ТЕХНИЧЕСКИЕ НАУКИ
И ТЕХНОЛОГИИ

ЭНЕРГИЯ
ЭНЕРГИЯ
ENERGY

DOI 10.51885/1561-4212_2022_1_30
МРНТИ 44.41.01

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RENEWABLE ENERGY POTENTIAL OF KAZAKHSTAN

ҚАЗАҚСТАННЫҢ ЖАҢАРТЫЛАТЫН ЭНЕРГИЯ КӨЗДЕРІНІҢ ӘЛЕУЕТІ

ПОТЕНЦИАЛ ВОЗОБНАВЛЯЕМЫХ ИСТОЧНИКОВ ЭНЕРГИИ КАЗАХСТАНА

Abstract. *2017 was the year when capital of Kazakhstan Astana was hosting EXPO2017 "Future Energy". The preparation for a such big event has stimulated attention of the government to development of its own renewable energy resources. It was planned that to the end of 2020 3% of produced energy would be the energy from renewable energy sources. Towards 2025 it would be produced 6% towards to 2030 it would be 10%. By year 2050 more than 50% should be used from renewable sources. Kazakhstan with its huge territory and not very big population is having great potential for renewable energy production. Most of the territory has sufficient amount for solar energy harvest and also large amount of area with high speed of wind has large potential to produce sufficient amount of wind energy. Such areas as Jungar Gates and Chylyk Corridor are having huge potential for production of energy by wind turbines. Part of Kazakhstan between Balkhash Lake and Aral Sea is not very populated due to shortage of water. At the same time this area has very high level of solar irradiation. It is possible to harvest large amount of solar energy in that area in case of many solar panels arrays installation. The problem, difficult to overcome, would be the maintenance of these solar panel arrays due to low population and poor living conditions. There are at least two major reasons to go for renewable energy development in the country. First one – Kazakhstani leadership is looking into opportunities to change from resource economy (it is one of oil producing countries – it has more than 2 % of world oil reserve and many other resources) to technology driven one. In this case resources will be used to produce different products. Due to that, one of the challenges is to move from fossil fuel driven energy production to alternative sources and the potential is there. It provides users with benefits if they supply energy produced by alternative sources to the grid with preferable rates.*

Keywords: *renewable energy, solar, wind, hydro, biomass, geothermal.*

Аңдатпа. *2017 жылы Қазақстанның елордасы Астана «болашақ энергиясы» ЭКСПО-2017 көрмесін қабылдады. Осындай ауқымды іс-шараға дайындық үкіметтің жеке жаңартылатын энергия көздерін дамытуға назарын аударды. 2020 жылдың соңына дейін өндірілетін энергияның 3 %-ы жаңартылатын энергия көздері есебінен болады деп жоспарланған болатын. 2025 жылға қарай оны 6 %, 2030 жылға қарай – 10 % өндіретін болады. 2050 жылға қарай 50 %-дан астамы жаңартылатын көздерден пайдаланылуы тиіс. Аумағы орасан зор және халқы аз Қазақстан жаңартылатын энергия өндірісі үшін үлкен әлеуетке ие. Аумақтың көп бөлігінде күн энергиясы жеткілікті, сонымен қатар желдің жылдамдығы жоғары үлкен аумақ жеткілікті жел энергиясын өндіруге үлкен әлеуетке ие. Жоңғар қақпасы және Шелек дәлізі сияқты аудандар жел турбиналары арқылы энергия өндіру үшін үлкен әлеуетке ие. Балқаш көлі мен Арал теңізі арасындағы Қазақстанның бір бөлігі су тапшылығына байланысты қоныстанбаған. Сонымен қатар, күн сәулесінің өте жоғары деңгейі*

