P a r t 8

RENEWABLE ENERGY SOURCES

8.6. Analytics

8.6.2. Green Energy of Kazakhstan in the 21st Century: Myths, Realities and Prospects

O.B. Antonov, Aikona Media LLP, Almaty, Kazakhstan

1. INTRODUCTION

Renewable energy resources are natural energy carriers, constantly renewed by natural processes.

Renewable energy resources are based on the use of:

- energy sources: solar radiation, energy of wind, rivers, seas and oceans, the internal heat of the earth, water, air;
- energy of the natural movement of air, water flows and the naturally occurring temperature gradients and the density difference;
- energy of biomass produced as garden wastes and animal residues, man-made forests and algae;
- energy from industrial wastes, municipal solid wastes and sewage sludges;
- energy from burning plant biomass, thermal processing of wastes of timber and woodworking industry.

Type of renewable energy is a renewable source of energy, the name of which reflects its appearance (solar, geothermal, hydro, etc.) or natural phenomena (wind, wave, tidal, etc.), or the type of energy (biomass, "mine gas", etc.).

Wind energy is an energy sector, specializing in converting a kinetic energy of air masses in the atmosphere into electrical, mechanical, thermal, or any other form of energy, easy to use.

Hydropower is a kind of energy, being a complex of large natural and artificial subsystems, serving for transformation of water flow energy into electrical energy.

Solar energy is a kind of energy, based on the conversion of electromagnetic solar radiation into electrical or thermal energy.

Geothermal energy is a kind of energy, based on the production of electricity from the energy, contained in the bowels of the earth.

Bioenergy is an energy production of various types of biofuels (solid fuels - wood chips, wood pellets, husk, straw, etc., biogas and liquid biofuels of different origin).

Energy using low-temperature heat capacity represents methods of utilizing the low potential heat from environment (soil temperature at a depth of less than 10 meters, sewage waters, industrial water discharges, etc.).

Basic terms and definitions are given in accordance with GOST R 51387-99 "Energy saving. Regulatory and methodological support", GOST R 51237, GOST R 51238, GOST R 51594, GOST R 52808 relating to alternative energy sources and the general sources of information in Internet.

2. BACKGROUND

1) From the Power Sector Development Program until 2030 (Government Resolution № 384 of the Republic of Kazakhstan dated April 9, 1999)

"In 1990, when Kazakhstan's electricity need is 104.7 billion kW·h, the own production amounted to 87.4 billion kW·h (at 17.9 million kW of the installed capacity) and a cash deficit reached 17.3 billion kW·h.

In subsequent years, new generating capacities with the design production of about 8 billion kW·h were put into operation, including two power units of 525 MW at Ekibastuzskaya State District Power Plant (one of them - in December 1990), turbine of 110 MW at Karagandinskaya CHPP-3, gas turbine power plant of 100 MW at the JSC "Akturbo" and hydro unit of 117 MW at Shulbinskaya hydropower plant. Thus, a potential for the production of electricity on the own power plants today could reach about 95 billion kW·h that at the installed capacity of 18.2 million kW corresponds to 5 thousand hours of the installed capacity use.

As a result of the decline in effective demand for electricity, its production in 1996 fell to 59.3 billion kW·h, and in 1997 - to 52.2 billion kW·h, in 1998 - to 49.215 billion kW·h. Compared to 1997, electricity generation in 1998 decreased by 5.7%. Thus, consumption in 1998 was 53.027 billion kW·h, or 7.2% below the level of 1997. Balance import amounted to 3,812 billion kW·h.

Basic equipment of power plants has considerable wear due to service hours in excess of the estimated resources.

The structure of electricity generated by different types of power plants in relative units as of 2015 is estimated by the following indicators:

Coal-fired TPPs	66,8%
Gas-fired TPP	21,2%
Hydro Power Plants	11,2%
Nuclear Power Plants	0,6%
Wind Power Plants	0,2%

The total electricity production based on renewable energy sources (including hydro sources) in Kazakhstan totaled 8.3 billion kW·h in 1995 and will increase to 9.8 billion kW·h in 2015".

2) From the Power Sector Development Program in the Republic of Kazakhstan for 2010 - 2014 (Government Resolution of the Republic of Kazakhstan dated October 29, 2010 № 1129)

"As of January 1, 2010 the installed capacity of power plants in Kazakhstan amounted to 19.1 thousand MW, the available capacity made 14.8 MW.

Gaps and limitations of power amounted to 4.3 thousand MW, including:

- 1.1 MW - at hydropower plants due to restrictions on water consumption and increased backwater of tailrace, and due to the work of small hydropower plants relating to watercourse;
- 1.5 thousand MW at Ekibastuzskaya SDPP-1 in connection with conservation of units 1, 2 and 8, being out of operation;
- 1.7 thousand MW - due to the poor state of the main and auxiliary equipment of thermal power plants, lack of heat consumption, non-standard fuel combustion.

Today, about 41% of all generating capacities have been working more than 30 years.

To cover the increase in the prospective need in power and electricity, development of TPPs is planned to be realized according to the following main directions:

- modernization and reconstruction of existing TPP equipment;

- commissioning of new facilities at the existing power plants;
- construction of new TPPs (combined heat power plants, thermal power plants, hydro power plants, gas turbine power plants);
- involvement of renewable energy in the balance (wind, solar power plants - SPPs).

By the year 2014 it is expected to increase the electrical load to 15.4 MW.

To cover the growth of electric load it's required to implement the measures for expanding and technical upgrading the existing power plants, as well as construction of new ones".

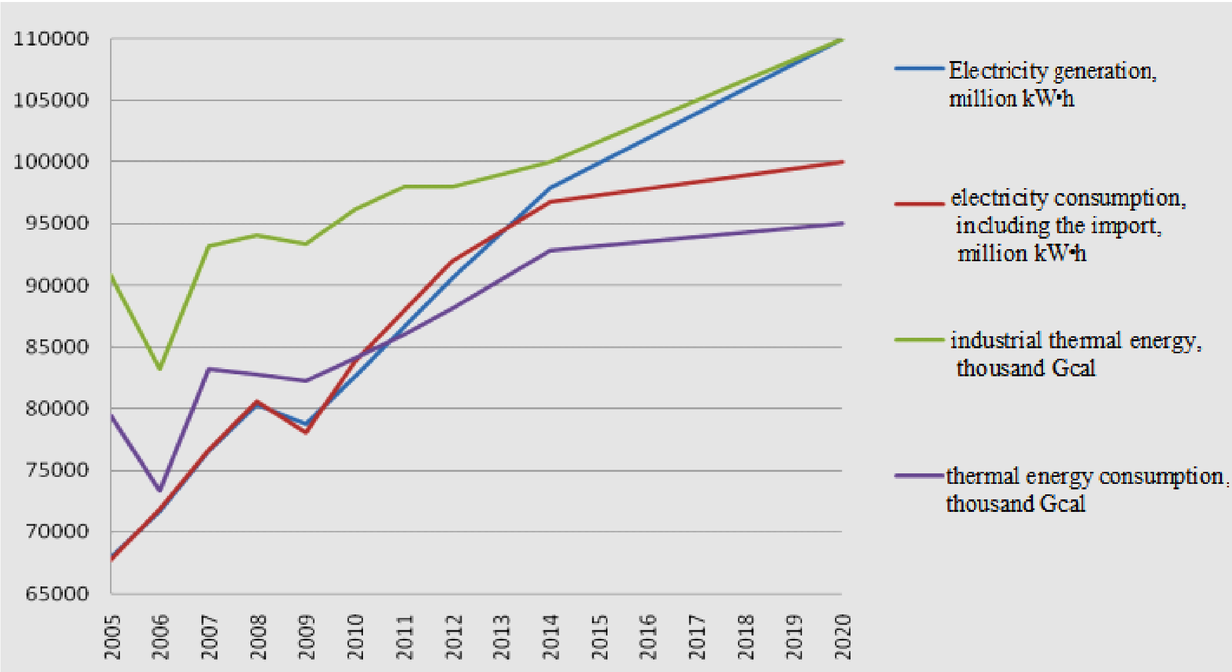

Fig. 1. Dynamics of heat and electricity production in the Republic of Kazakhstan for 2005-2020 (according to the Agency on Statistics and Governmental plans till 2020).

