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Faculty of Electrical Engineering
Department of Electrical Power Engineering (13115)

Bachelor Thesis

Possibilities of usage of Wind Power in the Republic of Kazakhstan

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Study program: **Electrical Engineering, Power Engineering and Management**
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1. Theoretical overview of Renewable Energy Sources
2. Introduction to Wind Power
3. The potential of WP in the energetical and economical sectors of Kazakhstan
4. The possibilities of development of WP in Kazakhstan

Bibliography/Sources:

[1] Law of the Republic of Kazakhstan "About support of use of renewable sources of energy"
[2] Rules of purchase of electricity at the qualified power generating organizations
[3] Wind resource of Kazakhstan - Wind Atlas. PB Power. 2009 PB Power

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Declaration

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Abstract

At present, there is increase in the use of various types of renewable energy sources (RES) in the world. This is connected with changes in the new trend of global energy policy, that emphasis the importance of transition to green energy and its resource-saving technologies.

International organizations like the United Nations (UN) and others alike, pay significant attention to this issue. The European Union (EU) allocates significant amount of funds for the research and development of RES. There is also increase in the number of international symposiums, conferences and meetings devoted to the development of research in this area.

Renewable energy sources is the best solution at this present time to produce power because crude oil is expensive and harmful to the environment, it is sustainable and more economical than other sources of energy. Hence, this work investigates the technical approach to the research, development and use of wind energy technology in this present time. It further discusses the economical and potential use of wind energy in different regions of Kazakhstan. This is aimed at having the possibilities of developing RES in Kazakhstan, based on wind energy, according to the climatic, economical and legal conditions, available in the region.

Abstrakt

V současné době je nárůst v používání různých typů obnovitelných zdrojů energie (OZE) na světě . To je spojeno se změnami v novém trendu globální energetické politiky , která klade důraz na význam přechodu k zelené energii a jejích technologií šetřících zdroje .

Mezinárodní organizace jako Organizace spojených národů (OSN) a další podobně věnuji velkou pozornost této problematice . Evropská unie (EU) přiděluje značné množství finančních prostředků na výzkum a vývoj obnovitelných zdrojů energie . K dispozici je také zvýšení počtu mezinárodních sympozií , konferencí a setkání věnovaných rozvoji výzkumu v této oblasti .

OZE je nejlepším řešením nyní k výrobě elektrické energie , protože je to udržitelné a ekonomicky výhodnější než jiné zdroje energie, například ropa je drahá a škodlivá pro životní prostředí . Proto tato práce zkoumá technickou přístup k výzkumu, vývoji a využití energetických technologií větru v této současné době . Dále pojednává o ekonomické a potenciální využití větrné energie v různých regionech Kazachstánu . Tato je zaměřena na který má možnosti rozvoje OZE v Kazachstánu , na základě větrné energie v závislosti na klimatických , ekonomických a právních podmínek použitelne v regionu .

Contents

1 Intoduction

Current sustainable social and economical development of the Republic of Kazakhstan is described by year-to-year increase of Gross Domestic Product, which amounts to 8 per cent. Oil and gas and mining industries are the main contributors to such increase in GDP. The government has adopted state programs on economic diversification and agriculture and non-fossil fuel production development. The focal target set by the President for Kazakhstan is to become one of the top-30 world competitive countries[3].

In the meantime the economic development of the country is marked by huge energy consumption. The indicators for specific energy consumption per GDP amount to 2 toe/1000USD, and exceed corresponding indicators of OECD countries. Energy consuming economy leads to irrational use of fossil-fuel resources, reduces competitiveness, substantially contaminates environment. The Industrial Innovative Development Strategy of Kazakhstan focuses on reduction of energy consumption by half to 2015. The energy sector consumes significant energy resources causing considerable environmental contamination. Kazakhstan is the third largest emitter of energy related greenhouse gases emissions per GDP (6.11 kg CO_2/USD) [3]. As a party to the United Nations Framework Convention on Climate Change Kazakhstan is about to ratify Kyoto Protocol and accept the commitment to reduce greenhouse gases emissions. Thereupon in order to provide sustainable social and economic development Kazakhstan demands efforts to improve energy efficiency and protect environment. Introduction of the renewable energy sources is one way to reduce fossil-fuel consumption and may add to mitigation of bad environmental impacts.

