features and preparedness to accept biofuels

Energy policy in the country is primarily based upon the extraction, processing and distribution of fossil fuels, namely, coal, oil and gas. Coal is the main primary energy source for the power plants with minor oil input whereas oil and gas are extracted to provide fuel for domestic consumption and to export crude oil and natural gas to the foreign markets. The shares of total primary energy sources are shown in the Figure 4-1.

Figure 4-1 Total primary energy sources

Kazakhstan has a great potential of fossil fuels energy sources and can be considered as the one of the major countries in the region by its proven reserves not only of oil and gas but also of coal and uranium reserves. The Government of Kazakhstan and foreign investors continue to focus heavily on the hydrocarbons sector. Kazakhstan is the largest oil producer in the former USSR after Russia possessing almost 2 percent of the world’s proven oil reserves. The country produces nearly 1 mln. barrels per day (IEA, 2004c). Oil production is increasing annually on average by 8-9% and predicted to produce around 1, 6 bln. barrels per day by 2010 from three major fields – offshore Tengiz, Kashagan and onshore Karachaganak (UNECE, 2000).

By hydrocarbon reserves Kazakhstan ranks among ten leading countries in the world. According to Shkolnik (2005) recoverable hydrocarbon reserves of the Republic of Kazakhstan, including onshore, are:

- crude oil (12 billion barrels, or 1.6 billion tons)
- natural gas (1 trillion cubic meters)

Kazakhstan's real GDP grew by around 9% in 2003 due to the continuous increase in oil exports and foreign direct investment inflows. Around 80 to 90 per cent of total FDI goes to the oil and gas sector (Agency of Statistics of RK, 2004). This includes large oil projects, but
also a wide range of other activities supplying the oil and gas sector (including transport, services, infrastructures, equipment, and engineering. Substantial energy resources form the basis for the country's good economic performance.

Refinery is not receiving so many foreign investments as production sector, and the main reason is that the domestic prices for the refinery products remains low and there is no incentives to refine oil and gas locally as export of crude oil to international markets will make more revenues. Thus, refinery performance is on the moderate level (EIA US, 2006).

The refining sector in Kazakhstan has three major oil refineries supplying the northern region (at Pavlodar), western region (at Atyrau), and southern region (at Shymkent), with total crude oil refining capacity of 20, 5 mln. tons per year (UNECE, 2000). The refinery at Pavlodar is supplied mainly by a crude oil pipeline from western Siberia (since Russian reserves are well placed geographically to serve that refinery); the Atyrau refinery runs solely on domestic crude from northwest Kazakhstan; and the Shymkent refinery is supplied by oil from Kazakhstan’s fields at Kumkol, Aktyubinsk, and Makatinsk, although it is linked by pipeline to Russia. Marubeni Corporation (Japan) began reconstructing the Atyrau refinery in 2004, and it completed most repairs by 2005. Finally, TengizChevroil, the Chevron Texaco-operated venture developing the Tengiz gas field announced in early 2004 that it had started construction of a new gas refinery as part of its "second generation" project. Apparently, the project will double refinery production in comparison to 2003.

As for gas distribution Kazakhstan has two separate natural gas distribution networks: one is located in the west and serves natural gas fields; another one is located in the south and provides imported natural gas for the southern regions of the country. The main reason of the slow development of natural gas resources delivery is that the natural gas producing areas are not connected to the industrial areas of the country because of internal pipelines lack. However, the development of the Amangeldy gas field will help Kazakhstan's southern region cease importing Uzbek gas. Kazmunaigaz, the national oil and natural gas company, operates Kazakhstan's main natural gas pipelines (UNECE, 2000).

Natural gas potential is a respective competitor to Russia’s natural gas, and several export pipelines alternatives are being considered which may give additional opportunities for the natural gas markets opening. The two branches of the Central Asia-Centre gas pipeline, the main gas export pipeline from Central Asia, meet in the southwestern Kazakhstan’s city of Beyneu before crossing into Russia at Alexandrov Gay and feeding into the Russian pipeline system. Therefore, Kazakhstan is a major transit route for gas from Turkmenistan to Russia and to other markets across the territory of the former Soviet Union (EIA US, 2002).

Kazakhstan possesses region’s largest recoverable coal reserves, with 39 billion tons of mostly anthracitic and bituminous coal. Kazakhstan produces coal not only for domestic supply but also exports it to Russia and Ukraine (UNECE, 2000).

The coal production in Kazakhstan has dropped by roughly 35 percent since independence (EIA US, 2006). The decline in coal production after independence was mainly due to overall decline in economic development and safety issues related to mining activities. Actually, at that period country’s economic depended much on foreign investments and it was challenging investment area for many foreign investors as the stability was doubtful.

Coal accounted for 52 percent of total energy consumption in 2002. Electric generating plants mostly use coal for electricity generation (UNECE, 2000).
Other non-renewable natural resources with energy potential are large quantities of uranium, with reserves of around 1.5 million tons representing 19 percent of the world's supply. In 2004, Kazatomprom produced approximately 4000 tons of uranium, and the company has plans to increase production to 15000 tons by 2010 (Kazatomprom, n.d.). Kazakhstan's nuclear power plant, the 90-MW Nuclear Power Plant at Aqtau city, which has been shut down since April 1999, was sold in April 2003 by the government of Kazakhstan to Kazatomprom, the national nuclear power company. Kazatomprom having exclusive rights to the production and sale of Kazakhstan plutonium intends to maintain and operate the plant's thermal generators and water distribution facilities for regional consumption.

The Ministry of Energy and Mineral Resources is the central executive body of the Republic of Kazakhstan, responsible for the management of issues in the sphere of energy and mineral resources. The main tasks of the Ministry are:

- development and organization of the energy policy implementation;
- development of the strategic plans on the energy supply and distribution;
- development and implementation of the state policy in the energy-saving sphere, utilization of renewable and non-conventional energy sources.

Different state bodies and institutions participate in the energy related activities:

- Investment projects (Agency on Investments, Ministry of Industry and Trade, Ministry of Finance);
- State assets and privatization (Ministry of Finance, the Committee of State Property and Privatization);
- Environmental issues (Ministry of Environmental Protection)
- others

The Law of the Republic of Kazakhstan on "Electric Power" by 2004 sets legislative, economic and organizational basis for the state policy in the areas of production, transmission, distribution and consumption of electric power and thermal energy. The Law of the Republic of Kazakhstan on "Energy Saving" regulates the public relations in the energy-saving sphere with the goal to establish economic and organizational conditions for effective use of the fuel and energy sources of the Republic of Kazakhstan and environment protection. The state programme on energy saving and reduction of greenhouse gases emissions is under development.