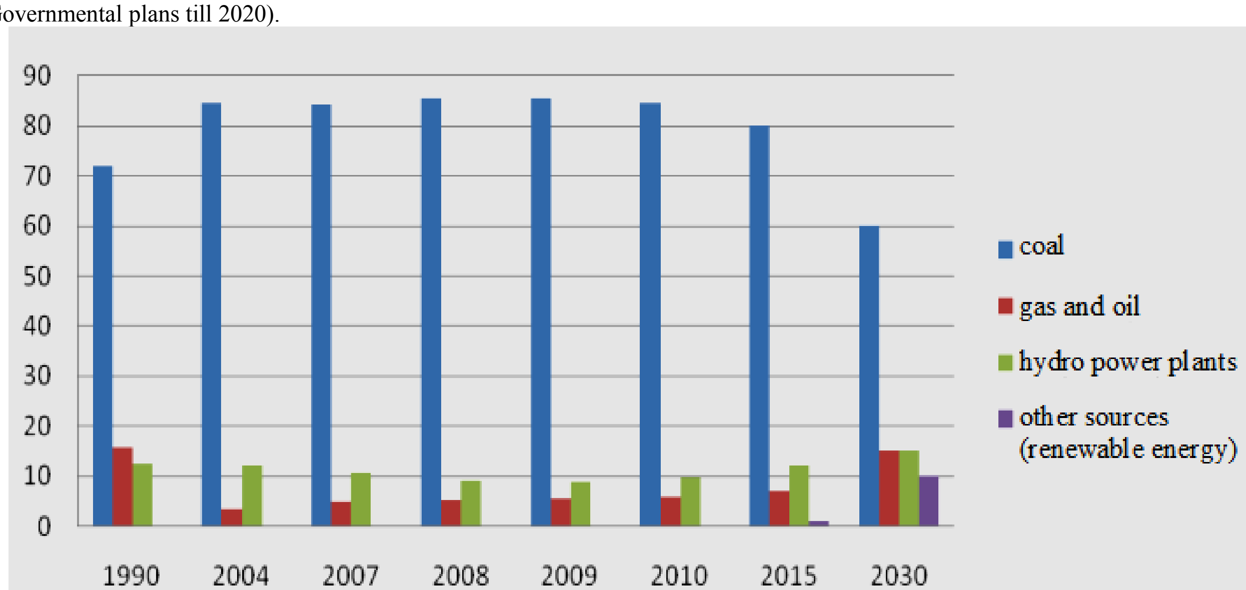

Fig. 2. Structure of energy resources in electricity generation in Kazakhstan for 1990-2030 (according to the Agency on Statistics and Governmental plans till 2030).

3. FRAMEWORK OF GREEN ENERGY IN KAZAKHSTAN

3.1. Solar Energy

3.1.1. Procedure of helio-potential in Kazakhstan

Available solar energy varies during the day due to the relative motion of the sun and depending on cloud cover. At noon in clear weather irradiance produced by the sun, can reach 1000 W/m^2, whereas in a dense cloud it may fall to less than 100 W/m^2 even at midday. Amount of solar energy varies with the angle of the plant and its surface orientation, decreasing with distance from the south.

Methods for producing electricity and heat from solar radiation are:

- photovoltaics - generating electricity using photovoltaic cells;
- solar thermal energy represents the heating of a surface, absorbing the sun rays, and the subsequent distribution and use of heat (focusing of solar radiation on a vessel with water for subsequent use of heated water in the heating system or steam power generators).

Commercial photocells have the certain rated output, expressed by Peak Power Watts (WP). It is a parameter of their maximum power in standard test conditions when solar radiation is close to its maximum of 1000 W/m^2, and the cell temperature is 25°C. In practice, photocells work in such conditions not often.

Despite the northern latitude of Kazakhstan geographic location, solar energy resources in the country are stable and acceptable, due to favorable climatic conditions.

According to the results of research (Ministry of Industry and New Technologies of the Republic of Kazakhstan) solar energy potential in the southern areas of the country reaches 2500 - 3000 hours of sunshine a year and is 1.3-1.8 billion kW·h per 1 m^2 per year.

Kazakhstan area, available for the installation of photovoltaic or solar heaters, is at least 50% of the total land area (2,724,902 km^2), the potential energy of the sun can be 1700 TW·h per year.

Given the fact that the efficiency of photovoltaic panels does not exceed 30%, we can estimate the technical potential of solar energy at 500 TW·h per year.

3.1.2. Validity of constructing solar power plants

Experts of the International Energy Agency (IEA), believe that in 40 years solar energy at the appropriate level of spreading the advanced technologies will produce about 9000 TW·h that is 20-25 % of electricity demand, that will provide CO_2 emission reduction by 6 billion tons annually.

The cost of energy received from a solar battery is reduced every year. Thus, in 2011 it decreased by 50%, since 2008 cut of the price amounted to 75%. In 2011, the cost of 1 watt of solar energy for the first time fell below $ 1.

Method of calculating the payback period of solar power plants is quite simple and based on three main factors: energy consumption for the solar cell production (EC), solar energy conversion efficiency (η) and average radiation power in the region, where it is planned to place a solar cell (SP):

$$EP = EC/(\eta \cdot SP).$$

For example, a solar cell based on polycrystalline silicon requires 600 kW·h per 1 m^2 of solar module. At efficiency of 12 % and average annual capacity of solar radiation of 1700 kW·h payback period of the module is less than 4 years. Given the growth of the photoconversion efficiency and production optimization one can expect that by 2020 payback period of polycrystalline solar cells drops by half.

Thin-film elements (10 % of the world market in 2011) use very small volumes of semiconductor material, so the most energy-intensive processes are production of the base (120 kW·h per 1 m^2) and installation of elements in the modules (also 120 kW·h per 1 m^2). An efficiency of thin film silicon solar cells is approximately 6 %. As a result, energy consumption for the production of such an element recouped within three years, and more efficient (η = 9-12 %) thin-film modules based on cadmium telluride (CdTe) and copper indium diselenide (CIGS) can be repaid less than in a year.

Thus, solar cells repay energy invested in them already in 2-4 years after their commissioning, and the next 25-30 years they will supply the customers with environmentally friendly electricity. Over its lifetime, solar power plant, providing a small house with the energy, will prevent emission of more than 100 tons of carbon dioxide and one ton of sulfur and nitrogen oxides.

3.1.3. Programs and plans of Kazakhstan relating to the use of gelio-potential

1) From the Power Sector Development Program of the Kazakhstan Republic until 2030 (Government Resolution of the Republic of Kazakhstan dated April 9, 1999 № 384)

"Solar water heaters (SWHs), developed in Kazakh Research Institute of Energy and made on the basis of polymeric materials, are more than an order cheaper than traditional ones. Calculations of specialists of the Institute show that the use of such SWHs can be economically profitable, even in a city where there is a large number of different energy sources. At the annual demand of Kazakhstan of 2.0 million m^2 SWHs, Kazakh Research Institute of Energy is able to produce 150 thousand m^2".

2) From the Alternative and Renewable Energy Development Action Plan of Kazakhstan for 2013-2020 (Government Resolution of the Republic of Kazakhstan № 43 dated January 25, 2013).

"Implementation of projects in the field of renewable energy. By 2020 it is planned to put into operation about 31 renewable energy plants with a total installed capacity of 1040 MW, including: 4 solar plants of 77 MW:

Table 1. **A list of wind plants anticipated for the construction according to the Plan for 2013-2020.**

№	Name of action	Implementation period, years	Anticipated costs, USD million
1	Construction of 2 MW SPP in Kapshagay city, Almaty Oblast	2014	11,33
2	Construction of 24 MW SPP in Zhambyl district, Zhambyl Oblast	2015	57,67
3	Construction of 50 MW SPP in Kyzylorda Oblast	2017	96,80
4	A project of introduction of clean energy using solar photovoltaic system in the Republic of Kazakhstan	2014	10,00
Total:			176

3.1.4. Practical results of gelio-potential development in 2013

A project of the state organization "Samruk-Energo" on construction of 2MW SPP in Kapshagay city, launched in 2012, is not over yet.

There are projects implemented by private companies unrelated to the state programs: 1 MW SPP realized by LLP "KazEkoVatt" in the settlement Otar, Zhambyl Oblast, 52 kW SPP in Akimat locale, Sarybulak aul, Almaty Oblast.

3.2. Wind power

3.2.1. Procedure of calculating the wind potential

Initial information for determination of climatic characteristics of wind energy resources is based on regular observations made at the network of meteorological stations (State Hydrometeorology Committee of the USSR before 1991). As a rule, these observations were carried out over several decades and formed the basis of calculations and estimations, still used in the Republic of Kazakhstan by public and private organizations (Ministries, Committees, Research Institutes).

1) According to estimation of experts of the Ministry of Industry and New Technologies (MINT) of Kazakhstan, wind power potential is 920 billion kW·h of electricity per year. Within the project "Kazakhstan - Wind Power Market Development Initiative" wind potential has been studied at various venues in the areas of the Republic of Kazakhstan. For 8 of them there were conducted preliminary investment studies. At all of them there was confirmed the average annual wind speed (about 5-6 m/s) suitable for the successful implementation of projects. Under this project *Wind atlas of Kazakhstan* was developed.

2) According to the Ministry of Environmental Protection (MEP) of Kazakhstan theoretical wind potential is about 1820 billion kWh/year, which is 25 times the volume of consumption of fuel and energy resources of the Republic, and the economic potential is estimated at more than 110 billion kW·h, which is 1.5 times more than the annual domestic consumption of energy resources of Kazakhstan.

For an accurate assessment of wind potential of prospective sites it's required to conduct special meteorological studies using meteorological masts of 30-80 meters high for at least one year. Weather data received will be used to calculate the annual electricity generated by wind power plants.

3) According to local experts' estimation, the technical potential of wind energy in the country is about 3 billion kW·h per year.

4) Wind potential of Kazakhstan UNDP experts estimate at 0.929 - 1.82 billion kW·h per year. Studies conducted under the UNDP project on wind energy, show the presence in some areas of Kazakhstan with a total area of about 50,000 km^2 an average wind speed exceeding 6 m/s. This makes them attractive for wind energy development. The most important are wind power resources of Zhungar corridor (17 billion kW·h per m^2).