2 Fundamentals

2.1 RES. History of development

The history of the alternative energy sources dates back to ancient times. In fact, any new fuel, discovered by humans, became alternative to the old ones at some period of time. For example, in the Middle Ages coal became an alternative to wood, which people commonly used earlier to heat their houses and cook food.

However,nowadays we put a new meaning into the term “alternative energy”. Today alternative energy is that derived from the sources, which do not deplete or exhaust natural resources and do not harm the environment. Modern understanding of the alternative sources of energy appeared about 1970th, when the most developed countries first felt the shortage of gas.

Wind power technology dates back many centuries. There are historical claims that wind machines, which harness the power of the wind date back beyond the time of the ancient Egyptians. Hero of Alexandria used a simple windmill to power an organ whilst the Babylonian emperor, Hammurabi, used windmills for an ambitious irrigation project as early as the 17th century BC. The Persians built windmills in the 7th century AD for milling and irrigation and rustic mills similar to these early vertical axis designs can still be found in the region today. In Europe the first windmills were seen much later, probably having been introduced by the English on their return from the crusades in the middle east or possibly transferred to Southern Europe by the Muslims after their conquest of the Iberian Peninsula. It was in Europe that much of the subsequent technical development took place. By the late part of the 13th century the typical ‘European windmill’ had been developed and this became the norm until further developments were introduced during the 18th century. At the end of the 19th century there were more than 30,000 windmills in Europe, used primarily for the milling of grain and water pumping [4].

2.2Modern position of RES in the World

Practical use of alternative energy sources today received intensive development in many countries .

Amid growing population, reducing the world's proven many fossil fuels, increasing the prices of hydrocarbons and aspirations of countries to reduce dependence on imported raw materials, interest in the use of new energy sources increases.

The renewable energy sources (RES) are product of natural processes : energy from solar radiation , wind energy, water energy hydrodynamic ; geothermal energy : heat the soil , groundwater, rivers , reservoirs , biomass, biogas and other fuels from organic waste used for the production of electricity and (or) thermal energy. Using of renewable energy has become one of the fastest growing sectors of the economy. In the leading countries of the European Union (EU), according to the International Energy Agency (IEA), energy production from renewable energy sources is growing annually by 10-20%[10].

One of the leading position by level of development of RES taking Germany, that produce almost all kinds of RES. In 2004, Germany adopted a special law («EGG») which provides for expanding the share of renewable energy in electric power industry in 2020 to 35% in 2030 - up to 50%. In 2011 the figure was 20%.

The total capacity of solar power plants in the world exceeded the threshold of 100 GW, according to the European Photovoltaic Industry Association (EPIA). During 2012 the EU set new photovoltaic cells capacity of 17 GW. About half of this increase (8 GW) provided Germany. For comparison, the total power of the European wind energy over the same period increased by 12 GW, and gas-fired plants - 5 GW[5].

2.3 Wind power - one of the main types of RES

Wind power is renewable and produces no greenhouse gases during operation, such as carbon dioxide and methane.

Wind energy has been used for hundreds of years by windmills to pump water or grind grains. Airflows can be used to run wind turbines. Modern windmills – wind turbines are used to generate electricity. They are mounted on a tower at the height of 100 feet (30 meters) aboveground to advantage from faster and less turbulent winds. The turbines use two or three propeller-like blades mounted on a shaft to capture wind's energy.

Today, the wind power is most popular among alternative sources of the electric energy, but not so far to make a real competition to traditional sources. Besides, the lack of the information has an effect in society: nobody wants to think about ecologically clear future for next generations.

It has been undeservedly forgotten in 20-30 years of XX century in case of industrial boom and unstopping growth of megalopolises, when it was necessary for energy more and more cheaply. Besides in that time, wind force did not associate to process energy reception, though, it was possible already. Wind energy was considered as an auxiliary means, for example, winds - pumps for water from chinks at the country farms, or as an exotic way for pleasant sea travels under a sail.