Environmental problems associated with the energy sector are of great variety. Energy sector is the main source of greenhouse gases emissions. It’s been estimated that more than 160 million tons of carbon dioxide was emitted in 2004 from fuel combustion (IEA, 2004d). Electric power plants running on fossil fuels are the huge sources of air, water and soil pollution. Oil production companies operating in Caspian region are considered to be serious pollution emitters. Caspian Sea is a closed ecosystem which causes the problem when it comes to self-cleaning processes as they are slower in closed systems without connection to oceans. Water pollution is therefore is highly sensitive issue, especially, for living organisms and species. Caspian Sea known for its sturgeon fisheries is particularly vulnerable to oil and gas exploration activities, oil spills and flooding of old oil fields. Some of the main environmental concerns are associated with degradation of coastal habitats and landscapes, accidental oil spills, old oil spills handling, threats to human health and biodiversity, deficiency of
environmental assessments of offshore and onshore operations. Oil refineries cause soil pollution problems (UNECE, 2000).

Use of renewable energy resources and nontraditional environmentally clean energy resources are considered to be sustainable response to these problems (Tonkopiy, 2003). There is a need for regulative documents on investment, tax and tariff policy for stimulating the energy saving process, development of clean coal technologies and renewable energy sources.

In 1992 Kazakhstan signed the UN Framework Convention on Climate Change and ratified it in 1995. Kazakhstan signed the Kyoto Protocol on March 12, 1999 but not yet ratified although the country is very close to finish the process of ratification. Kazakhstan has also expressed it’s will to join Annex 1 countries. The country ranks the third by the amount of CO2 released per capita, therefore, efficient measures needed to improve the situation and to contribute to the solution of human health and environmental problems (EIA US, 2006).

It is clear from the current energy policy of Kazakhstan that there is a need of strict control and adoption of advanced technologies to reduce the negative impacts caused by the fossil fuels based energy production and use.

4.1.2 Renewable energy policy

There is no strong conception of sustainable development as well as there are no strict indicators identifying efficient development of the energy sector. At the same time it may be noted that renewable energy sources are closer to the idea of sustainability. Technologies based on the renewable energies will play a crucial role for the whole humankind in future in view of increasing energy consumption and fossil fuels scarcity.

The development of the alternative energies is the part of the diversification program established by the government of Kazakhstan. The country is slowly decreasing its dependence on oil and gas based energy production by strengthening other energy sectors such as wind, solar, hydropower and biomass power industries.

Central-Asian region especially needs the development of renewable energies to improve energy supply in the remote areas. Despite its huge oil and gas reserves Kazakhstan faces the problem of energy supply and electricity distribution to the rural areas. Large distances, poor infrastructure and communication put the burden on the energy production and distribution in the country (UNESCO, 2003).

Thus, to meet these targets – diversification of energy sources and supply of remote areas of the country with energy – the country has to think about renewable sources of energy as the sustainable response to these challenges.

Climatic conditions are favorable for solar energy in the country. The highest potential is in the southern region and in the regions near the Aral Sea and Lake Balkhash. Aral Sea region being considered as the regional environmental disaster is in especial need for the stable energy supply to improve socio-economic situation in the region. High rates of unemployment due to the lack of alternatives to replace traditional fisheries and environmental and health problems are the main consequences of agricultural activities managed in the wrong way. Solar energy may resolve the problems of local population, specifically, providing the local demand for electricity and heat and new working places at the energy generating facilities (UNDP 2004).
The Republic’s geothermal resources have been explored as a result of oil and gas exploration and production. The hottest and most extensive geothermal reservoirs were found in the south and southwest of Kazakhstan. Biomass is potentially another area for the introduction on renewable sources of energy.

Hydropower potential in the country is significant. Kazakhstan has 7,000 rivers more than 10 km long, 155 rivers more than 100 km long and 7 rivers more than 1,000 km long. Over 12 per cent of the electricity is provided by the hydro power. Hydropower plants are primarily located on the Irtish River, which flows from China across the northeast Kazakhstan. With the water withdrawal by China and Russia energy supply from this hydropower source becomes a matter of not only effective work of the existing power generating system, but rather a political issue which is a subject to the international agreements (Tonkopiy, 2003).

With the growing electricity consumption and increasing export, the state needs improvements in the whole infrastructure, including transmission and distribution lines, which haven’t been renovated since the soviet times. Distribution losses are from 15 to 30 per cent by different estimates.

The wind energy potential is also very considerable. This is related to Kazakhstan's unique geographical location in the wind belt of the Northern Hemisphere. In the research carried out by "Kazselenergoproekt", the fifteen most promising sites for construction of large wind power stations have been identified. Experts note that besides these sites, the "intensity of wind potential in a number of locations in the country is as high as 10 megawatt per a square kilometer - such wind potential is unique". Most famous in this regard is the potential of Dzhungarian Gates and Shelek Corridor, located near the Chinese border (UNDP 2004).

In total, Kazakhstan's wind energy potential is estimated at 1.82 trillion kWh but currently 98% of its energy consumption is derived from coal, oil, and gas. By 2030 wind energy is expected to supply 500 MW, or about 12% of Kazakhstan's energy needs(UNDP, 2004).

Combined with a power sector transitioning to private holdings, the low price of electricity and a general lack of awareness towards renewable energies (with the exception of hydro), implementation of renewable energy sources is not an easy task.

The main deficiency of the current energy policy is the lack of appropriate regulation to introduce renewable sources of energy to the market. Some parts in the recently adopted Environmental Code, Law on Energy Savings and Law on Electric Power mention the use and development of renewable and non-conventional sources of energy. There are no separate documents that regulate policy in the renewable sector. Discussion under the headings of the Ministry of Environmental Protection is going on but taking into account that the Concept on Biofuels has already been approved and the Renewable Energy Concept is still under consideration and this is the main miscounting in the current policy framework for the biofuels development.

**4.1.3 Biofuels market development concept**

The Concept on Biofuels Market Development from 2007 to 2010 was initiated by the Ministry of Agriculture and approved in March 2007. In principle, the Concept aims at “the sustainable development of agriculture and increase of its effectiveness based on the promotion of biofuels industry” (2007). Three policy frameworks provided the main input into the elaboration of this Concept: agricultural, industrial and innovation, environmental. The objectives of the Concept are:
the expansion of the feedstock resources for the biofuels production in Kazakhstan;

- the development of the bio-industries within regional specialization;

- the elaboration of economic instruments and incentives for the production and use of biofuels;

- the integration into the global system of biofuels production and market

First of all, the Concept is an important document for the biofuels production development in Kazakhstan as it defines the policy framework and certain measures to overcome the barriers existing in the agricultural and other sector. Secondly, despite the fact that authorities are often blamed for bureaucracy and slowness in decision-making, the Concept was elaborated and approved relatively quick if we take into account that the discussion have started in 2006. Thirdly, the Concept is a good-starting point for the biofuels development and helpful for the stimulation of further discussions and policy debated in the area. The Concept has attracted the attention of stakeholders and made preliminary analysis on the current situation and preparedness of the country to implement biofuels projects.

Another important issue related to the biofuels development is that it is a bridge of several sectors of economy – energy, manufacturing, agricultural business, trade. Therefore, consistent and comprehensive policy is needed to avoid contradictions in different policies.