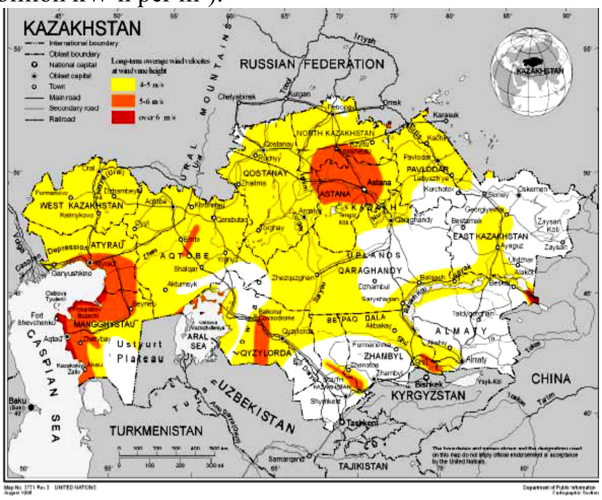

Fig. 3. Distribution map of wind energy resources in the territory of Kazakhstan (UNDP data)

As can be seen from the map of wind potential of Kazakhstan, major wind streams at an altitude of 50-70 meters make from 4 to 5 m/s. UNDP experts made their calculations relating to potential and determined the promising sites using the European experience, where the main sources are powerful coastal wind turbines with horizontal axis of rotation, designed for wind speed of 5-12 m/s. For Kazakhstan it is not a good example, as can be judged by the following arguments.

Bladed wind turbine (horizontal-axis) begins to produce current at the wind speed of 3 m/s and is off at the wind speed over 25 m/s. The maximum power is reached at a wind of 15 m/s. Output power is proportional to the cube of the wind speed: at increasing the wind speed twice from 5 m/s to 10 m/s, the power is increased by eight times.

The most efficient design for areas with low speed wind flows are **wind turbines with the vertical axis of rotation, the so called rotary** or carousel. The principal difference between the generator rotor and the blade one is that for the vertical generator 1 m/s is enough to start generating electricity. Now more and more such plants are being produced as not all consumers live on shore, and inland wind velocity is generally between 3 and 12 m/s. In this wind mode, the efficiency of the vertical installation is much higher. It should be noted that vertical wind turbines have a few more significant advantages: they are almost quite, and require absolutely no handling at a service life of over 20 years. Braking system, developed in recent years, guarantees stable operation even under periodic squally gusts up to 60 m/s.

Enterprises of Kazakhstan and the Russian Federation are jointly developing, manufacturing and commissioning complex energy systems (CESs) based on the wind rotor turbine of the model range 2 ÷ 5 ÷ 10 ÷ 20 kW.

They are equipped with solar inverters and batteries, smart chargers and remedies according to requirements of autonomous objects, providing reliable energy supply to consumers.

3.2.2. The validity of constructing wind power plants in Kazakhstan

Interest in the development of wind energy is due to the following factors:

- renewable energy resource which does not depend on fuel prices;
- no harmful emissions and greenhouse gases;
- developed world market of wind plant production;
- competitive cost of installed capacity (1000-1400 U.S. $/kW);
- competitive cost of electricity that does not depend on the cost of fuel;
- short terms of WPP construction with adaptation of its capacity to the required load;
- possibility of decentralized electricity supply for remote areas.

A main part of the cost price of energy produced by WPPs is defined by initial construction costs (the average cost of 1 kW of the installed capacity is U.S. $ 1,000).

Wind generators during operation don't consume fossil fuel. Operation of 1 MW wind turbine during 20 years can save 29 tons of coal or 92 thousand barrels of oil.

The following directions of wind power development are being promising for the Republic of Kazakhstan:

- independent wind energy systems of low power of 2, 5, 10, 20, 100 kW for supplying separate objects;
- energy complexes of an average power of 200-800 kW for supplying distributed load in areas with low population density;
- energy complexes with large power units of 1600-5000 kW for use in synchronized power systems.

3.2.3. Programs and plans for the use of wind potential

1) From the Power Sector Development Program until 2030 (Resolution of Government of the Republic of Kazakhstan dated April 9, 1999 № 384).

"Based on the available meteorological data there were selected first sites for construction of wind power plants (WPPs):

Junggarskaya WPP	40 MW;
Shelekskaya WPP	140 MW;
Saryozekskaya WPP	140 MW;
Alakolskaya WPP	140 MW;
Karoyskaya WPP	20 MW;
Shengeldinskaya WPP	20 MW;
Kurdayskaya WPP	20 MW.

The total capacity of Wind Power Plants will be about 520 MW with an annual power generation of about 1.8 - 2 billion kW·h. Investments in the construction of these windfarm is about 500 million U.S. dollars”.

2) In 2006-2009 under UN Development Project there were conducted researches and prepared recommendations for the development of wind power in Kazakhstan until 2024. They were shaped as the Wind Power Development Program until 2015 with the outlook until 2024.

“The Program provides the use of wind energy potential of the country for the production of electricity in the amount of 900 million kW·h per year by 2015 and 5 billion kW h by 2024. It is expected that the implementation of this document will help to reduce energy shortages in remote regions of Kazakhstan, experiencing difficulties in energy supply at present.

It was assumed that in March 2011 in Zhambyl Oblast of Kazakhstan implementation of major projects: wind power complex in Zhanatas (400 MW) and Shokpar (200 MW) will be started. Investments in their construction made about $ 1 billion.

By 2014, with the state support it is planned to build the following wind power complexes:

- near Shelek corridor - the one of the installed capacity of 51 MW;
- near Zhungar gates (50 MW at the first stage);
- in Ulan Oblast (24 MW) and some others”.

3) From the Power Sector Development Program of the Republic of Kazakhstan during 2010 - 2014 (Government Resolution of the Republic of Kazakhstan dated October 29, 2010 № 1129)

“Introducing new capacities through the implementation of projects on renewable energy (wind power plants):

in Almaty Oblast:

- WPP near Shelek corridor with the installed capacity of 51 MW, to be introduced in 2011;
- WPP near Dzhungar gates with the installed capacity of 50 MW at the first stage, to be put into operation in 2012;
- WPP in Ulan district with the installed capacity of 24 MW, to be commissioned in 2011.

in Mangistau Oblast:

- WPP in Tubkaragan district with the installed capacity of 40 MW, to be put into operation in 2012.

in Akmola Oblast:

- WPP in Ermentau district with the installed capacity of 35 MW, to be commissioned in 2013.

in Karaganda Oblsat:

- WPP in Karkarala district with the installed capacity of 10 - 15 MW, to be started in 2013.

in South Kazakhstan Oblast:

- WPP in Baydybek district with the installed capacity of 40 MW, to be commissioned in 2014;

in Kostanay Oblast:

- WPP near Arkalyk with the installed capacity of 41 MW, to be started up in 2014”.

4) From the Alternative and Renewable Energy Development Action Plan of Kazakhstan for 2013 - 2020 (Government Resolution of the Republic of Kazakhstan dated January 25, 2013 № 43)

“Implementation of projects in the field of renewable energy. By 2020 it is planned to put into operation about 31 renewable energy objects with a total installed capacity of 1040 MW, including:

13 Wind Power Plants	793 MW
14 Hydro Power Plants	170 MW
4 Solar Power Plant	77 MW

Table 2. **A list of WPPs planned for construction according to the Plan during 2013-2020**

№	Name of action	Implementation period, years	Anticipated costs, USD million
1	Building of 45 MW WPP near Ereymentau city, Ereimentau district, Akmola Oblast	2014	118,06
2	Building of 30-50 MW WPP near Ereymentau city, Ereimentau district, Akmola Oblast	2017	200,00
3	Building of 300 MW WPP in Badamsha settlement, Kargaly district, Aktobe Oblast	2015 - 2020	548,80
4	Building of 51 MW WPP in Shelek corridor, Almaty Oblast	2015	85,87
5	Building of 60 MW WPP in Shelek district, Almaty Oblast	2017	180,00
6	Building of 72 MW WPP near Junggar Gates, Almaty Oblast	2018	100,00
7	Construction of 24 MW wind farm on Umysh pass, Tainty settlement, Ulan district, East Kazakhstan Oblast 24 MW	2014	53,89
8	Building of 21 MW Korday WPP in Zhambyl Oblast	2016	36,34
9	Building of 100 MW Zhanatas WPP, Sarysu district, Zhambyl Oblast	2016	190,00
10	Building of 15 MW WPP in Karkarala district, Karaganda Oblast	2016	66,67
11	Construction of 48 MW WPP at the site near Arkalyk city, Kostanay region	2016	105,33
12	Building of 19.5 MW WPP in Fort Shevchenko, Mangistau Oblast	2015	36,15
13	Installation of 1,5 MW WPP in Novonikolskoe settlement, Kyzylzhar district, North Kazakhstan Oblast	2013	1,23
Total:			1723

3.2.4. Practical results in wind potential development in 2013

No project from the Plan of the Government of the Republic of Kazakhstan has been implemented.

There are several projects of private organizations that are not related to the state programs:

- 1.5 MW WPP realized by LLC "Isen Su" in Korday district, Zhambyl Oblast,
- 0.75 MW WPP realized by LLC "Rodina" in Rodina village, Tselinograd district, Akmola Oblast.