бар. Бұл аймақта көптеген күн панельдерін орнатқан жағдайда күн энергиясының көп мөлшерін жинауға болады. Халық санының аздығы мен өмір сүру жағдайының нашар болуына байланысты күн панельдерінің осы массивтеріне қызмет көрсету қиын болады. Елде жаңартылатын энергия көздерін дамытудың кем дегенде екі негізгі себебі бар. Біріншісі – Қазақстан басшылығы ресурстық экономикадан (бұл мұнай өндіруші елдердің бірі - оның әлемдік мұнай қорының 2 %-дан астамы және басқа да көптеген ресурстары бар) технологиялық экономикаға өту мүмкіндіктерін зерделеуде. Бұл жағдайда ресурстар әртүрлі өнімдерді өндіру үшін пайдаланылады. Осыған байланысты проблемалардың бірі қазбалы отын негізіндегі энергия өндіруден балама көздерге көшу болып табылады және бұл үшін әлеует бар. Ел Үкіметі Қазақстанда энергия өндіру үшін баламалы көздердің үлесін ұлғайтуды өндірушілер мен тұтынушыларды көтермелеу бағытында заңнама әзірлеуде. Бұл пайдаланушыларға балама көздерден алынған энергияны қалаған тариф бойынша желіге жеткізсе, артықшылық береді.

Түйін сөздер: *жаңартылатын энергия, күн энергиясы, жел, су энергиясы, биомасса, геотермалдық энергия*

Аннотация. *В 2017 году столица Казахстана Астана принимала ЭКСПО-2017 «Энергия будущего». Подготовка к такому масштабному мероприятию стимулировала внимание правительства к развитию собственных возобновляемых источников энергии. Планировалось, что до конца 2020 года 3 % производимой энергии будет за счет возобновляемых источников энергии. К 2025 г. его будет производить 6 %, к 2030 г. – 10 %. К 2050 году более 50% должно использоваться из возобновляемых источников. Казахстан с его огромной территорией и небольшим населением имеет большой потенциал для производства возобновляемой энергии. На большей части территории имеется достаточное количество солнечной энергии, а также большая территория с высокой скоростью ветра имеет большой потенциал для производства достаточного количества энергии ветра. Такие районы, как Джунгарские ворота и Чиликский коридор, имеют огромный потенциал для производства энергии с помощью ветряных турбин. Часть Казахстана между озером Балхаш и Аральским морем не очень заселена из-за нехватки воды. В то же время здесь очень высокий уровень солнечного излучения. В этом районе можно собрать большое количество солнечной энергии в случае установки множества солнечных панелей. Проблема, которую трудно преодолеть, будет заключаться в обслуживании этих массивов солнечных панелей из-за низкой численности населения и плохих условий жизни. Есть как минимум две основные причины для развития возобновляемых источников энергии в стране. Первый - руководство Казахстана изучает возможности перехода от ресурсной экономики (это одна из нефтедобывающих стран – у нее более 2 % мировых запасов нефти и многие другие ресурсы) к технологической. В этом случае ресурсы будут использоваться для производства различной продукции. В связи с этим одной из проблем является переход от производства энергии на основе ископаемого топлива к альтернативным источникам, и потенциал для этого есть. Правительство страны разрабатывает законодательство в направлении поощрения производителей и потребителей к увеличению доли альтернативных источников для производства энергии в Казахстане. Это дает пользователям преимущества, если они поставляют энергию, произведенную из альтернативных источников, в сеть по предпочтительным тарифам.*

Ключевые слова: *возобновляемые источники энергии, солнечная энергия, ветер, гидроэнергетика, биомасса, геотермальная энергия.*

Introduction. Kazakhstan, officially the Republic of Kazakhstan is a transcontinental country which is located in Asia and Europe. At the same time, it is the world's largest landlocked country, with an area of 2,724,900 square kilometers (1,052,100 sq mi) see Fig. 1. Kazakhstan is ninth largest in the world country [1, 2]. In the Central Asia economically Kazakhstan is dominant, generating around 60 % of region's GDP. This comes mainly from oil, gas, and mining industries. Kazakhstan was the last of the Soviet republics which has declared independence during the dissolution of the Soviet Union on 16 December 1991 [3].

The population of Kazakhstan is over 19 million people as of now. Considering its large land area and population, its population density is among the lowest, at less than 7 people per square kilometer (18 people per sq. mi.). As the country extends across two sides of the Ural River,