The analysis of the concept and its significance for the biofuels market development leads to several findings:

1) The concept is designed to promote the production of bioethanol from wheat and biodiesel from rapeseed oil. It does not include biogas in its scope due to the local specifics of biogas production. It does include biobutanol as the potential biofuel but does not consider neither technology specification or advantages and disadvantages over bioethanol and biodiesel. Second generation biofuels are mentioned in the concept from the perspective of ongoing research in the foreign countries but are not considered as the potential for the domestic production. Bio-products are also noted as the additional advantage of biofuels production, and the technology platforms are considered for the production of bio-products. However, the Concept does not include any recommendations and plans for bioproducts.

2) The concept has limited time framework till 2010. It does not say how the biofuels development may proceed after 2010. Short-term prospective defines urgent measures and problem-solving for the biofuels sector. Further development of biofuels in the country may be defined by other programmes adopted after the Concept but this is not mentioned in the document;

3) R&D as the main instrument to improve and upgrade biofuels technologies and production efficiency is not included into the measure section; in fact, the development of scientific potential is paid little attention in the Concept;

4) Coordination of stakeholders has not been studied in the concept. It is very important to define clear responsibilities for stakeholders involved to make
the Concept effective. Especially, in the field of domestic consumption it is crucial to encourage transport and fossil fuels sector to participate in the process of biofuels introduction in the domestic market to achieve preparedness of local transportation and infrastructure.

5) Estimates on the feedstock availability, production costs and export potential are not clearly explained. For example, feedstock availability is defined on average basis and does not take into account high yield fluctuations and annual changes of the market demand for wheat. It does not account for the possible increase of domestic consumption of the feedstocks. Competition of feedstock between biofuels and food use is mentioned but no methods for the sustainable co-existence of two industries are applied. Besides, production costs are calculated using Biohim, the only bioethanol plant in the country, data and Russian sources. No specific costs related to the biofuels production are taken into account though in strategic documents detailed estimates and calculations are avoided it is necessary to include these points and related measures to solve these issues. For example, production cost is defined at $0.21 per liter for bioethanol and $0.38 per liter of biodiesel from rapeseed oil. The Concept takes into account the tax problem that makes bioethanol production cost equal to $3.36 per liter which is not competitive neither with fossil fuels or bioethanol production in other countries. Regional specifics in the country, specifically, the difference in economic development that may further increase or decrease the production cost are not mentioned.

Another point to rise is the expansion of sown area to increase feedstock availability. It is unclear from the Concept what kind of lands are planned to be developed as additional lands for crops cultivation. From the agricultural profile of the country it is obvious that certain amount of lands are not cultivable either due to the unsuccessful techniques use in past that withdrew them from crop rotation or existing agricultural problems including irrigation and soil erosion.

6) Legislation procedures. In the Concept there is no reference to existing laws that may have input or may hinder further development. Strategic programmes such as Agricultural development, Industry and Innovation Programme and Sustainable Development are referred. However, there should be clear instruction on the elaboration and adoption of specific laws on renewable energy sources as well as the law on biofuels.

The estimations in the Concept show that Kazakhstan has the capacity to produce around 3 bln. liters of bioethanol and 270 thousand liters of biodiesel. It is planned that 6 biofuel production plants will be constructed. The obligatory use of biofuels in transport fuels is expected as blends at 5%. These are estimations of the Ministry of Agriculture. However, before implementation of these measures it is necessary to re-study the capacities and to see if the transport sector and fuel distribution sector are ready for these implementations. And, another study on feedstock availability and environmental impact assessment is needed for the construction of additional plants.

Overall analysis shows that the Concept is a kind of encouragement and promotion document that should motivate further studies and considerations. Action plan on the realization of this Concept which is now being discussed among the ministries should take it into account.
4.1.4 Draft law on biofuels

Draft law on biofuels was initiated at the end of 2006 in the Parliament of Kazakhstan. The Working Group on the discussion and editing this draft was created. At the moment the draft text is very rough and cannot be referred as the final document. However, some comments are still valid for further consideration.

First of all, the law is aimed at the regulations of activities in the biofuels industry sector. It’s been interesting to see the definitions given in the text. If we consider biofuels industry as the whole chain including production, transportation and distribution of fuels we should not limit it to only transportation fuels and give the specification for this type of fuel in the law. Therefore, biofuels can be not only additives to automotive fuels but also used in heat supply systems as well as electricity generation.

Further, the text includes encouragement of biofuels producers. It would be necessary to define the form of encouragement and to see what options may be applied: special tax exemptions, subsidies, other preferences.

The law also prescribes the certification of biofuels. This is another area of discussions. So far, certificates and labeling are not organized in the country. Environmental code defines that these forms of monitoring shall be applied but it has not been started. Certification schemes for biofuels production might be difficult in the absence of organized and competent administrative work done beforehand and established procedures for the certification.

The law will define the minimum percentage of biofuels added to the automotive fuels as well as overall percentage of the use of biofuels in the transport sector. As for now, the targets are to use 7% and 10 to 12% blends with bioethanol and 5, 30 and 100% blends with biodiesel. This should be very consistent with the approved Concept on Biofuels Market Development. In the concept there is a target to use blends at 5% for both types of biofuels. It is possible to use certain time framework establishing short-term and long-term targets. Time framework is also important if it is related to the tax exemptions or subsidies.

The law on biofuels is crucial for the development of biofuels sector. Its main tasks should include:

- clear definitions of biofuels;
- regulation of the feedstock extraction and supply;
- tax regulations (some consider it the major input because current regulations defines very high excise-duities on alcohol production that makes bioethanol production costs uncompetitive) (Sutyaginskiy, pers.comm., 2007);
- standardization, certification, classification and codification (the biofuels should be classified according to the national standards as well as in conformity with the international if the products are to be provided for export, certificates are needed to monitor and control the quality, classification should be done in order to make clear distinguishing between different types of alcohol – this issue is connected with excises regulations as well);

As the draft law is still under development and far from being approved as the final version of the law, it would be useful to involve all stakeholders, including agricultural business and NGOs. Environmental institutions should also give their feedback on the draft law.
4.2 The main actors in the biofuels area: involvement and participation

Currently, participation and involvement of all stakeholders leave much to be desired. Ministry of Agriculture has initiated the development of the strategic vision on biofuels sector. The Working group created to comment on the text of the Concept has been sending their comments and notes. However, the interest was low and comments were made on the routine basis. For example, comments received from KazMunaiGaz have not reflected the position of the company on this issue. Comments just outlined some deficiencies of the Concept such as transport routes for the distribution and export of biofuels, dependence of biofuels competitiveness on world oil prices market, and so on.

The role of national companies is not clear. For example, the tasks for the Sustainable Fund Kazyna which is now working on the research and marketing strategy of biofuels are not defined. KazAgro, national holding, is not mentioned as well. After the study of different comments and opinions I have concluded that the Concept has not fully addressed and incorporated all of them.