About 40 wind rotor generators of 10-100 kW were installed as power sources for telecommunication equipment of Kazakhtelekom.

Within the United Nations Development Programme in 2009, 2 MW WPP was built (total cost of the project on study of the weather conditions in Kazakhstan and the construction of a pilot plant made $ 7 million over three years).

3.3. Hydropower

3.3.1. Procedure of assessing hydro potential of Kazakhstan

Hydro power (water power) is the energy of water moving in a stream on the earth's surface. There are three categories of hydropower potential (GP): theoretical, technical and economic.

While determining the theoretical hydro potential a complete surface river flow with an average land elevation of 800 meters to the ocean level is considered. Water energy (power) is calculated as the product of water mass by the gravitational acceleration and by the difference in height (or the product of the gravitational acceleration by the flow volume and height difference). Electricity produced is defined as the product of the power by the number of hours per year (8760 hours).

Technical hydro potential is a part of the theoretical one, which can technically be used taking into account the annual and seasonal oscillations in river flow, the availability of suitable cross-sections for the construction of hydroelectric power stations, as well as water loss due to evaporation, filtration, etc. Theoretical to technical potential conversion factor is different for various regions and countries of the earth, but it is usually taken as an average for 0.5.

Economic hydro potential is a part of the technical potential, the use of which in a particular place and time can be considered economically viable. It is smaller than the technical one, estimated to be from 0.6 to 0.75 of the technical potential.

Table 3. **River flow of Kazakhstan (according to "Kazhydromet" for 2011)**

Volume of water resources for the period	Total, mln. m^3	including:	
		being formed in the territory of Kazakhstan	coming from neighboring countries
2007	117,5	64,9	52,6
2008	89,7	50,3	39,4
2009	100,0	58,2	41,8
2010	143,6	77,2	66,4
2011	101,8	57,3	44,5

An average flow of all rivers is taken for 100 million cubic meters per year. Drop of water (average) is generally accepted to be 800 m.

Theoretical hydropower potential is 6960 billion kW·h.

Then the technical potential will be 3480 billion kW·h.

The minimal economic potential can be considered equal to 2088 billion kW·h.

The amount of electricity generated by all rivers of Kazakhstan is equal to 626 billion kW·h, taking into account that the use of river energy on average does not exceed 0.3 for a year.

This parameter is 7 times larger than the electricity generated by all power plants of Kazakhstan in 2012.

Note. For small hydropower plants relating to alternative energy sources, flow of large rivers is 57.3 million m^3 (58 % of total amount of flows) and is not included in the calculations for small hydropower plants.

Thus, for small hydropower plants hydro potential of Kazakhstan is not more than 42 % of the estimated one and does not exceed 263 billion kW·h, which is 3 times the entire electricity generation in Kazakhstan in 2012.

According to the UN Programme for the Economies of Central Asia (SPECA), renewable hydro potential in Central Asia at the moment is only used by 10 %. The main volume of hydro potential is concentrated in Tajikistan (69 %), being number eight in the world after China, Russia, USA, Brazil, Zaire, India and Canada. Kyrgyzstan share makes 22 % of regional hydropower.

Table 4. **Hydropower potential of rivers in Central Asia (the Eurasian Development Bank, 2007)**

Countries	Installed capacity of hydro power plants, MW	Electricity generated by hydro power plants (2005), billion kW·h	Economic hydro potential, billion kW·h per year	Use of hydro potential, %	Share of Central Asian rivers in hydro potential, %
Tajikistan	4037	17,1	317	6	69
Kyrgyzstan	2910	14,0	99	14	22
Kazakhstan	2248	7,9	27	29	6
Uzbekistan	1420	6,0	15	49	3
Turkmenistan	1	0	2	0	0

3.3.2. The validity of small hydro power plants construction

Construction of small hydro power plants (SHPPs) has broad development prospects in different regions of the world with transboundary river basins. Small hydro power is free from many of the disadvantages of large hydro power plants and is recognized as one of the most economic and environmentally friendly ways to generate electricity, especially when using small streams.

Benefits of SHPPs:

- mitigate the effects of global climate change on the environment by reducing CO_2 emissions;
- efficient technologies;
- minimum flood areas and buildings;
- local and regional development;
- help to maintain the river basin;
- electrification of rural areas;
- small payback period.

During construction and operation of SHPPs a natural landscape is preserved, there’s virtually no pressure on the ecosystem. In comparison with fossil fuel power plants small hydropower plants have the following advantages: low cost of electricity and maintenance costs, relatively inexpensive replacement of equipment, longer life of HPPs (40-50 years), integrated water resources (electricity, water, land reclamation, water conservation, fisheries).

Table 5. **Summary of HPP types, technical and economic parameters (according to the IEA and CEA)**

Technical indices	International definition of HPP types							
HPP categories	MicroHPPs (<1 MW)			SmallHPPs (1-10 MW)			Other HPPs (>10 MW)	
Hydro turbine efficiency, %	Up to 92			Up to 92			Up to 92	
Construction period, months	6-10			10-18			18-96	
Possible lifetime period of HPPs, years	Up to 100							
Installed capacity utilization factor, %	40-60 (50)			34-56 (45)			34-56 (45)	
HPP loading factor, %	98			98			98	
Impact on environment								
Emissions of CO_2 and other green-house gases, kg/MW·h	minor							
HPP construction costs (as of 2008, $)								
Investment costs, including construction works, $/kW	2500-10000 (5000)			2000-7500 (4500)			1750-6250 (4000)	
Operation and maintenance costs, fixed and changing, $/kW	50-90 (75)			45-85 (65)			35-85 (60)	
Economic lifetime period, years	30							
Total cost of generated electricity, $/(MW·h)	55-185 (90)			45-120 (82,5)			40-110 (75)	
Prognosis period	2010			2020			2030	
Investment costs, including construction works, $/kW	5000	4500	4000	4500	4000	3600	4000	3600
Total cost of generated electricity, $/(MW·h)	90	82,5	75	81	75	67,5	73	67,5
Share of HPP electricity in the common electric power market	16-17			18-20			20-21	

3.3.3. Programs and plans for the use of hydro potential

1) From the Power Sector Development Program until 2030 (Resolution of Government of the Republic of Kazakhstan dated April 9, 1999 № 384)

“Capabilities of using energy resources of Kazakhstan rivers are assessed by the institute "Almatyhydroproject" based on regional layouts of HPP location in the East, South-east and South regions. Capabilities of creating 564 new HPPs and reconstructing 14 HPPs previously being under operation are reveled.

Out of the total number of 578 hydro power plants, there are 38 large ones (with the capacity of over 30 MW), and 540 small power plants (up to 30 MW). Total installed capacity of 38 large hydro power plants is 3296 MW, electricity generation makes about 12 billion kW·h. Total capacity of small hydro power plants is 2412 MW, electricity generation is about 11 billion kW·h.

The Institute "Almatyhydroproject", having considered a large number of projects, selected 23 projects being the most promising for introduction.

Table 6. **A list of HPPs planned for the construction under the Plan of 1999**

№	Name of project	Installed capacity, MW	Net Power, MW	Electricity generation, GW·h	Investments, U.S. $ mln	Project scrutiny	Construction time, years
North (East Kazakhstan region)							
1	Shulbinskaya HPP counterregulator (Irtysh River)	78	600	400	300	Feasibility study	2006-2010
2	Restoring the pipeline of Ulbinskaya HPP	27,6		114	15	Technical and economic estimate	2000-2005
3	Chain of HPPs on Kalzhir river	112	70	560	250	Regional scheme	2011-2020
4	Pechinskaya HPP on Bukhtarma river	200	200	800	320		2021-2030
5	Ust-Yazovskaya HPP on Bukhtarma river	150		750	280	Yes	2021-2030
South (Almaty, Zhambyl and South Kazakhstan regions)							
6	Kerbulakskaya HPP on Ili river	49,5	300	277	90	Feasibility study	2000-2005
7	Maynakskaya HPP on Charyn river	300	250	928	350		2000-2005
8	Kyzylkungeyskaya HPP on Koksu river	150	150	530	210	Regional scheme	2006-2010
9	Kyzylbulakskaya HPP on Koksu river	40		240	80	Regional scheme	2006-2010
10	Toktyshak HPP-1 and HPP-2 on Koksu river	19,5		118	37	Preliminary feasibility study	2000-2005
11	Bodarevskaya HPP on Koksu river	32	25	140	80	Yes	2011-2020
12	Junggar HPP on Tentek river	68	68	210	140	Yes	2011-2020
13	Tunguruzskaya HPP on Tentek river	32		115	110	Yes	2011-2020
14	Kostyantynivska HPP on Tentek river	100	80	340	220	Yes	2021-2030

15	Panfilov HPPs (1-4) on Usek river	25,6		131	53	Technical and economic estimate, project	2006-2010
16	Issykskaya HPP on Issyk river	4,2		22	7	Technical and economic estimate	2000-2005
17	Merkenskaya HPP-3 on Merke river	4,8		28,8	8,5	Feasibility study development	2000-2005
18	Recondition of Tekeskaya HPP on Tekes river	1,1		6,2	1,5	Feasibility study development	2000-2005
19	Bartogayskaya HPP on Chilik river	20		57	20	Yes	2006-2010
20	Chilic HPP-19 and HPP-20 on Chilik river	19,2		107	28	Feasibility study development	2011-2020
21	Cherkasskaya HPP on Lepsy river	8,8		44	15	Feasibility study development	2011-2020
22	HPP-1 and HPP-2 on Agynykatty	13,5		92	22	Feasibility study development	2011-2020
23	HPP on Small Almaty river (Medeo and Prosveshchenets)	6		30	9	Feasibility study development	2000-2005

Thus, construction of small hydro power plants with a total capacity of 600 MW and cost of 800-900 million US dollars is planned".