Kazakhstan is the country that has territory in two continents Europe and Asia. [1, 2] The capital of Kazakhstan is Nursultan, the city which has been rebuilt starting in 1997 on the site of Tselinograd city, small regional Centre at that time. The former capital of Kazakhstan was Almaty, the country's largest city. Nursultan is very modern and fast developing city. In recognition of fast economic development of the country, On November 22, 2012 Astana (at that time was the name of the Capital) was chosen by the International Exhibitions Bureau (BIE) as the venue to host EXPO-2017, which supposed to be focusing on future energy issues [4]. The exhibition has been opened 10 June and was operating until 10 September 2017. The preparation towards to EXPO 2017 has created much of attention to renewable energy development in Kazakhstan. Kazakhstan government planned to move towards to “green energy” achieving overall energy generated by renewable sources 3 % by 2020, 10% by 2030, and 50% by 2050. It is possible to achieve, as country has huge potential for development of renewable sources of energy. Especially good and prospective resources are wind, small hydro, and solar resources [5, 6]. Reasonably prospective is also to develop biomass and geothermal sources. Kazakhstan's territory is occupied from the Caspian Sea on west to the Altay Mountains on east and from Western Siberia on north to the oases, deserts and Tian Shan Mountains of Central Asia on south. The plain area of the Kazakh Steppe, with an area of around 804,500 square kilometers (310,600 sq mi), occupies one-third of the country and it is the world's largest dry steppe region. This area is characterized by grasslands and sandy regions. There are a number of water reserves, including the Aral Sea, Lake Balkhash and Lake Zaysan, the Charyn River and gorge and the Ili, Irtysh, Ishim, Ural and Syr Darya rivers [1, 2].

Figure 1. Map of Kazakhstan

Country is very rich in mineral and fossil fuel resources. Development of petroleum, natural gas, and mineral extractions, has created large portion of country’s GDP and attracted over $40 billion in foreign investment in Kazakhstan since 1993. The extraction of these resources created around 57% of the nation's industrial output (or approximately 13% of gross domestic product). Kazakhstan is rich on many minerals such as: uranium, chromium, lead, and zinc reserves, manganese, copper, and ranks in the top ten for coal, iron, and gold. It is also an exporter of diamonds. Kazakhstan also currently has the 11th largest proven reserves of both oil and natural gas [3].

Materials and methods of research.

Electricity sector of Kazakhstan

The electricity sector of Kazakhstan is one of the most important sectors of the national economy. Energy sector has changed quite substantially since country has declared its independence. A number of energy enterprises have been privatized and many of them have been restructured. Whole energy sector has received sort of freedom in establishment of own wholesale and retail markets with the freedom to certain extend own tariffs. The competition developed in this sector in many cases brought increase of electricity tariffs and establishment of local monopolies. There are also other players at the local energy market at the same time. They are mainly: The Unified Power System (UPS) of Russia and Central Asia. The UPS of Kazakhstan is conditionally divided into three zones: Northern Zone (Akmola, Aktobe, Kostanay, Pavlodar, North Kazakhstan, East Kazakhstan, Karaganda regions); Southern Zone (Almaty, Zhambyl, Kyzylorda, south Kazakhstan regions); and Western Zone (Atyrau, west Kazakhstan, Mangystau regions). The electricity sector of Kazakhstan includes the following major subsectors: electricity generation, transmission, supply and consumption [7, 8].

Energy market of Kazakhstan is consuming currently around 100 billion kWh (kilowatt-hours). During Soviet era maximum consumption was recorded in 1990 (104.7 billion kWh [kilowatt-hours]). After dissolution of USSR the level of electricity consumption was reduced to 50.7 billion kWh in 1999. It has happened due to closure of many enterprises and huge downturn of industry. The industry is peaking up now and due to that energy consumption is steadily growing by about 5 % per year on average. In 2015, electricity consumption in Kazakhstan returned to about the same amount as 1990 and continues to grow. At the same time energy generation is slightly prevailing over consumption about 2 %. Large part of part of the electricity sector's assets was built long time ago and is in need of modernization due to natural wear (service life from 40 to 60 years). That requires significant investment. Most of the electricity generation is happening at the old type of power plants. Mainly traditional power stations are dominating in the energy sector in Kazakhstan. Most of these power plants are fossil fuel fired. There is great amount of fossil fuel resources widely available and used at the most of power generating facilities [5, 8].

Until 2010 Kazakhstan used to export energy to neighboring countries and after 2010 started to import energy as the local capacity did not satisfy growing demand. The north of the country is selling power to Russia from Ekibastuz and south of Kazakhstan is purchasing it from Kirgizstan and Uzbekistan [5]. Currently generation of energy is fully covering demand of Kazakhstan industry.