The wind energy renascence beginning is in 60-70 years of the twentieth century. It was caused by appreciable price rise of traditional energy reception and comprehension of the ecology problems, especially in large cities and industrial centers. Besides, in a number of regions with population growth and increase of volumes of current energy consumption, electricity has begun catastrophically to not suffice consumer requirements. The misbalance between manufacture and consumption could make 30-40 %, and even all 50 %.

Technical progress is one more factor that has influenced on renewal interest to a wind power. It is paradoxical - the forgotten old technology returning to the market due to development of other new technologies, in sphere of construction and industrial manufacture especially. Imagine huge blades of a rotor, which is established on a tower reaching 80 or even 120 meters of height and the transfer mechanism inside rotating generator, which makes electricity.

Due to what a hundred years the people went under a sail, ground a grain and pumped water from underground, today it can provide us with the electric power and thus, rather cheaply. The simple wind can be used to make useful and necessary job for us, as before, during all history. The kinetic wind power can be changed in other forms of energy, in mechanical and then in electrical.

The acceptable force wind (from 6,5-7 м/s) blows in many regions of earth. As a matter of rule, it should be more then this speed to rotate turbines quickly enough and to make the electric power. Today it is possible to get and to use the separate turbine of average capacity for a private house, farm or village school. It gives quite enough energy for this purpose. The modern turbines of average capacity make from 50 up to 300 k/Wt. usually. The turbine of 300 k/Wt. (300,000 Wt.) can give energy for 3000 bulbs on 100 Wt. each. There is only problem with a wind; it does not blow with constant force and in the same direction all the time. So, if you have decided to get wind turbine for personal needs, it is better to consult with weather forecast in your area[8].

But even in case of all nuances of wind energy, today there are no doubts any more, that it really has helped many people and enterprises with reduction of their expenses on the electric power. That is the reason to think about purchase of this equipment for an own house or business as not so auxiliary but basic source of power supply. That occurs already in many regions of a planet. Though, the turbines depend on a wind, extremely, but their electric power is not connected to the prices for coal, petroleum and services of the companies - suppliers of the electric power.

The situation in the fuel market can develop differently, but for the users of a wind power, the price on kW/t. always remains the same. Missing details, there are two basic cost parameters: compensation of expenses on purchase / installation (cost efficiency) and expense for service. The keeping money positive experience on the electricity bills is in the united States already - conducting country on use of this energy sources type and Germany also, Holland and other countries.

Thus, the wind power turbines are considered by the experts as one of the most effective energy means today , by the cost option, especially, for the consumers (private persons and enterprises), which want to be really independent from negative tendencies of the energy market in the long term. When this very specific and unusual industry segment (for the CIS countries) will be developed enough, it will be an opportunity of competitive prices market formation. And it will be one more real alternative to expensive and not safe traditional sources of the electric energy.

Areas where winds are stronger and more constant, such as offshore and high altitude sites, are preferred locations for wind farms. This could require large amounts of land to be used for wind turbines, particularly in areas of higher wind resources. Offshore resources experience mean wind speeds of ~90% greater than that of land, so offshore resources could contribute substantially more energy[7].

A wind farm is a group of wind turbines in the same location used for production of electric power. A large wind farm may consist of a few dozen to several hundred individual wind turbines, and cover an extended area of hundreds of square kilometers, but the land between the turbines may be used for agricultural or other purposes. A wind farm may be located off-shore to take advantage of strong winds blowing over the surface of an ocean or lake.

2.4 Types and construction of Windmills

A wind turbine is a machine for converting the kinetic energy of wind into mechanical energy. If the mechanical energy is used directly by machinery, such as a pump or grinding stones, the machine is usually called a windmill. If the mechanical energy is then converted to electricity, the machine is called a wind generator.

Wind turbines are classified into two general types: horizontal axis and vertical axis. A horizontal axis machine has its blades rotating on an axis parallel to the ground. A vertical axis machine has its blades rotating on an axis perpendicular to the ground.

There are a number of available designs for both and each type has certain advantages and disadvantages. However, compared with the horizontal axis type, very few vertical axis machines are available commercially.