2) From the Power Sector Development Program during 2010-2014 (Resolution of Government of the Republic of Kazakhstan dated October 29, 2010 № 1129)

"Introduction of new capacities through the implementation of renewable energy projects (small hydro power plants - SHPPs)

in Almaty Oblast:

- a chain of small HPPs on Koksu river with the total capacity of 42 MW, to be launched in 2012;
- small HPP on Baskan river with the installed capacity of 4.37 MW, to be introduced in 2011;
- small HPPs on Issyk river with the total capacity of 5 MW, to be commissioned in 2011 - 2012;
- small HPPs on Shelek river with the total capacity of mpre than 30 MW, to be put into operation in 2014 - 2015;
- small HPP on Lepsy river with the installed capacity of 4.8 MW, to be introduced in 2012.

in South Kazakhstan region:

- Small HPPs on Keles river with the total capacity of 10 MW, to be commissioned in 2011 - 2014.

3) From the Alternative and Renewable Energy Development Action Plan in Kazakhstan for 2013 - 2020 (Government Resolution of the Republic of Kazakhstan dated January 25, 2013 № 43)

"By 2020, it is planned to put into operation 31 object related to renewable energy with the total installed capacity of 1040 MW, including 14 HPPs of 170 MW:

Table 7. **A List of HPPs planned for the construction under the Plan in 2013-2020**

№	Name of event	Implementation period, years	Anticipated costs, USD million
1	Construction of HPP-1 and HPP-2 on Koksu river, Kerbulak district ,Almaty Oblast with the total capacity of 42 MW	2016	75,49
2	Construction of 5 MW HPP-5 on Karatal river, Eskeldinsky district, Almaty Oblast	2014	31,00
3	Construction of 4.35 MW Verkhne-Baskanskaya HPP, Sarkand district, Almaty Oblast	2015	9,40
4	Construction of 15 MW Nizhne-Baskanskaya HPP - 1-3, Sarkand district, Almaty Oblast	2015	37,26
5	Construction of HPP on Issyk river, Yenbekshikazakhsky district, Almaty Oblast with the total capacity of 4.8 MW	2015	5,84
6	Construction of 4,8 MW HPP-2 on Lepsy river, Sarkand district, Almaty Oblast	2015	6,86
7	Construction of HPP 1, 2 on the Grand Almaty Canal, Almaty Oblast with the total capacity of 12 MW	2015	Under design and analysis
8	Construction of HPPs 19-22 on Shelek river, Yenbekshikazakhsky district, Almaty Oblast with the total capacity of 60.8 MW	2015	Under design and analysis
9	Construction of small HPPs on Gromatuha, Ulba, Serzhiha rivers near Ridder city, East Kazakhstan region	2018	Under design and analysis
10	Construction of 2,1 MW Karakystakskaya HPP, T. Ryskulovsky district, Zhambyl Oblsat	2013	6,79
11	Construction of 9,2 MW Tas-Otkelskaya HPP, Shu district, Zhambyl Oblast	2013	7,00
12	Construction of 4,5 MW Merkenskaya HPP, Merke district, Zhambyl Oblast	2015	32,71
13	Construction of 2 MW Ryszhan HPP on Keles river, Saryagashsky district, South Kazakhstan Region	2015	1,29
14	Construction of 3 MW Azamat HPP on Keles river, Saryagashsky district, South Kazakhstan Oblast	2016	2,10
Total:			412

3.3.4. Practical results of the development of hydro potential in 2013

Beside the large 300 MW Moinakskaya HPP, the construction of which started in 1989 and not related to small HPPs, no facilities under the state programs have been implemented.

In Almaty Oblast private investor built 4,4, MW Karatalskaya HPP-3, not included in the list of the state program. LLP "Rem-KomStroy" also built 1,5 MW HPP in Zhambyl Oblast.

3.4. Thermal power engineering

3.4.1. Procedure of Kazakhstan thermal potential assessment

Geothermal power engineering is a branch of power engineering, based on the production of electricity from the energy contained in the bowels of the earth.

Geothermal gradient is a physical quantity that describes the growth of temperature of rocks in degrees Celsius at certain parts of the earth strata. It's mathematically expressed by the change in temperature per the unit of depth. In geology, in the calculation of geothermal gradient 100 meters are taken per the unit of depth. In various areas and at different depths the geothermal gradient is not constant and is determined by composition of rocks, their physical condition, and thermal conductivity, heat flow density, proximity to intrusions and other factors. Usually geothermal gradient varies from 0.5-1 to 20 °C and on average makes about 3°C per 100 meters.

Geothermal power engineering is divided into two areas: petrothermal and hydrothermal.

For Kazakhstan hydrothermal power engineering is important using the temperature of geothermal sources at Geothermal Power Plant (GeoPP).

Heat generated inside the planet, enables running GeoPPs with the total capacity of 200-250 million kW at drilling depths up to 7 km and the timing of the station of about 50 years. In addition, there can be involved geothermal heating system with the capacity up to 1.2-1.5 billion kW at drilling depths up to 4 km and a service life of 50 years.

Geothermal sources, according to the classification of the International Energy Agency, are divided into five types:

1) dry steam geothermal field: relatively easy to develop, but quite rare. However, half of all existing GeoPPs in the world use the heat of these sources;
2) sources of wet steam (a mixture of hot water and steam) are more common, but their development has to address the issues of preventing corrosion of GeoPP equipment and pollution (removal of condensate due to the high degree of salinity);
3) geothermal water fields (containing hot water or steam and water) are so-called geothermal reservoirs, which are formed by filling the underground cavities by precipitation water heated by close lying magma;
4) hot dry rocks heated by magma (at a depth of 2 km or more): their energy reserves are the largest;
5) magma, which is molten rock, heated up to 1300°C.

Resources of thermal (thermal power) water are counted within the fields or operational areas to justify the construction of intake structures for heating specific objects and within major hydrogeological regions to justify the promising general schemes of using these waters for various needs of the national economy, as well as areas and volumes of exploration works.

According to studies conducted in Kazakhstan and in view of studies conducted during 1970-1990, the following data have been obtained:

Table 8. **General characteristics of artesian basins, promising for geothermal water extraction (according to the Ministry of Geology and Mineral Protection of Kazakhstan, 1994)**

№ п/п	Name of the region	Area, thousand km^2	Groundwater temperature, °C	The depth of the geothermal water, m	Number of wells penetrated the geothermal waters, units.	Number of settlements and commercial facilities in the area of occurrence of geothermal waters
1	Irtysh Artesian Basin	86	20-40	900-1000	17	6
2	Artesian basins of the southern part of the West Kazakhstan	176	40-100	600-3000	23	11
3	Artesian basins of Syrdarya system	192	40-85	1000-2000	23	29
4	Artesian basins of Ili system	28	40-165	1200-4600	10	12
	Total:	482			76	58

Energy potential of Kazakhstan geothermal waters is characterized by the following: annual renewable geothermal water resources in Kazakhstan for temperature zones of 40 to 100°C and higher are generally defined: by volume - 10.3 km^3, by warmth - 97.1 million tons oa equivalent fuel, which corresponds to 790 billion kW·h.

This means that the estimated energy potential of Kazakhstan geothermal waters exceeds similar potential of oil produced annually in recent years in Kazakhstan (70-80 million tons).

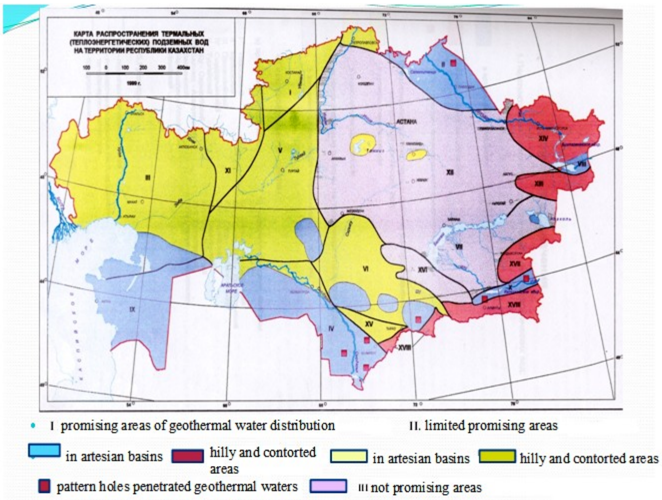

Fig. 4. Distribution map of Kazakhstan geothermal groundwaters (LLP "Institute of Hydrogeology and Environmental Geoecology named after U.M. Akhmedsafin", 2007)

3.4.2. Justification of GeoTPP construction

Advantages of geothermal method of energy obtaining are evident - it is applicable everywhere, in every place of the globe: drilling a deep enough hole, you penetrate into the heated middle and lower layers of the crust. This path looks especially attractive, where there are difficulties with energy development, including the alternative one, where there is insufficient solar energy, stability and strength of the wind, where hydropower is limited.