Renewable energy resources of Kazakhstan

Kazakhstan has initially joined to Kyoto Protocol and latter to Paris Agreement and is moving towards reduction of greenhouse effect, especially after the event when capital of Kazakhstan city Astana was hosting EXPO 2017 "Future Energy". Preparation to this event has generated many new projects dedicated to use of the green energy and reduction of energy generation with use of the fossil fuel. Renewable energy in Kazakhstan has great opportunity to be generated. The amount of energy generated by the renewable sources could be stored with use of the batteries and also by pumping water to storage of the hydro power stations to meet high demand during the peak hours [20].

Due to large territory of Kazakhstan renewable energy potential of it is great. Potentially most of the renewable energy sources are available: wind, solar, hydro, and biomass. Unfortunately,

until now all these sources are not developed widely. Mainly only hydropower plants are sufficiently producing energy in Kazakhstan. The amount of that in the total energy generation was in 2012 about 12% [5]. In Table 1 renewable energy resources and their usage are represented.

Table 1. Renewable energy potential and use in Kazakhstan [5]

Capacity	Energy resources					
	Hydro Power Plants		Solar	Wind	Bioenergy	Geothermal
	Large HPP	Small HPP				
Available in operation	8.5 billion kWh	0.54 billion kWh	0.3 billion kWh	0.3 billion kWh	3 million kWh	Heating of houses
Technical Potential for installation	105 billion kWh	65 billion kWh	3.9 – 5.4 billion kWh	1820 billion kWh	3.5 billion kWh	0.02 billion kWh free flow

Hydropower plants. Kazakhstan is having much of natural capacity of hydropower. Hydropower plants can generate in theory total amount of 170 billion kWh per year and only small portion of that is in use. Main rivers are Irtysh, Ili and Syr-Darya. The most economically suitable resources are located at the east of the country (Altay Mountains) and south of the country. In these areas are located large and medium size Hydropower Plants: Bukhtarma HPP, Ust-Kamenogorsk HPP and Shulbinsk HPP at Irtysh River, Kapchagay HPP at Ili River, Shardara HPP at Syr-Darya River, and Moynak HPP at Charyn River. There are in Kazakhstan 15 large hydropower plants (>50 MW) today. There are also a number of small HPP operating in Kazakhstan. The overall generating power of all large and small hydropower plants is about 2500 MW and they produce over 8 Billion kWh per year. Small HPPs (below 35 MW) are located mainly in the southern region facing the deficit of energy. The electricity cost produced by these small HPP is low and they are able to cover the energy deficit existing in that region. Small hydropower plants are also environment friendly and could be located close to the consumers. All hydropower plants account for up to 13 per cent of the country's total generating capacity [9].

Other renewable energy sources. Total renewable energy sources (RES) wind, solar, biogas, geothermal produce around 1 % of energy generation. At the same time Kazakhstan has the potential of wind, solar, hydrothermal power and the hydro power of small rivers which exceeds 1 trillion kWh per year (about 10 times the energy consumption in the country). Apart from partial use of hydro power, the potential for RES is not used sufficiently in Kazakhstan. However, wind and solar power resources in the country are stable and acceptable for the economic, viable generation of electricity. The main goal is to increase the share of these sources in the energy mix of the country [6].

Wind power. Kazakhstan is very much suitable for wind energy applications. Economically possible is to generate about 760 GW. Most of territory has average wind speed suitable for energy generation (4 – 6 m/s).

In the Kazakhstan wind map Fig. 2 we can see that the most suitable for wind energy generation are three sites; one on the north of the country and two on the south Jungar Gates and Chylyk Corridor with wind speed 5 to 9 m/s. Last two sites have wind potentials of 525 W/m2 and 240 W/m2 respectively. The total wind energy potential in Kazakhstan is estimated to be from 0.929 to 1.82 GW. There are a few wind power stations already in operation: Yerementau with 45 MW, Kordayskaya with 21 MW, and K -1 with 1.6 MW capacities. Large number of projects is planned to be built in high wind speed areas: Jungar Gates 50 MWt, Chylyk Corridor

51 MWt, Ulan region of East Kazakhstan oblast 24 MWt and others. The most prospective regions in Kazakhstan for wind power plants are west (Caspian Sea region), central, and south part [10, 11, 12].

Solar power. Kazakhstan has large area with high insolation that could be suitable for solar power generation especially in the south part of the country see Fig 3. Most of these parts of area are having from 2200 to 3000 hours of sunlight per year. Such length of sunlight can produce from 1200 to 1700 kW/m2 annually.