Another sort of participants of particular importance is research institutions, experts and specialists. Biofuels are the dynamic and changing sector not only from the economic perspective but also from the scientific and research angle. In Europe and US there are a lot of research efforts towards new technologies and production processes that will increase the efficiency and productivity of biofuels production. Other countries producing biofuels also invest into the R&D activities. For Kazakhstan it would be necessary to think about scientific base for the biofuels and, generally, bioenergy development. For instance, National Biotechnology Center does not have specific department dealing with biofuels. It is a department on fermentation; however, its connection to the biofuels sector has not been defined. No other research organization is involved into R&D on biofuels. Center on Marketing and Analytic Research under the Sustainable Fund Kazyna has started the preparation of so-called master-plan on biofuels development which has been stopped due to the lack of financing and now the project is carried by the Department of Innovation Project within the Fund. This project is aimed mainly at the study of domestic capacities to provide export markets for biofuels.

As I mentioned several times in the previous parts the strong coordination between different stakeholders is needed because biofuels industry is placed at the interfaces between agriculture, energy, petrochemistry, transport sectors. Therefore, the stakeholders may be divided into several groups by the level of participation:

The first group is government institutions involved into implementation of national biofuels programmes: Ministry of Agriculture, Ministry of Energy and Mineral Resources, Ministry of Environmental Protection, Ministry of Industry and Trade, Local authorities, Ministry of Transport and Communications, Ministry of Finance. These bodies share responsibilities according to their area of competence. Ministry of Agriculture as the initiator of biofuels programme should take the leading coordinating role and facilitate the process of information exchange and joint policy elaboration.

The second group is national companies that will participate in the process of decision-making by the expressing their opinions and information exchange. But the most important responsibility is to propose and implement projects on biofuels production and distribution in the sustainable way for the advantage of all affected parties. This group includes KazMunaiGaz, national oil and gas company, National Holding KazAgro, Sustainable Fund...
Kazyna, KEGOC, electricity generation and distribution network company, and other companies interested in the biofuels projects.

The third group is private business, foreign and domestic that will be responsible for the implementation of individual projects. This role of this group is significant. One of the main objectives of the Concept is to improve rural development and to boost agricultural business. Thus, agricultural small and medium enterprises are the main facilitators of the process of local businesses development.

The fourth group is public, including non-governmental organizations, associations and unions that also will contribute to the decision-making process, and participate in the projects. The main responsibility of this group is unbiased monitoring and feedback to the authorities on the biofuels industry performance.

The fifth group is academic and research organizations that are responsible for technologies studies, know-how and R&D activities. This group may also include individual national and international experts.

The biofuels sector is being started now; therefore, it is especially significant to catch up with the trends and latest development in the area. There is no need to invent a bike – that is an approach that should be taken for the first generation biofuels development, but the long-term strategy would include new technologies for the second generation biofuels. And this strategy may expand the existing groups of participant to include petrochemistry industry, waste management facilities and other sectors. The Figure 4-2 shows the possible scheme of participation of different sectors in the biofuels development. On the left side sectors that should be represented from the very beginning of biofuels concept implementation are introduced. On the right side the sectors that should join the process of biofuels development when the second generation technologies and biogas production will take place.
Figure 4-2 The structure of stakeholders in biofuels development in Kazakhstan

- Energy sector
- Agricultural sector
- Environmental organizations
- Business
- Research
- Public
- Biofuels in Kazakhstan
  - Petrochemistry
  - Waste management
  - Manufacturing
  - Machinery
5 Biofuels Production: Case Studies and Export Potential vs. Domestic Consumption

5.1 Bioethanol project: Biohim plant on the advanced grain processing

In September 2006 Biohim Company has completed the construction of the first bioethanol production plant in Kazakhstan. This is the first plant not only on the territory of Kazakhstan but also in the Commonwealth of Independent States. The plant is located in Taiynsha town in the North-Kazakhstan region about 150 km from Petropavlovsk, regional center.

The construction was initiated by the company and financed through the loan of 60 million dollars US of the Bank of Development of Kazakhstan, national development institute within the structure of Sustainable Fund Kazyna. Total investments into the construction of the plant are around 90 million dollars US. The main objective of the plant is to provide integrated processing of grain into bioethanol with the production of by-products. Total amount of production is planned to be 63.1 million USD per year, 57% of them is profit gained from bioethanol selling. Profitability of the project in total will be 25 %, and all expenses on the project will be paid through seven years.

New complex will begin development of advanced technology sector in Kazakhstan for traditional agricultural products processing into new products.

Figure 5-1 Biohim plant layout
This industrial complex includes elevator, two mills, and gluten separation equipment section, bioethanol production section that consists of fermentation, distillation and storage facilities. All equipment is delivered from abroad: Germany, Austria, England, Switzerland, and Russia. The layout presented in the Figure 5-1 is now being used for the planning of other bioethanol production facilities.

The production capacity is 220 thousand liters of bioethanol per day. The company provides wheat feedstock from its own fields of 220 thousand hectares. The technology of wheat conversion into bioethanol is typical: preparation of the feedstock and its conversion into starch milk, saccharification and fermentation, distillation and dehydration. Bioethanol fermentation facility is equipped by the Austria-Frings GmbH.

### Table 5-1 Biohim plant production structure

<table>
<thead>
<tr>
<th>Feedstock volume</th>
<th>220 000 tons of grain per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production, tons/year</td>
<td></td>
</tr>
<tr>
<td>Bioethanol</td>
<td>57 000</td>
</tr>
<tr>
<td>Flour</td>
<td>58 000</td>
</tr>
<tr>
<td>Gluten</td>
<td>19 200</td>
</tr>
<tr>
<td>Fodder yeast</td>
<td>24 000</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>25 600</td>
</tr>
<tr>
<td>Bran</td>
<td>64 000</td>
</tr>
</tbody>
</table>

Source: Sutyaginskiy pers.comm.

The plant is very interesting from the perspective of rural development. If we look at the town where the plant was constructed we can see that the town had no infrastructure for the business development, and it was one of the many small towns located in the rural areas of Kazakhstan where employment is low, and people are leaving for the bigger cities to get jobs and provide stable incomes. Now the plant hires about 300 of personnel. Road infrastructure is planned to be improved, social programmes will be implemented.

The plant has elaborated its own standard for the bioethanol “Fuel denaturized ethanol” for internal use. The standard was elaborated using ASTM – standard specification for denaturized fuel ethanol for blending with gasoline for use as automotive spark-ignition engine fuel. This standard defines the concentration at 99.5% and can be blended with gasoline up to 30%. It is interesting to mention that Biohim is now negotiating with the tax authorities on the elaboration of national standard. Excise duty on alcohol products at present is about 3 dollars US per liter. There should be clear distinguishing between technical and drinkable alcohol to apply lower excise duties to the technical ethanol (Sutyaginskiy pers.comm.).

The plant construction was fully supported on the regional level. Cheap electricity is provided from the electricity company by lower prices, railway road is built to connect the plant with the main railway communications to make transportation less problematic for the plant’s
products. It will be 76 tanks for bioethanol transportation in total. The administration is also planning to introduce waste water biological treatment facility as well as biogas production from grains and manure. There are plans to supplement the production complex with poultry farm and pig farm. To utilize carbon oxide the plant will also be provided with the plant house for flowers growing.