But along with the simplicity of explanation and attractive application, the difficulties of application are obvious. First of all, it is expensive. To drill the well of 10 km or 5 km deep with the current technologies is very expensive, and even not always technically possible. This is speaking about drilling, but the entire system will need to be maintained.

Further, there are other questions - the process of pumping water into the well to this depth is technically complicated and requires energy, heat losses occur during transport of steam to the surface, as well as sensitivity of wells in case of lithosphere movement and a number of other factors.

But, in principle, these difficulties can be overcome. For the moment there are no technologies (at least, cost-effective ones) of drilling to a depth of about 10 km. Therefore, it is limited to significantly lower depths (up to 2 km). There subsurface heating (up to 120-130°C) allows the use steam for heating and electricity generation.

Possibilities of practical use of geothermal waters:

- electricity generation (temperature 80 -100°C);
- heat supply (temperature of 65-80° C);
- hot water supply (temperature of 50-65°C);
- balneology, greenhouse facilities (temperature below 40°C);
- irrigation in agriculture (temperature below 30°C).

3.4.3. Programs and plans for the use of thermal potential

1) From the Power Sector Development Program until 2030 (Resolution of Government of the Republic of Kazakhstan dated April 9, 1999 № 384)

"An analysis of geothermal and biological resources available in the Republic shows that their quality and potential for electricity generation is not high enough. It's most expedient to use geothermal energy for heating".

3.4.4. Practical results of the development of thermal capacity in 2013

The Government of Kazakhstan hasn't developed and implemented any projects relating to the use of geothermal potential from 1992 to 2013.

3.5. Bioenergetics

3.5.1. Procedure of estimating Kazakhstan biopotential

Biofuel is a fuel from vegetable or animal raw materials from waste products of organisms or organic industrial wastes.

There are different types of biofuel: liquid (ethanol, methanol, biodiesel), solid (wood, briquettes, pellets, wood chips, straw, husk) and gaseous (synthesis gas, biogas, hydrogen).

Gaseous fuel is the cheapest and easy to produce: various gas mixtures with carbon monoxide, methane, hydrogen produced by the thermal decomposition of raw materials in the presence of oxygen (gasification), without oxygen (pyrolysis), or during the fermentation by bacteria.

Biogas composition is as follows: 50-87% of methane, 13-50% of CO_2, minor impurities of H_2 and H_2S. After purification of biogas from CO_2 biomethane is obtained.

A list of organic wastes suitable for the production of biogas is: manure, poultry manure, grain and molasses grains after distillery, brewer's grain, beet pulp, sewage sludge, fish and bottomhole shop wastes (blood, fat, intestine, paunch manure), grass, household wastes, dairies etc.

Landfill gas is one of the varieties of biogas. It's obtained at landfills from municipal wastes.

Biogas output depends on dry matter content and a kind of raw material. One ton of cattle manure produces 50-65 m^3 of biogas with a methane content of 60 %, 150-500 m^3 of biogas from different plant species with a methane content of 70 %. The maximum amount of biogas is 1300 m^3 with the methane content up to 87 % which can be obtained from fat.

There is a theoretical (physically feasible) and technically – feasible gas output. In the 20th century technically feasible gas output made only 20-30% of the theoretical. Today, the use of enzymes, boosters for artificial degradation of raw materials (such as ultrasound or liquid cavitators) and other devices enables to increase the biogas output at the ordinary facilities from 60% to 95%. In practice, 1 kg of dry matter produces from 300 to 500 liters of biogas.

1) Production of biogas from human wastes, livestock and agricultural wastes.

According to the average data, the amount of manure from domestic animals in Kazakhstan for one year is as follows:

Cattle - up to 5 tons;
Horses and camels - to 3 tons;
Pigs - up to 2 tons;
Sheep - up to 0.5 tons;
Bird - up to 0.15 tons.

Calculation allows estimating the biogas potential for domestic animals leaving in Kazakhstan:

Table 9. **Evaluation quantities of raw materials suitable for the production of biogas (according to the Agency for Statistics for 2012)**

Name	Number of animals in all categories of farms, heads	The amount of wastes, tons per year
Cattle	5 702 436	28512180
Sheep and goats	18 091 902	9045951
Pigs	1 204 277	2408554
Horses	1 607 455	4822365
Camels	173 232	519696
Poultry of all kinds	32 870 143	4930521
Total wastes, tons per year		50239267

A volume of biogas from domestic animal wastes (rate of 30 m^3 of gas per 1 ton of manure) will be not less than 1,507,178,024 m^3. Consequently, the potential of biogas from domestic animals during housing in Kazakhstan may be up to 2260.7 million kW·h (assuming that 1 m^3 of biogas produces at least 1.5 kW of electricity).

2) Production of biogas from agricultural wastes - grains and oilseeds

According to the Statistics Agency of the Republic of Kazakhstan the grain and leguminous crops in 2012 amounted to 14.04 million tons in primary form (prior to treatment). Given that the wastes after recycling and green mass balances in the fields are not less than 30% of the harvest, we can estimate recyclable organic mass of 4.6 million tons. One ton of biomass, containing organics, can produce not less than 50 m^3 of biogas.

Technical potential of biogas from agricultural wastes can be estimated at 230 million m^3 of gas or 345 million kWh.

3) Obtaining landfill gas from municipal wastes

In 2011, the landfill received 3,554,410 tons of municipal wastes. Before that it has been already deposited 51,183,498 tons of wastes.

If we consider that municipal wastes contain at least 40% of biodegradable wastes, for the production of landfill gas 21,895,163 tons of available reserves should be taken into consideration.

To estimate the annual production of landfill gas annual amount of municipal wastes transported to landfills can be taken into account.

On average, in Kazakhstan, one person produces 1.5 m^3 of municipal wastes. With a population of 16 million people, the annual volume of wastes is to be more than 24 million m^3.

The calculation shows that the technical potential for landfill gas is 2.5 million m^3 of 24 million m^3 of Kazakhstan wastes.

According to optimistic estimates, one cubic meter of gas can produce 1.5 kW·h of electricity plus about 3 kW·h of thermal energy.

Consequently, the technical potential of landfill gas in Kazakhstan is 3.75 MW·h of electricity and additional 7.5 MW·h of heat energy is obtained when combustion heat of landfill gas is used properly.

Table 10. **Summary potential assessment of biogas and landfill gas annual production in Kazakhstan**

Biomass processing technology	Annual volume of wastes, million tons	Biogas output, million m^3	Energy potential, million kW·h
Animal waste recycling	50,2	1507	2260,7
Agricultural waste (cereals and legumes) recycling	4,6	230	345
Municipal and household waste recycling	24	2,5	11,25
Total:			2616,95

3.5.2. Justification of BioPP construction

According to the Stanford University estimate 385-472 million hectares of land in the world are outside of agricultural activity. Planting raw materials at these lands for biofuel production will increase its share to 8 % in the global energy balance. A share of biofuel in transport can make from 10 % to 25 %.

Biogas production allows preventing methane emissions into atmosphere. Methane influence on a greenhouse effect is 21 times stronger than that of CO_2 in the atmosphere and it stays there 12 years. Capturing methane is the best short-term way to prevent global warming.

Recycled manure, grains and other wastes are used as fertilizers in agriculture. This cuts the use of chemical fertilizers, reduces load on groundwaters.

At present the area of filled landfills and disposal sites of Kazakhstan suitable for extraction of landfill gas occupies more than 5 thousand hectares. In these areas, the specific gas yield is 120-400 m^3/per ton of solid wastes. Thus, the potential of biogas available for energy production is more than 1 billion cubic meters per year.

3.5.3. Programs and plans for the use of biopotential

2) From the Power Sector Development Program until 2030 (Resolution of Government of the Republic of Kazakhstan dated April 9, 1999 № 384)

"The most appropriate is to use geothermal energy for heating and biological resources for biogas production with its subsequent use for heating and cooking, as well as the production of fertilizers".

3.5.4. Practical results of biopotential development in 2013

No projects related to biopotential implementation have been provided by the state programs in 1999-2013. In 2010, the biogas plant was built by LLP "Karaman-K", processing 44 tons of manure a day (about 100 kW of power) in Karaman village, Kostanay Oblast, but still no permission is received to connect it to the overall grid.

3.6. Potential of low-temperature environments

3.6.1. Procedure of evaluation of the low-temperature potential of Kazakhstan

Use of low-grade heat from the Earth or secondary energy resources is possible through heat pumps almost everywhere.

Heat pump is a device for transferring thermal energy from low potential heat source (having low temperature) to the consumer (heat medium) with a higher temperature.

The heat pump condenser contains a heat exchanger, releasing the heat to the consumer, and the evaporator is a heat exchange apparatus, utilizing a low-grade heat: secondary energy resources and (or) non-conventional renewable energy sources.