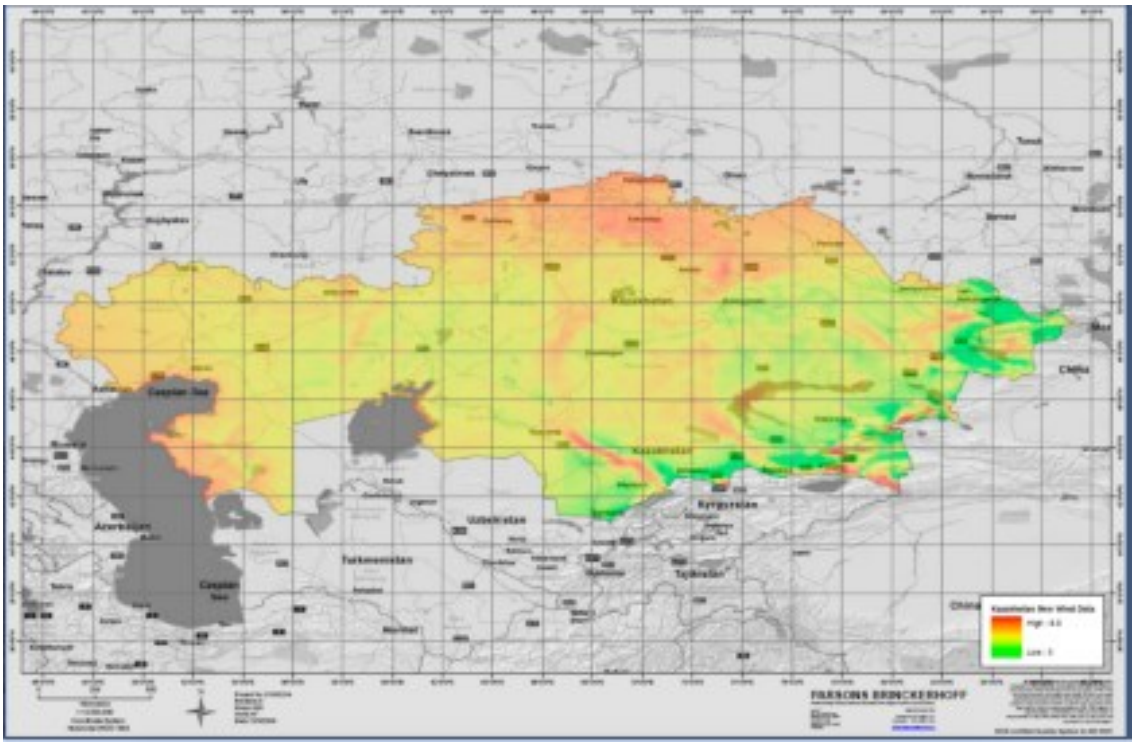

Figure 2. Kazakhstan wind map

Up to 2.5 billion kWh per year is possible to generate potentially from Solar Power Plants. This is suitable for use of both solar thermal (concentrated) and solar photovoltaic (PV). South Kazakhstan, Kyzylorda oblast and the Aral Sea region are the most suitable to build solar power plants. In the large desert areas, it would be most favorable to build solar thermal plants as they can store the energy in the form of heat. This is most efficient compare to batteries storage of the energy. These thermal plants can provide energy on demand, even after the sun has set, enabling both base and peak loads to be met. There are a few solar power plants installed in Kazakhstan: Burnoe with 50 MW, Kapshagayskaya with 2 MW, Otar with 0.5 MW capacities. Solar thermal project was financed by UN and in 2002 to install 50 prisms of solar power plant with capacity 100 liters of water each using water from Syr Darya River to provide heating and drinking water for residents of two villages in the Aral region. According to the Plan of Activities for Alternative and Renewable Energy in Kazakhstan 28 solar energy projects will be implemented until end 2020 with total installed capacity of 713 MW.