There are plenty of ideas to implement using the capacities of this plant. For example, the mayor of the region suggested implementing pilot project on bioethanol blends up to 85% in the public transport. Another idea is to build wind mills to provide the plant with the renewable energy sources in addition to biogas production or to add produced bioethanol into mazut and to make cleaner energy supply of the plant. There are plans to start testing of local fuels blending with bioethanol produced on the plant by the German company BASF.

The plant is also planning to introduce ISO 9001 but this is an issue of experience and expertise because so far the plant suffers the lack of trained and educated personnel to run the operations. It has conducted trainings in Almaty and Austria for 25 people and now these people educate other operators.

The issue of training and proper education is an important factor that plant representatives raised during our discussion. It can be a serious barrier in the successful implementation of biofuels projects. Therefore, specific arrangements should be negotiated together with the Ministry of Science and Education to think about training programs and workshops for the workers of biofuels production plants.

The administration of the plant is very interested in different options bioethanol production may bring but, the most important factor, the plant has outrun the regulations in the area, so the production cannot be started with its full capacity until the relevant law will be adopted although plant was very successful in getting the license for the production of bioethanol in the end of March.

So, the short summary of the main findings of the site visit to the plant based on the discussions with the administration, technologists and international experts may be introduced as follows:

1) The main advantages of the plant are obvious: agricultural diversification; rural development and social indicators improvements (employment, higher living standards, revenues from all sectors related to the plant operation, etc.); better infrastructure and communication; innovative and environmentally technologies introduction; investments attractions into the region; illustration of what biofuels production is

2) The plant has also long-term vision: to make the production cycle close-loop and waste-free (wheat-bioethanol-CO2 capture-beverages production-grains conversion into fodder yeast or use in biogas installations-livestock production-manure utilization for the biogas production-biological waste water treatment-wind mills); as owners of the plant are also the wheat cultivation land owners they are extremely interested in the yield increase techniques and improvements of agricultural practices and preservation of this land; the plant administration is also aware of second generation biofuels and ready to further study these options and to make add-ons to the plant complex if feasible;
3) Biohim has initiated negotiations on the elaboration of regulations for the biofuels production and has provided significant input during discussions on the Concept on Biofuels Market Development; standards that plant has set up for the internal use are now under consideration in the Tax Committee to use it as the reference for the introduction of new standards that will allow to decrease excise-duty on bioethanol production and distribution;

4) There are difficulties at present for the bioethanol production: the lack of legal regulations and taxation procedures; the lack of trained stuff; export routes are not settled (transportation through Russia is very expensive due to the high deposit rates for the transit, uncertainty with the acceptance of biofuels in EU, no existing routes to Japan, China is setting up protective measures for the domestic biofuels imposing high tariffs on foreign products; lack of access to the main sea ports, etc.);

5) There are difficulties related to the plant’s operation: construction of the elevator was improper and decreasing the efficiency of wheat feeding from the elevator to the mills; grain storage is problematic due to the elevator’s problems; gluten separation has been stopped (it is crucial to have proper gluten separation in place to get rid off the gluten so the starch left may be proceeded to the bioethanol production facility, high gluten content may damage water supply system as well as destroy yeasts in the fermentation facility); waste water treatment facility construction has not been started yet; quality control is deficient as no competent personnel for the control and monitoring of final products quality (this deficiency may cause problems as internationally accepted high requirements to the suppliers will not allow low quality products to get to the market).

6) It is a double-edged weapon to build a plant in the absence of regulations and infrastructure. On the one hand, the plant can boost the development and to speed the process up; on the other hand, it may fail to negotiate with the authorities and lose the business – high risks are involved in any case. In this case, Biohim was lucky to get governmental support from the very beginning through the loan of Kazakhstan Bank of Development.

So far, Biohim plant being pioneer is the main illustration of biofuels production in the country. Lessons learned from the construction and operation of the plant should be taken into account during the implementation of other similar projects.

5.2 Ecomuseum’s pilot project on biogas installations in Central Kazakhstan

Though the analysis on biogas\(^1\) production potential has not been included into the scope of the thesis it would be interesting to know the experience of the country in this field to better understand the reasons the sector has not been promoted so far.

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\(^1\) **Biogas** typically refers to a (biofuel) gas produced by the anaerobic digestion or fermentation of organic matter including manure, sewage sludge, municipal solid waste, biodegradable waste or any other biodegradable feedstock, under anaerobic conditions. Biogas is comprised primarily of methane and carbon dioxide (Wikipedia).
Biogas project was initiated by the non-governmental organization Ecomuseum based in Karaganda, Central Kazakhstan, in 2000 for the period of four years. The project has been implemented with the participation of INFORSE-Europe and Bioenergy Department of The University of Southern Denmark, and Renewable Energy Agency located in the Ukraine.

Initially, the project was aimed at the reduction of water pollution of Nura river that is the part of the large river system Irtysh-Ob. The pollution caused by the decay of dung from livestock production is not only harmful for human health and water system but also a significant source of methane emission contributing to the climate change problem. Besides, project has advantage of using renewable energy source such as biogas for the heating purposes.

The project has been financed through the Small Grants Programme of GEF, UNDP and HIVOS funding.

The population affected by the project is around 1 million people. The situation at the moment of project starting was critical. People did not have enough money for gasoline to take the dung out of the river banks and stacked it directly on the banks and into the river. Sanitary conditions were far away from safe for the human health (Kalmykova pers.comm.).

Therefore, the project is of high need for the local population taking into account that livestock production is the main source of income for inhabitants. 5 pilot biogas methane tanks were installed in the region. The tanks are easy in installation and operation. An interesting note that methane tank and digesters existed in the Soviet period, however, the use of these tanks was limited and actively promoted only in Kyrgyzstan. Kazakhstan has no experience in biogas production technologies (Kalmykova pers.comm.).

So, the main results of the project may be summarized as follows:

- the technologies of biogas production were studied and adapted to the local conditions which is valuable experience for further development;

- methane tanks may be installed in any farm, however, the cost for the production of biogas varies depending on the size of the farm.

- Biogas installation needs the permanent access to water supply that is a main barrier for small remote areas;

- Biogas projects have not attracted governmental support – this is the main success factor because due to the high cost of production it is really difficult to promote biogas production without state support;

- The main problem associated with the biogas projects is to train people to maintain the installation and to provide permanent feedstock that is why biogas projects are better implemented in medium and large-size farms or unions of several farms;

- Biogas projects are especially important for the remote areas in Kazakhstan that are not connected to the national electric grids. Electricity and heat supply shortages in these areas may be overcome
by the biogas production; besides, by-product of biogas production is fertilizers that can be used for plant cultivation; in previous parts it was mentioned that due to the high prices for fertilizers farmers do not use them losing therefore valuable soils and destroying arable lands – this problem can be perfectly addressed by the biogas production facilities;

- Another important factor for the successful implementation of biogas projects is the high capital investments into the projects that is a barrier;

- According to Nekrasov (2007) biogas projects are profitable mainly due to the environmental benefits, production of fertilizers, by-products vitamin B12 and protein additives; biogas production itself contribute only 10% of the overall effect of the project;

Biogas production was not studied well during the previous years in Kazakhstan, and this is the main reason of quite reluctant attitude both from government and public. The lack of information and awareness does not allow to see the advantages of biogas production on the territory of the republic as well as to manage the difficulties hindering the development in this area.