As chiller, heat pump consumes energy for the thermodynamic cycle (compressor drive). Heat pump conversion factor is the ratio of heat output to the electricity consumption; it depends on the temperature in the evaporator and condenser. The temperature level of heat supply from heat pumps today may vary from 35°C to 62°C. That allows using virtually any heating system. It saves energy up to 70 %. Industries of the technically developed countries produce a wide range of vapor compression heat pumps of the heat capacity from 5 to 1000 kW.

Reserves of low potential heat (LPH) are enormous. Their economic potential, i.e. the amount of energy, which obtaining from this type of resource is currently economically justified, in Russia in 2003 was equal to 31.5 million tons of equivalent fuel per year, even without considering LPH of flue gases from energy and process plants. This represents 22% of the country's total energy consumption, exceeds the economic potential of wind and solar energy.

Supposing that Kazakhstan industry is comparable with the Russian industry in terms of production output, in 2003 the economic potential of Kazakhstan LPH made 0.75 million tons of equivalent fuel per year.

Consequently, in 2013 the economic potential of LPH, being virtually not used during the last 10 years, will be at least 1 mln. tons of equivalent fuel/year, which corresponds to the annual electricity generation of 8.1 million MW·h.

3.6.2. The validity of using heat pumps

One method of utilizing low potential heat is based on the Rankin thermodynamic cycle. In the thermal circuit such volatile organic substance as freon is used as the working fluid.

A structure of different power systems is identical and consists of two main parts - the heating circuit, which converts thermal energy into mechanical and electromechanical parts, and electromechanical part, which converts mechanical energy into electrical one of the required quality.

The most effective, but the most expensive configurations of heat pumps provide heat extraction from the ground, the temperature of which does not vary throughout the year at a depth of several meters, making installation almost independent of the weather. According to the data published in 2006, in Sweden there's half a million of the systems, in Finland - 50,000, in Norway the number of the systems reached 70,000 per year. When the energy of soil is used as a source of heat, the pipe, in which antifreeze is circulating, is buried in the ground by 30-50 cm below the level of soil freezing in the region. In practice it is 0.7-1.2 m.

It does not require drilling, but requires more extensive ground work on a large area, and the pipeline is more susceptible to the risk of damage. The efficiency is the same as at the removal of heat from the wellbore. Special soil preparation isn't required.

Table 11. **Sources of industrial low-potential heat**

Man-made systems
Industrial enterprises (heat of gas compression in compressors, heat of combustion products of various fuel types)
Cooling water systems, industrial effluents and treatment plant sewages (liquid heat)
Biogas plants, gas generators, pyrolyzers (calorific value of fuel generated in these plants)
Vehicle heat movers (exhaust heat)
Refineries (calorific value of associated gas)
Communication objects (heat losses of equipment)
Poultry farms, farms, etc. (biofuel energy)
Woodworking enterprises (energy from waste incineration)

The advantages of heat pumps, firstly, should include the efficiency: transfer of 1 kW·h of thermal energy to the heating system requires just 0.2-0.35 kW·h of electricity.

All systems operate using loops and require virtually no maintenance costs, except the cost of electricity needed to operate the equipment.

Another advantage of heat pumps is the ability to switch from the heating mode in winter to the air-conditioning in summer: instead of radiators, fan coils or "cold flow" systems are connected to an external collector.

A greater price of the installed equipment is a disadvantage of heat pumps used for heating.

To install the heat pump upfront costs are required: the cost of the pump and the system installation is $ 300-1200 per 1 kW of the necessary heating power. Payback period of heat pumps is 4-9 years, at their service life of 15-20 years before overhaul.

The industry uses heat pumps utilizing energy of the emitted gases (exhaust steam).

Steam turbine installations operating on the organic coolant are widely used in Germany for production of mechanical energy and electricity generation (power of 50-800 kW). In Japan the "cold" steam is used by the plants with a capacity up to 3000 kW.

Using heat pump installations, spending 1 kW·h of external electricity for their drive, 3-6 kW·h of thermal energy having more high potential is received. In four of the most advanced countries in this respect (USA, Sweden, UK, Germany) currently about 10 million heat pumps are under operation, saving up to 220 million tons of equivalent fuel per year. In Russia 2-3 thousand heat pump installations are under operation.

3.6.3. Programs and plans for the potential utilization

The practical options of using heat pumps in Kazakhstan should include the use of heat of municipal sewage waters and cogeneration mode at industrial enterprises using thermal installations.

Effectiveness of capital investments in energy production using renewable energy is 2-3 times higher than in the fuel and energy complex of the industry.

Thus, the most important result of using renewable energy resources is saving the primary fuel, which mainly determines the magnitude of the resulting economic effect.

Efficiency of involving renewable energy resources also grows by increasing the number of consumers of low-temperature potential at district heating of industrial centers and residential areas bordering with the enterprises. This improves the environmental situation when closing the small boiler-houses, polluting the environment.

3.6.4. Plans and practical results of the development of low-temperature potential for 2013

Programs of the Government of the Republic of Kazakhstan haven't stipulated any projects from 1991 to 2013. In 2012, LLP "Mashzavod" began production of heat pumps in Ust-Kamenogorsk; there was implemented a pilot project on heating the village school in Praporshchikovo settlement, Glubokovsky district, East Kazakhstan Oblast.

Industrial heat pump plant NT-3000 of the JSC "Kazzinc" with the capacity of 3.7 Gcal was launched in 1999 and still works.

4. PROSPECTS OF GREEN ENERGY

1) From the Strategy of efficient using the energy and renewable resources of the Republic of Kazakhstan to sustainable development by 2024 (Government Resolution of the Republic of Kazakhstan dated January 24, 2008 N 60)

Table 12. **Assessment of the global renewable energy potential (according to the Ministry of Energy of the Republic of Kazakhstan, 2008)**

Name of resource	Resource base, TW	Economic efficiency, TW
Solar radiation	90 000	1000
Wind	1200	10
Waves	3	0,5
Tides	30	0,1
Geothermal stream	30	-
Biomass growing, TW/year	450	-
Geothermal heat	1011	> 50

Expected results:

- increase in the share of alternative energy sources in the Republic of Kazakhstan to 0.05% in 2012, to 1% in 2018, to 5% by 2024;
- providing substitution of alternative energy sources: 0,065 million tons of equivalent fuel (tef) by 2009, by 2012 - 0,165 million tef, by 2018 - 0,325 million tef, by 2024 - 0,688 million tef, and by 2030 - 1.139 million tef;
- increase in the renewable energy share (excluding large hydro power plants) in electricity generation with capacities up to 3000 MW and 10 billion kW·h of electricity per year by 2024.

2) From the Alternative and Renewable Energy Development Action Plan of Kazakhstan for 2013 - 2020 (Government Resolution of the Republic of Kazakhstan dated January 25, 2013 № 43)

"By 2020, it is planned to put into operation 31 renewable energy objects with a total installed capacity of 1040 MW, including:

13 Wind power plants	793 MW
14 Hydro power plants	170 MW
4 Solar power plants	77 MW

3) From the Alternative and Renewable Energy Development Action Plan of Kazakhstan for 2013 - 2020 (Government Resolution of the Republic of Kazakhstan dated April 30, 2013 № 424)

Strategic objectives in the energy sector

by 2020	energy generation from the own sources, satisfying the needs of the economy, will make 100%; the share of alternative energy sources in total energy consumption will be more than 3%; Nuclear PP and Balkhashskaya TPP are built and put into operation; vertically-integrated company with the nuclear fuel cycle is created; the existing generating power capacities and energy distribution networks are reconstructed and modernized
by 2015	the share of alternative energy sources in total energy consumption will be more than 1.5%; the first stage of Balkhashskaya TPP is completed

4) Estimated potential and degree of development (author's estimate).

Using data from the last program of the Government for the power sector development based on renewable energy in 2013 and data on the projects implemented in the past 15 years in Kazakhstan, we can estimate the level of using all possible potential energy sources:

Table 13. **Exploiting the potential of renewable energy in Kazakhstan in the 21st century**

Renewable energy branch	Potential, billion kW·h	Extent of implementation in the 21st century (2000-2013), % of the potential	Planned use until 2020, of the potential
Solar Energy	1700	0,000016	0,0004125
Wind Power	1000	0,000055	0,0070014
Hydropower	600	0,004466	0,0069481
Geothermal Energy	790	0	0
Biogas Energy	2,6	0,000001	0,000001
LTP-Energy	8,1	0,000062	0,000062
Total:	4100,7	0,0046	0,014

The results are disappointing: in 2020 the power sector of Kazakhstan will be "black" because more than 70 % of power plants will consume oil and gas. It is very doubtful that the equipment of thermal power plants built in the Soviet Union times (being depreciated to 70 %) will be replaced, it will only become more old. And the use of renewable energy sources for electricity generation and heat production will unlikely exceed 1 % of the existing potential.

5) Evaluation of the effectiveness of using the renewable energy potential in Kazakhstan.