Bioenergy. Kazakhstan has 76.5 Mha agricultural lands, 10Mha forest and 185Mha steppe

grasslands providing a lot of biomass wastes and residues. All that can provide the potential to generate bioenergy. Kazakhstan is producing and exporting different crops with average grain yield of 17.5 – 20 Mt. That produces roughly 12 – 14 Mt of biomass wastes. Currently biomass wastes are poorly used and not much of the residues are used also. It is known that at least 400000 households keep cattle, horse and sheep. It is estimated that electricity potential from biomass can be as much as 35 billion kWh per year and also can produce about 44 Gcal per year. There is only one large scale biogas unit in operation which is a biogas plant at Vostok village in the Kostanai region until now. This plant was installed with the aim to deliver 3 million kWh of electricity annually [14].

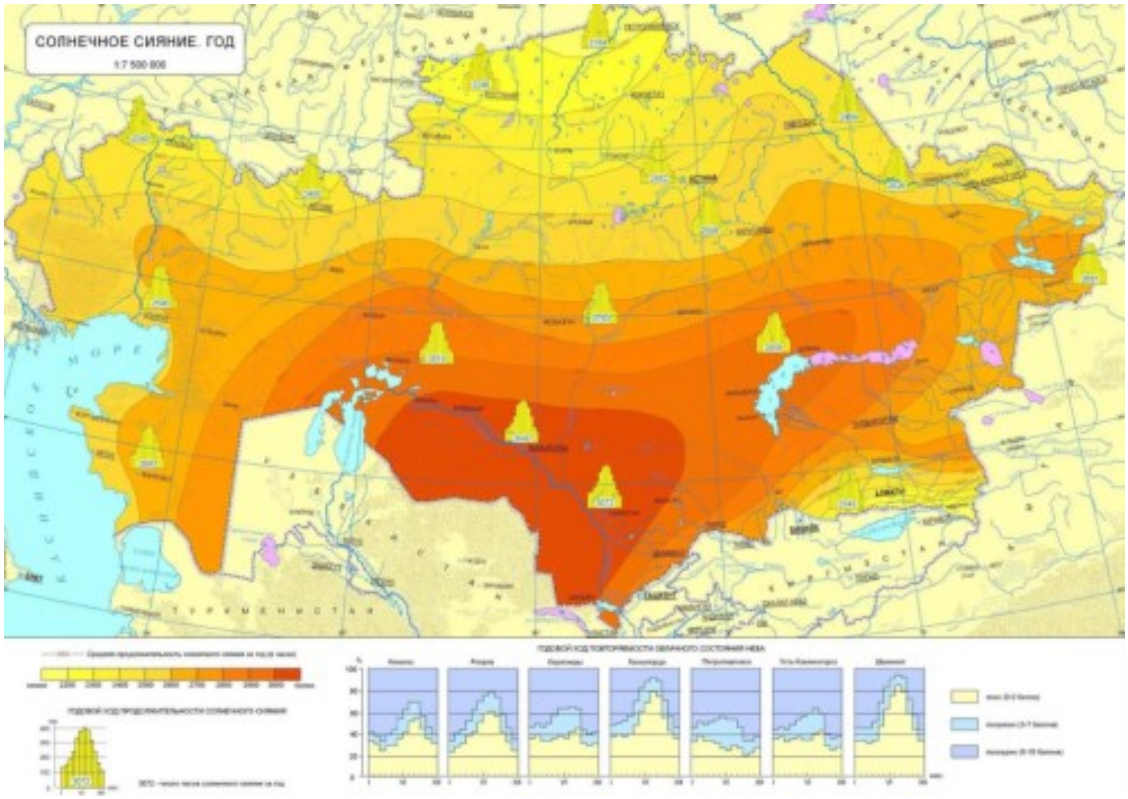

Figure 3. Map of solar activity in Kazakhstan

Geothermal resources. There are a number of large resources of middle- and low-temperature thermal water in Kazakhstan. These sources with thermal water temperature of 80 °C are used mainly for heating of residential buildings and as in case of thermal water resources (temperature 80-120 °C) near the city of Almaty are used for heating greenhouses in winter and for air-conditioning in summer [5, 15] see Fig. 4.

State support for the renewable energy generation

Kazakhstan has become very active in the creating sustainable environment just after getting independence. Country is a participant of the United Nations framework convention on climate change (UNFCCC) (since 1995). Kazakhstan has ratified the Kyoto Protocol to UNFCCC in 2009, and recently has signed Paris Agreement on Climate Change thus committing itself to reduce greenhouse gases. Development of renewable energy sources is regarded as one of the most

efficient methods of mitigating the harmful impact of energy sector activities on the environment. All the activities related to building renewable energy sources are part of the Program for Accelerated Industrial and Innovative Development. Appropriate legislation was developed to stimulate production of energy by renewable sources. Development of renewable energy was declared as one of the priority directions of establishing the future economy sectors. The use of RES is regulated by the Law of the RK on Support to the Use of Renewable Energy Sources, adopted in 2009 and updated in 2013 [16, 17].