First of all, taking into account the huge livestock production potential in the country it can be estimated that this is a stable source of biogas feedstock – waste from agriculture (see Table 5-2).

Table 5-2 Animal dung production

<table>
<thead>
<tr>
<th>Animal breeding</th>
<th>Livestock population, 1000 heads</th>
<th>Manure production per head per year, cub.m.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>54 574</td>
<td>135-540</td>
</tr>
<tr>
<td>Sheep and goats</td>
<td>14335</td>
<td>22-45</td>
</tr>
<tr>
<td>Pigs</td>
<td>1282</td>
<td>5-159</td>
</tr>
<tr>
<td>Horses</td>
<td>1164</td>
<td>315-495</td>
</tr>
<tr>
<td>Camels</td>
<td>131</td>
<td>-</td>
</tr>
<tr>
<td>Poultry</td>
<td>26 200</td>
<td>1-1,5</td>
</tr>
</tbody>
</table>

Source: Ecomuseum, 2003

Secondly, waste management system may provide organic waste from households and food industry. Nowadays Kazakhstan as other post-Soviet countries of Central Asia is facing great problems of waste treatment and disposal. The waste management system is not developed and lacking an appropriate standards of monitoring and treatment technologies.

Currently in Kazakhstan almost 97% of municipal waste is landfilled. The average waste generation per capita in the country is around 300 kg. There is no modern equipment or facility for waste collection, recycling or incineration. There are official landfills for municipal wastes in all oblast and regional capitals. Very few of them meet international sanitary and hygiene conditions, norms and standards (e.g. monitoring systems for groundwater, air and
soil in the vicinity of the landfills; protective layers; waste pretreatment and separation; possible methane recovery facilities; collection and treatment of leachate). There are also unauthorized or illegal landfills inside and outside. For example in Almaty, organic waste content in the municipal waste generated is around 75-80% out of total waste (UNECE, 2000).

So, one of the potential solutions might be biogas production. The use of biogas is of great variety. But the most important from the local prospective is the use in combined heat and power plant as a mean to switch from coal-based power plants to the renewable energy based plants.

With the ratification of Kyoto Protocol the feasibility of biogas projects will be increased and technology transfer will take place because it is obvious that to manage biogas projects the combination of knowledge, technologies and large investments is needed (Kalmykova pers.comm., Nekrasov pers.comm.).

5.3 Export markets versus domestic consumption

One of the most important issues for the biofuels sector today is the availability of markets. For Kazakhstan it is even more significant due to the country’s geopolitical position. First of all, remote distances to the sea ports and high costs for railway and vehicle cargo transportation take the largest share of the final product cost. Secondly, being located between Russia and China the country has to deliver competitive products otherwise the biofuels produced either in Russia or in China will replace them, especially, taking into account the economy of scale it is expected that products from China would be available by cheaper prices as it is occurring now with other manufacturing goods. That is why export and domestic consumption potentials should be studied carefully to define the main market for local biofuels.

Domestic consumption is an attractive option for two main reasons:

1) Strategic reason. First generation biofuels promoted currently in Kazakhstan cannot be the long-term option because technologies of the second generation will replace them according to different estimates in 5-10 years. Domestic consumption will not require the installation of high capacities. Estimations show that around 430 thousand tons of wheat will be required to produce bioethanol for the domestic consumtion. Therefore as a short-term option and smooth switch to more efficient technologies bioethanol from wheat can be produced and consumed domestically without burden to the land use based on existing capacities. Besides, there is no need to build new bioethanol plants as this will require large investments and impose high risks. Biohim plant is producing 57 thousand tons of bioethanol per year is able to provide northern regions with bio-additive to the gasoline. Existing alcohol plants are not operating on their full capacity. It is possible to use their capacity to produce bioethanol. So, no environmental burden to land and competition with food, less air emissions from transport sector, value-added agricultural production, additional incomes can be listed as the major advantages of this approach.
Table 5-3 Estimations of bioethanol production amounts for the domestic consumption

<table>
<thead>
<tr>
<th>Average gasoline consumption, ton per year</th>
<th>5% of bioethanol additive, ton per year</th>
<th>Average yield of ethanol from wheat, liter per ton</th>
<th>Wheat feedstock demand, ton per year</th>
<th>Low quality wheat available, ton per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,300,000</td>
<td>115,000</td>
<td>350</td>
<td>430,000</td>
<td>1,000,000</td>
</tr>
</tbody>
</table>

Source: Ministry of Agriculture; Tassekeyev pers.comm.

2) Environmental reason. It was mentioned previously that domestic consumption will not impose much burden on land use as it does not require the developing of new lands or increase of use of existing ones. Another environmental advantage is environmental performance of the country. First of all, it has been estimated that over 1 mln. tons of emissions released into the atmosphere from transport sector including carbon oxide, nitrogen oxides, sulphur dioxide, benzaperene, other harmful substances (UNEP/GRID-Arendal, 2000). Greenhouse gases emissions are another major concern for the transport sector, especially in big cities and industrial center such as Almaty, Ust-Kamenogorsk, Aqttau, Karaganda, Atyrau, etc. Transport is responsible for about 20-25% of CO2 emissions and this number is constantly growing. Transport is not the only problem in terms of air pollution problems. The biggest emitter, so far, is heat and electricity generation sector. In previous parts the discussion on energy related problems was introduced. Therefore, it is obvious that significant measures have to be undertaken to overcome environmental problems caused by the use of conventional sources of energy.

In addition, domestic consumption of biofuels is necessary for the country from the informative point of view. Biofuels introduction into the domestic market will allow increase in public awareness, stimulation of research activities and new opportunities for small- and medium-size enterprises.

Export opportunities have already been placed into the focus of the Concept on Biofuels Market Development though it is arguable whether this priority is advisable. There are advantages of export orientation for the whole agricultural sector on large scale:

- large governmental and foreign investment can be attracted into the projects;
- diversified market
- decrease of dependence on oil and gas export;
- technology transfer from industrialized countries
- overall image of the country.

Export of biofuels is not a solution for the rural and environmental problems the country faces. It seems just another form of extraction of raw materials which is not a solution at all. For example, it is the world market available for bioethanol from wheat, especially, if the country manages to produce bioethanol at $0.21 per liter it will be even competitive to the sugar cane bioethanol from Brazil (Ministry of Agriculture, 2006). With proper marketing and good transportation strategy it is possible to become one of the exporters of bioethanol until second generation biofuels come to the market. But with biodiesel the situation is different. The cost will not decrease till the cost of biodiesel from palm oil. Secondly, feedstock
availability is questionable because the current situation is not in favour of biodiesel production as oilseed crops are needed to meet the increased food market demand. Furthermore, biodiesel produced in the country will not find market outside. In EU, specifically, in Germany rapeseed oil biodiesel plants have huge capacities but deficient feedstock availability. Therefore, it is expected that these countries would rather buy raw rapeseed oil than biodiesel to load their capacities (Zimmerman pers.comm.). Another issue is food industry. Export potential of biofuels from energy crops may become negligible due to the increasing demand on both domestic and international food market.