Table 14. **Comparative data on the level of capital investments for the construction of power plants in the world and Kazakhstan (according to IEA and the plans of the Government of Kazakhstan for the years 2000-2013)**

Type of power plants by the consumed resource	Capital investments in the construction of power unit, $ / kW			
	in the world (IEA data)		in the Kazakhstan (planned)	
	2005	2030	2000	2013
Renewable resources				
Biomass	1000-2500	950-1900	2000-4200	not planned
Geothermal energy	1700-5700	1500-5000	not planned	not planned
Traditional hydropower	1500-5500	1500-5500	2400	not planned
Small hydropower	2500	2200	1500	2230
Solar photoenergetics	3750-3850	1400-1500	not planned	2283
Solar Energy	2000-2300	1700-1900		not planned
Tidal power	2900	2200	not planned	not planned
Surface wind energy	900-1100	800-900	962	2172
Marine wind power	1500-2500	1500-1900	not planned	not planned
Non-renewable resources				
Nuclear Power Plants	1500-1800	-	not planned	5000
Coal-fired Thermal Power Plants	1000-1200	1000-1250	not planned	2500-2800
Gas-fired Thermal Power Plants	450-600	400-500	not planned	2800-3100

From the above material, the following conclusions can be made:

During 12 years of the new century, only one project has been implemented in Kazakhstan out of the planned by the Government – it is 300 MW Maynakskaya HPP, for which 720 million U.S. dollars were spent instead of 300 planned in 1999. If we look at the following list of objects (small hydro power plants), a simple pattern is visible: 10 out of 23 HPPs planned in 1999 moved to the government's plans for 2013. Four of the windfarm projects planned in 1999 are listed in plans for 2010 and 2013. It's needless to say, that the objects moved from the old plan to the new one will be again "redesigned and technically and economically justified", which usually requires 10-30% of budgeted funds.

The population of Kazakhstan has to develop "green" energy independently, because electricity rates over the past 12 years have increased by 3-4 times and further tariff increase will inevitably occur (Kazakhstan power sector is controlled by the state, which binds all prices to world oil prices).

There is no own production of wind power plants in Kazakhstan. In the market there are products from China, Russia or Ukraine, at prices ranging from $ 2000 to 3500 per kW of power.

Small hydropower plants aren't manufactured as well, but you can bring from Russia a container small HPP with the capacity from 5 to 25 kW at the price of $ 1500-2000 per kW.

A factory of solar modules of 2nd generation (LLP "AstanaSolar"), owned by the state corporation "Kazatomprom" was first launched in 2011, after 5 years of construction. Production is technically outdated (a module of 24 kg and 250 W costs $ 670) and can't compete with the Chinese modules (180 W), weighing 11 kg at a price of $ 135. Chinese film module of 100 W weighs only 5 kg, although costs $ 630, but is twice smaller in size than the polycrystalline.

Solar household collectors for 200-500 liters of water heating up to 90 °C cost from $ 1,500 to 3,500.

Biogas plants, widely used in neighboring Uzbekistan and Kyrgyzstan, aren't also manufactured; Russian and Ukrainian products cost between 1000 and $ 3000 per kW of power (excluding the output of thermal energy that is up to 30%).

Heat pumps (heating and cooling) are imported into Kazakhstan from China (under the European brands) at a price of 200 to $ 500 per kW. Heat pumps produced in Kazakhstan (eg, LLP "Sunday") are not in demand because of the high cost and the use of imported components (90 %).

CONCLUSION

Over twenty years of independence in the country changed 7 ministries responsible for energy sector of the country. Ministry of Energy (as in 99% countries of the world) has turned to the Ministry of Industry and New Technologies. Control for embodiment of plans to use alternative energy sources in 2013 was generally assigned to the Ministry of Environment and Water Resources (in 2012 it consisted of 23 employees having no relation to the energy sector!). And each time the plans for construction of hydro, wind and solar power plants demanded new budgets, because nobody demanded an expense report from the departed ministers.

According to a conservative estimate of GFI (the Program of the International Policy Center, USA), 123,057 billion US dollars were illegally derived from Kazakhstan abroad during the "zero" decade. That is, on average, $ 12 billion a year out of the country. Such amount of money could be spent for building 3-5 Nuclear PPs or 15-20 TPPs each year with the total capacity of 5-10 GW.

But in April 2013 a bet is placed on the construction of Nuclear Power Plant of 1 GW ($ 5 billion) and coal-fired Balkhashskaya Thermal Power Plant with a capacity of 1.32 GW (4 billion U.S. dollars). What a green energy is here (31 objects of 1 GW) costing "only" $ 2.3 billion?! It's much more interesting to "cut" the budget of $ 9 billion relating to 2 sites! So we would expect that after the event "Expo-2017", dedicated to the development of "green" energy, valued at $ 2.3 billion, a new program of energy development in Kazakhstan will be adopted, and the current plans will remain only plans (after active "cutting" the allocated budget).

REFERENCES

1. **ГОСТ Р 51387–99** «Энергосбережение. Нормативно-методическое обеспечение», Госстандарт России, Москва, 1999.
2. **ГОСТ Р 51237-98** «Нетрадиционная энергетика. Ветроэнергетика. Термины и определения», Госстандарт России, Москва, 1998.
3. **ГОСТ Р 51238-98** «Нетрадиционная энергетика. Гидроэнергетика малая. Термины и определения», Госстандарт России, Москва, 1998.
4. **ГОСТ Р 51594-2000** «Нетрадиционная энергетика. Солнечная энергетика. Термины и определения», Госстандарт России, Москва, 2000.
5. **ГОСТ Р 52808-2007** «Нетрадиционные технологии. Энергетика биоотходов. Термины и определения», Госстандарт России, Москва, 2007.
6. **Программа развития** электроэнергетики до 2030 года, Постановление Правительства Республики Казахстан от 9 апреля 1999 года № 384, Астана. (http://adilet.zan.kz/)
7. **Программа по развитию** электроэнергетики в Республике Казахстан на 2010 - 2014 годы, Постановление Правительства Республики Казахстан от 29 октября 2010 года № 1129, Астана (http://adilet.zan.kz/)
8. **Прогноз мировой энергетики** 2010. Основные положения. Прогнозы развития каспийского энергетического сектора 2010, IEA, 2010. http://www.worldenergyoutlook.org/publications/weo-2010/)
9. **План мероприятий** по развитию альтернативной и возобновляемой энергетики в Казахстане на 2013 - 2020 годы, Постановление Правительства Республики Казахстан от 25 января 2013 года № 43, Астана. (http://adilet.zan.kz/)
10. **Ветровой атлас** Казахстана, Казахстанская электроэнергетическая ассоциация, Астана, 2007.(www.atlas.windenergy.kz)
11. **Lessons Learnt** from the UNDP-GEF Project «Kazakhstan — Wind Power market development initiative», Astana, 2011 (http://www.undp.kz/library_of_publications/files/7075-25305.pdf)
12. **План мероприятий** по развитию альтернативной и возобновляемой энергетики в Казахстане на 2013 - 2020 годы, Постановление Правительства Республики Казахстан от 25 января 2013 года № 43, Астана, 2013. (http://adilet.zan.kz/)
13. **Охрана** окружающей среды и устойчивое развитие Казахстана 2007-2011, Статистический сборник, Агентство РК по статистике, Астана, 2012. (http://www.stat.gov.kz)
14. **Водно-энергетические ресурсы** Центральной Азии: проблемы использования и освоения, Отраслевой обзор, Евразийский банк развития (ЕАБР), Алматы, 2008. (http://www.eabr.org/general/upload/docs/publication/analyticalreports/obzor_water_final_rus.pdf)
15. **Современное состояние** и перспективы развития малой гидроэнергетики в странах СНГ, Отраслевой обзор №14, Евразийский банк развития (ЕАБР), Алматы, 2011. (http://www.eabr.org/general//upload/docs/AU/%E2%84%9614_2011_Gidroenergetika%20v%20stranqakh%20SNG.pdf)
16. **Руководство** по энергетической статистике, ОСЭР/МЭА, 2007. (http://www.gks.ru/metod/ManualRussian_web.pdf)
17. **Абсаметов М.К,. Муртазин Е.Ж.** Доклад «Роль и место «гидрогеотермальной энергетики» в «Стратегии устойчивой энергетики будущего Казахстана до 2050 года», ТОО «Институт гидрогеологии и геоэкологии имени У.М.Ахмедсафина», Алматы, 2013. (www.group-global.org/ru/storage_manage/download_file/29941)
18. **Сатпаев А.Г., Плеханов П.А., Антипов С.М.** Доклад «Оценка возможностей комплексного использования геотермальных вод в РК», ТОО «Институт гидрогеологии и геоэко-

логии им. У. М. Ахмедсафина» Алматы, 2010. (http://www.myshared.ru/slide/405481/)

19. **Сельское, лесное и рыбное хозяйство** в Республике Казахстан 2008-2012, Статистический сборник, Агентство РК по статистике, Астана, 2013. (http://www.stat.gov.kz)
20. **Жилищно-коммунальное хозяйство** Республики Казахстан 2008-2012, Статистический сборник, Агентство РК по статистике, Астана, 2013. (http://www.stat.gov.kz)
21. **Стратегия** эффективного использования энергии и возобновляемых ресурсов Республики Казахстан в целях устойчивого развития до 2024 года. Постановление Правительства Республики Казахстан от 24 января 2008 года N 60, Астана, 2008. (http://www.stat.gov.kz)
22. **План мероприятий** по развитию альтернативной и возобновляемой энергетики в Казахстане на 2013 - 2020 годы. Постановление Правительства Республики Казахстан от 30 апреля 2013 года № 424. Астана, 2013. (http://www.stat.gov.kz)