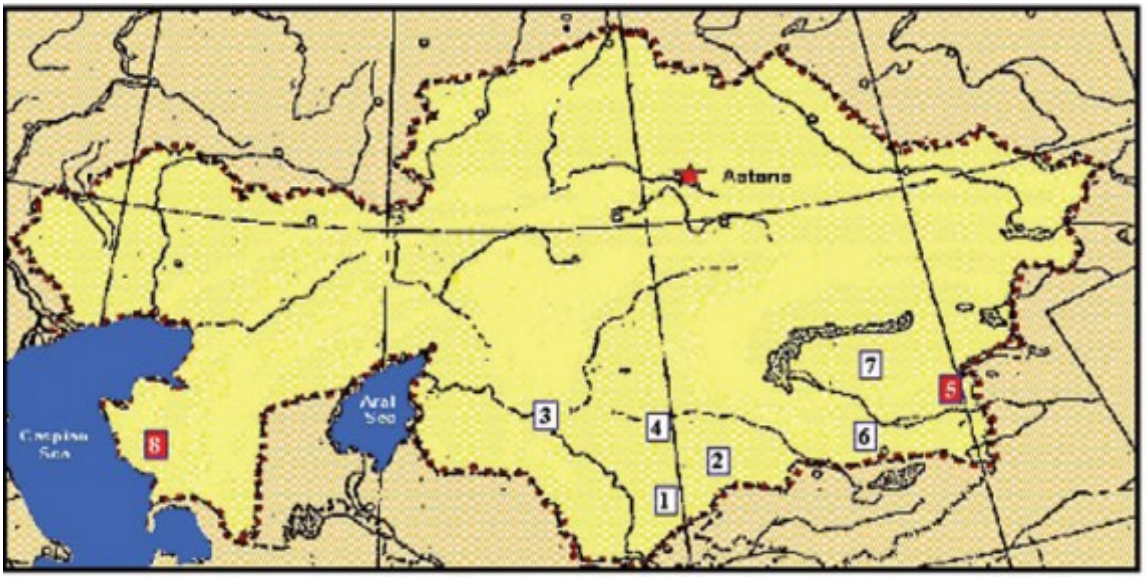

Figure 4. Main thermal water areas in Kazakhstan

This Law of RK on Support to Use of RES provides for economic mechanisms of support to the RES development and sets forth the basic principles of state regulation of RES use.

Article 9 of the Law on Support to Use of RES states that the regional power grid companies have the responsibility for the connection of the RES capacities to grids and the purchase of all electricity generated from RES by respective generation companies. In addition, such RES generation companies are exempt from payment for power transmission services. [17]

The law also provides for a number of incentives for these generation companies, including feed-in tariffs and connection of new facilities to the existing power grids.

Government of Kazakhstan Regulation (25 January 2013 N43) on Planning of Renewable Energy Development in Kazakhstan during 2013 – 2020 requires to complete 31 RES projects with total capacity of 1040MW including 13 Wind Power Plants – 793 MW, 14 Hydro Power Plans – 170 MW, and 4 Solar Power Plants – 77 MW.

In general moving towards green economy Kazakhstan government aims for the share of renewable energy in domestic electricity generation to rise to 10% by 2030 and 50% by 2050.

Government has guaranteed to purchase all the energy generated by RES using higher tariffs with yearly corrections to make attractive renewable energy generation.

Conclusions.

In spite of great renewable energy potential in Kazakhstan to implement that potential is necessary to overcome a number of barriers which are still pulling back renewable energy generation.

These barriers are: low electricity tariffs; transmission losses and inefficient technologies; weak regulatory and legal frameworks to stimulate the use of renewable energy in the electricity sector; persistent governmental body reforms; inadequate levels and quality of scientific support; awareness and information barriers; and a high-risk business environment. Development of alternative energy in Kazakhstan is constrained also because implementation of such projects requires bigger initial capital investments and recoupment period is going to be longer. Considering local conditions when the hydrocarbon resources of Kazakhstan are relatively inexpensive the government should create the conditions when the investors would be economically interested in such projects to make the investments in renewable energy profitable. Due to high cost of investment in construction of renewable energy facilities, their development as well as purchase and installation of equipment, direct project financing from the republican and local budgets may be considered as a possible stimulus.