The policy-makers are considering European Union, China and Japan as the main export markets. So far, China and Japan do not seem to be feasible due to the high transportation costs and undeveloped export routes. In addition, China is imposing high tariffs on foreign products to protect own producers (Sutyaginskiy, pers.comm).

European Union has very stringent requirements and standards for biofuels. Besides, supply chain control is another major concern for European market. Products are required to be produced in sustainable way without harm to human health and environment. Though Kazakhstan has never been claimed as the producer of low quality wheat or flour, for example, there is no efficient control and monitoring system that would show foreign customers the whole production chain. Therefore, to supply European markets with biofuels it is necessary to adapt standards compatible with those in Europe and to establish strong and effective supply chain management system. Besides, EU demonstrates significant success in the second generation biofuels research. According to the most optimistic predictions second generation technologies will allow EU use its own biomass potential without importing it from abroad. The only possible import will be from Ukraine which seems to possess the highest biomass potential among European countries, around 2, 9 EJ out of total 19 EJ (Faaji, 2007).

Biofuels export has definitely to be analyzed carefully. It is possible to export biofuels if not in large amounts and as the combination with domestic consumption. Export potential can be considered important from the economic point of view but from the social and environmental perspective export of biofuels has little input into these areas.
6 Recommendations and conclusions

6.1 Lessons and recommendations

Biofuels production and use in Kazakhstan is considered to be the good opportunity to achieve sustainable development in many sectors of the economy.

The main advantages of the sector are:

- economic diversification and agricultural diversification;
- regional development balance;
- value-added to the agricultural production;
- efficient land management;
- use of renewable sources of energy;
- social benefits and additional sources of income in rural areas;
- decrease of air pollution and greenhouse gases emissions from energy and transport sector;
- bioenergy research boosting;
- innovative solutions

There are certain barriers to surmount:

- short-term vision till 2010; first generation biofuels are in the focus;
- uncertainty, scientific, technologic and economic;
- no regulations and taxation scheme exist;
- feedstock availability is questionable (wheat is under high risk of competition with food industry and export to the international market; rapeseed oil is not of enough quantity at present);
- stakeholders not interested and not involved;
- biogas option is totally excluded though high potential is in place;
- infrastructure problems; transportation of feedstock and delivery of final goods are problematic as well as distribution of biofuels;
- domestic consumption is paid little attention that decrease social and environmental benefit for the population;

To sum up all the findings of this research these lessons and recommendations seem to be introduced as the most important:

Lesson 1. Be careful!
That what I have learned form the very beginning of the research and what has accompanied me through the following period. It is crucial to understand the local conditions and to see the reality from an unbiased prospective. Data and information are good proves of the conclusions but the more important to understand how the process is taking place in reality. Thus, judging not only by data which is not always correct and consistent or available but also by human factor was the first lesson.

This lesson helped me to understand that biofuels development in Kazakhstan can be either constructive or destructive depends on the approach people are guided by. Constructive in terms of overall advantages for the economy, especially, for the agriculture. And destructive, if designed and managed improperly. The snares for the biofuels sector to be designed and managed in the unsystematic and poor-founded way are:

- lack of knowledge (there is no clear understanding what biofuels are and what is the use of biofuels; furthermore, the knowledge is very superficial);
- false motivation (over-excitement versus under-excitement, no golden mean; some people think biofuels sector development is the only answer to the existing problems in the agricultural sector, some think there is no any measure to overcome these problems and prefer “do-nothing” scenario);
- lack of involvement (stakeholders should participate on the equal and valuable basis; strong coordination and information exchange is needed because if it is only agricultural sector interested in biofuels projects there is no chance to find market and provide infrastructure for the product – demand-supply relationship, supply chain management

Recommendation:
Knowledge provides comprehensive vision therefore it is important to be educated and trained to handle this kind of projects. Special attention should be given to the preparation of specialists and professionals in the field. The Ministry of Science and Education together with the Ministry of Agriculture may elaborate the joint educational programme aimed at the formation of scientific and technologic community. In Kazakhstan there no institution or any other educational organizations to train specialists for the biofuels or bioenergy sector. So, on the first stage cooperation with international educational programmes may be achieved as well as consultations from international experts in the field.

The strategy on the biofuels development in the country should include certain steps how to make this sector accessible and awaking interest of all stakeholders. It is possible if information is delivered in comprehensible way and clear messages individual for every stakeholder are available. In addition, public should be more aware of the development and have the opportunity to express its opinion.

Lesson 2. Policy is crucial!
The significance of the policy is hard to overestimate. It is an interesting situation in the agricultural sector. On the one hand, there is the strategy to increase export of wheat and flour to take leading positions on the world market. On the other hand, wheat is the feedstock for the biofuels which are also planned for the export in large quantities – 3, 2 bln. liters. In both cases Kazakhstan is planning to rank among five biggest exporters. This is the point when it is useful to think if the policies should be more realistic and noncontradictory to each other. If these plans are still valid in both cases then the capacity to fulfill these targets should be
studied more detailed because there is a high risk to lose positions in the existing export market and to get to the planned quota on the new export market.

**Recommendation:**

The strategy on biofuels development in Kazakhstan is represented by the Concept on Biofuels Market Development. There are policies needed to supplement the Concept. The first need is the Policy on Renewable Energy Sources. The second need is the tax policy for the renewables. Knowledge and information should be improved and upgraded constantly otherwise there is no possibility to catch up with the most recent and relevant trends on the international biofuels market. It is also necessary to build up supply chain management. As it was introduced as an example on the Biomass Conference in Berlin in May 2007 in Australia prior to the construction of bioenergy plant there was a need for 17 contracts to be signed and several rounds of negotiations. Therefore, the whole supply chain should be designed and thought through.

Policy framework may include all the elements considered in the Figure 6-1.

![Figure 6-1 Proposed policy framework for the development of biofuels production in Kazakhstan](image)

**Lesson 3. Mentality is important!**

Mentality is very important factor when implementing new projects in Kazakhstan. People are not used to accept innovations easily. It is always difficult to explain all advantages and disadvantages of the project because usually disadvantages are perceived as the barriers that cannot be surmounted and advantages are perceived as very small in comparison to existing situation. This is not always a case but it should be taken into account. Environmental benefits are of less importance for people who are struggling with social difficulties, therefore, it is important to highlight key social benefits in some regions of the country where people still have no access to clean water and affordable energy and employment level is low.

However, in recent year economic situation is getting better so social problems are becoming less severe. Mentality is also changing as more and more people get access to modern benefits and comforts, especially, to the information and communication. That is why it is even more important to provide full and objective information.
Biomass energy exists in many regions of Kazakhstan that causes a lot of environmental and legal problems because it leads to the indoor pollution and illegal logging. This kind of conventional use of biomass may be converted into more sustainable and profitable forms of energy supply. It just needs to be well-grounded for the local people so they can understand why they cannot cut trees and cannot burn them in their houses to provide heat and cooking energy which are essential needs.

Recommendation:
Policy should be inclusive. In other words, there must be specific individual approaches to the rural societies existing in great variances on the territory of Kazakhstan.

Policy should be accepted. Domestic consumption is totally impossible if local population does not understand why they should use bioethanol or biodiesel if they have driven vehicles on gasoline for years. Besides, in most rural areas the machinery and vehicles are of very old modifications, so there might be a problem to switch to biofuels even with low blends. People might get afraid of their engines to be destroyed by new unknown fuels.

Lesson 4. Environment is important!
It has been emphasized many times in the documents related to the biofuels development that the sector is very important for the agricultural sector and for the economic diversification. Mainly this highlighting is due to the export orientation of final products.

However, environmental concerns in the agricultural and rural areas should be prioritized as well. It should be taken into account that disputes around first and second generation biofuels are not in favor of the first. There are many reasons for that. Part of these reasons is of economic character. But the larger part is of environmental character. Environmental concerns around first generation biofuels are:

- energy balance (fossil fuels needed to produce first generation of bioethanol and biodiesel);
- biodiversity loss;
- land use expansion;
- fertilizers use increase and underground water pollution;

Recommendation:
Increase in productivity and soil fertility should be done in sustainable way. The main measure is to take lands out from the rotation (land set-aside approach). In order to avoid degradation and loss of fertile lands it is necessary to take out from the agricultural use many millions of hectares and to plant them with perennial grasses using them as meadows. This will allow preserving valuable agricultural lands for the future generations, to protect them from the destructive impact of erosion and machinery, to rapidly restore their fertility.

This approach can also contribute to the preparation of the country to the adoption of second generation biofuels after the first generation. Overall process should be accompanied by the introduction of ISO 14001 and all biofuels project should conduct environmental impact assessment to avoid negative consequences.
Another measure is to introduce effective certification scheme that will allow to control and monitor the whole supply chain.

Ongoing research should be developed within relevant organizations. National Biotechnology Center can also create the separate department to deal with scientific uncertainty and to participate in the global research efforts on the biofuels production efficiency increase.

### 6.2 Conclusions

The thesis has studied the potential development of biofuels industry in Kazakhstan. It was shown that geographically, climatically and by natural resources the country possesses huge potential for the development of literally any industry. Biofuels are in especial position because this sector has gained the governmental support and business initiative. Therefore, it is my strong belief that this bottom-up approach will be effective in the implementation of projects that should bring advantages to the society and profits to the national economy.

However, realistic and pragmatic treatment should be preferred over excessive excitement. Clear and feasible targets as well as well-grounded motivation can help to avoid mistakes and shortcomings.

If biofuels are to be developed in Kazakhstan the main decision for the policy makers lies in the area of market potential. It is important to define whether biofuels products will be introduced into the domestic market or exported to the international market. From the sustainable development perspective it is seen that domestic consumption is considered to be more preferable. Exporting biofuels to the international market seems to be attractive from the economic point of view because it will attract large companies investment and foreign investments inflows. However, exporting biofuels will have little effect on the communities that are involved into the production process.

And another observation that might be valuable from the long-term perspective is related to the likely future of biofuels development after 2010. First generation biofuels is the present but the second generation biofuels is the future. It is crucial to to create the necessary prerequisites for the introduction of second generation biofuels and to prevent from being stuck with first generation production of biofuels. Therefore, it is necessary to analyze the exact amount of biofuels production plants needed before second generation technologies and equipment enter the market.

Biofuels development is not a silver bullet to solve all the problems in the agricultural and energy sectors in Kazakhstan. It is one of the way to address the certain problems that were introduced in the thesis. It should be applied in the combination with other measures. If we see the reality of the country as the picture consisting of a number of puzzles and not assembled yet biofuels sector may be just one puzzle that may connect several others – energy, agriculture, environment.

Biofuels development as the concept can be a solution in the conditions of Kazakhstan in combination with other projects aimed at sustainable development, I assume. There are undoubted advantages of biofuels development in the country. The barriers might be overcome. There is no need to invent a bike. Many countries have developed this industry and their experience must be studied carefully to avoid mistakes and to follow successful examples applicable to the local conditions. There is a proverb saying “Fool is not learnt by mistakes, clever is learnt by his own mistakes and wise is learnt by others’ mistakes”. So, let us be wise!
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Abbreviations

ASTM – American Society for Testing and Materials
CHP – combined heat and power
IEA – International Energy Agency
ETBE – ethyl tertiary butyl ether
EU – European Union
FDI – foreign direct investment
GDP – gross domestic product
GEF – Global Environmental Facility
GHG – greenhouse gas
GW – gigawatts
KEGOC - Kazakhstan Electricity Grid Operating Company
kWh – kilowatt hour
MTBE - methyl tertiary butyl ether
Mtoe – million tonnes of oil equivalent
MW – megawatts
NGO – non-governmental organisation
OECD – Organisation for Economic Cooperation and Development
R&D – Research and Development
RES – renewable energy sources
RK – Republic of Kazakhstan
RME - rapeseed methyl ether
SWOT - Strengths, Weaknesses, Opportunities and Threats
TPES – total primary energy supply
TWh – terawatt hour
UNDP – United Nations Development Programme
USD – United States dollar
Appendix 1 Kazakhstan: average rainfall, evaporation and temperature


Appendix 2 Sample interview questions

- public officials (The Ministry of Agriculture, Sustainable Fund “Kazyna”, etc.)

1) Why biofuels? How did the idea of biofuels development appear in Kazakhstan?

2) The current situation and policy markers: how would you describe the trends and developments in biofuels sector?

3) What is the biofuels strategy and who are participating parties?

4) Agricultural sector and it’s role in the development of biofuels production

5) Soci-economic and environmental factors of biofuels development: pros and cons

6) What is the role of government in biofuels promotion?

7) How do you involve other participants?

8) Financing and investments from national and regional budgets, existing subsidies in the agricultural sector

9) Improvements in need and R&D activities

- project implementators (Ecomuseum, Biohim plant, etc.)

1) The history of the project and main initiators and supporters

2) Advantages and disadvantages of the project: what are socio-economic and environmental impacts

3) Project implementation: who participated, how and was there governmental support?

4) Feedstock availability and technology of production: what are the main lessons?

5) Main specifics of the project and improvements for future

6) Personnel issue: do we have competent stuff to work on such projects

7) What are the main barriers? How do you solve problems?

8) Consumers and markets issue

- researchers (Tassekeyev, Nekrasov and others)

1) How did you participate in biofuels related research?

2) What is the scientific potential of the country to develop biofuels sector?

3) Is there any experience exchange with international experts?
4) Are there any studies, research papers, etc. in this area?

5) Biofuels concept: your opinion and recommendations

6) Do you agree with biethanol and biodiesel being in the focus of the concept?

7) What are the barriers for biofuels sector? What do you think about future development? Is there any potential for the second generation biofuels?

8) What do you think about biogas option for Kazakhstan? Does it have potential to be developed? What are barriers?

9) What are environmental concerns and considerations? Can they be overcome?