Good practice would be beneficial if investment in renewable energy facilities will be done through public-private partnership. Such arrangement may be quite effective as the investment risks in this case are proportionally divided between the government and the private partner. The private party could be responsible for operational costs and management of the facility. In case of such cooperation the national economy will have the facility at a lower cost and the amount of investment from the business partner could be also reasonable. Public investment will reduce the tariffs because private partner will need to recover only its expenditure, so the cost of energy will be considerably lower.

Government also can introduce tax breaks for investments in the renewable energy investments as this is area of priority for the country. This type of incentive can stimulate “green” energy technology development. Development of “green” energy technology in the future will be also beneficial due to increasing cost of mineral resources extraction and also decreasing their resources.

Having such rich renewable energy potential and government desire to move towards to alternative energy Kazakhstan has all the factors to build “green” economy. Very good stimulus in the motion of the country towards that direction plays EXPO2017 “Future energy” which has been opened in capital of Kazakhstan 9 June 2017. This three month exhibition has shown commitment of the country to principles of “green” economy approach.

References

1. Kazakhstan. CIA World Factbook.
2. Encyclopedia Britannica, Kazakhstan: Introduction
3. Zarakhovich, Yuri (27 September 2006). "Kazakhstan Comes on Strong". Time. Retrieved 13 December 2015.
4. https://expo2017astana.com/en/
5. Energy Charter Secretariat, “Investment Climate and Market Structure Review in the Energy Sector of KAZAKHSTAN”, report, 2013
6. Renewable Energy Snapshot, UNDP report, 2013
7. Marat Karatayev, Michèle L. Clarke, “A review of current energy systems and green energy potential in Kazakhstan”, Journal of “Renewable and Sustainable Energy Reviews”, 55 (2016). – pp. 491–504.
8. KazEnergy report website: http://www.kazenergy.com/kz/2-44-45-2011/1473-2011-07-29-17-55-58.html
9. http://bourabai.kz/toe/kazenergy.htm; http://www.windenergy.kz/rus/articles/2/page/1/17
10. "Prospective of windpower development in Kazakhstan". UNDP-GEF. Retrieved 5 May 2016.
11. "Wind Energy". KZgreenenergy.com. Retrieved 5 May 2016.
12. Bolotov A.V., Bolotov S.A., Schoolnik V.S., “ Unlimited resources of alternative power”, Kazakhstan Power & Renewable Energy Investment Conference, Astana, 20 – 21.04.2016.

13. Development of solar energy in Kazakhstan: reality and prospects http://astanasolar.kz/en/news/ development-solar-energy-kazakhstan-reality-and-prospects
14. Marat Karatayev, Michèle L. Clarke, “Current energy resources in Kazakhstan and the future potential of
15. renewables: A review”, Energy Procedia, 59, 2014, pp. 97 – 104.
16. Eugene Hong, “Future of Renewable Energy in Kazakhstan”, Kazakhstan Institute for Strategic Studies, “Delovoi Kazakhstan”, 1.06.2012
17. Rystay Tuleubayeva, “Example of a Government Support Program Based on Fixed RES Tariffs”, Ministry of Energy of the Republic of Kazakhstan, 2016
18. “ABOUT SUPPORT OF USE OF RENEWABLE SOURCES OF ENERGY”, Law of the Republic of Kazakhstan, 4July 2009
19. Websites for RES development: http://strategy2050.kz/ru/news/1567; http://www.windenergy.kz/; https://articlekz.com/article/13881
20. Websites for government support for RES: http://www.gratanet.com/ru/publications/details/2210a; http://www.gratanet.com/uploads/user_7/files/Zakonodatelstvo_v_oblasti_vozobnovlyaemykh_istochnikov_ene.pdf; https://online.zakon.kz/Document/?doc_id=30445263; https://www.zakon.kz/4680246-zakonodatelstvo-v-oblasti.html
21. Sayan Kombarov Interview to Economist Journal: Renewable Energy Sources in Kazakhstan. 2021.