Figure 1 Vertical Axis Wind Turbine (HAWT) and Horizontal Axis Wind Turbine (HAWT) [4]

2.4.1 HAWTS

A horizontal Axis Wind Turbine is the most common wind turbine design. In addition to being parallel to the ground, the axis of blade rotation is parallel to the wind flow. Modern HAWTs usually feature rotors that resemble aircraft propellers, which operate on similar aerodynamic principles, i.e., the airflow over the airfoil shaped blades creates a lifting force that turns the rotor. The nacelle of a HAWT houses a gearbox and generator. HAWTS can be placed on towers to take advantage of higher winds farther from the ground.

The capture area of a HAWT, the area over which the sweeping blades can “capture” the wind, is given by

$$\mathrm{A} = \boldsymbol{\pi}(\boldsymbol{D}/\mathbf{2})^{\mathbf{2}} \qquad \textbf{(2.4.1)}$$

where **D** is the rotor diameter. However, this capture area must face directly into the wind, to maximize power generation, so HAWTS require a means for alignment (yawing mechanism) so that the entire nacelle can rotate into the wind. On smaller wind, a tail vane provides a “passive” yaw control. In large, grid-connected turbines, yaw control is active, with wind direction sensors and motors that rotate the nacelle[6].

2.4.2VAWTS

Although vertical axis wind turbines have existed for centuries, they are not as common as their horizontal counterparts. The main reason for this is that they do not take advantage of the higher wind speeds at higher elevations above the ground as well as horizontal axis turbines.

There are two main types of VAWTs, the Savnoius and the Darrieus. The Savonius operates like a water wheel using drag forces, while the Darrieus uses blades similar to those used on HAWTS. VAWTs typically operate closer to the ground, which has the advantage of allowing placement of heavy equipment, like the generator and gearbox, near ground level rather than in the nacelle. However, winds are lower near ground level, so for the same wind and capture area, less power will be produced.

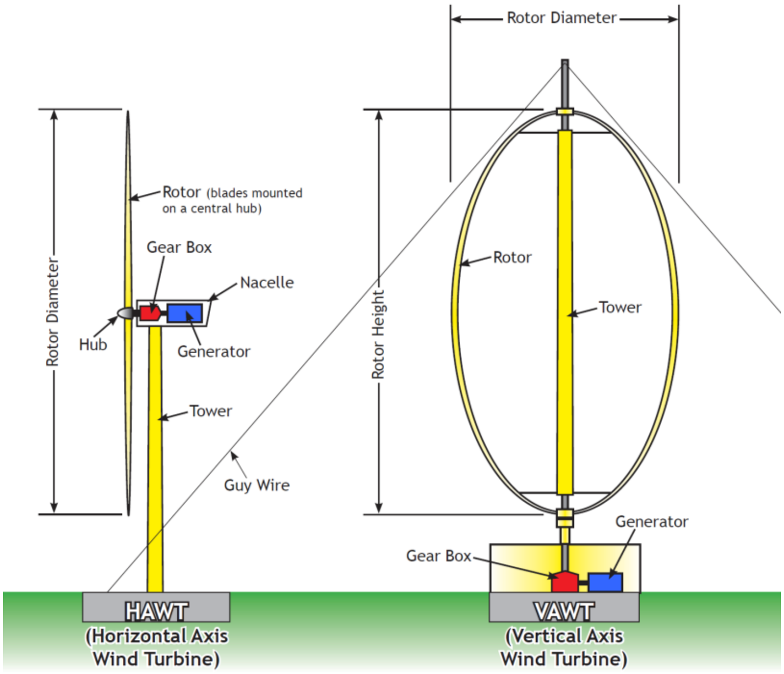


Figure 2 Structure of HAWT and VAWT [4]

Another advantage of a VAWT over the HAWT is that it doesn't require a yaw mechanism, since it can harness wind from any direction. This advantage is outweighed by many other disadvantages, including: time varying power output due to variation of power during a single rotation of the blade, the need for guy wires to support the tower and the fact that Darrieus VAWTS are not self-starting like HAWTS[9].

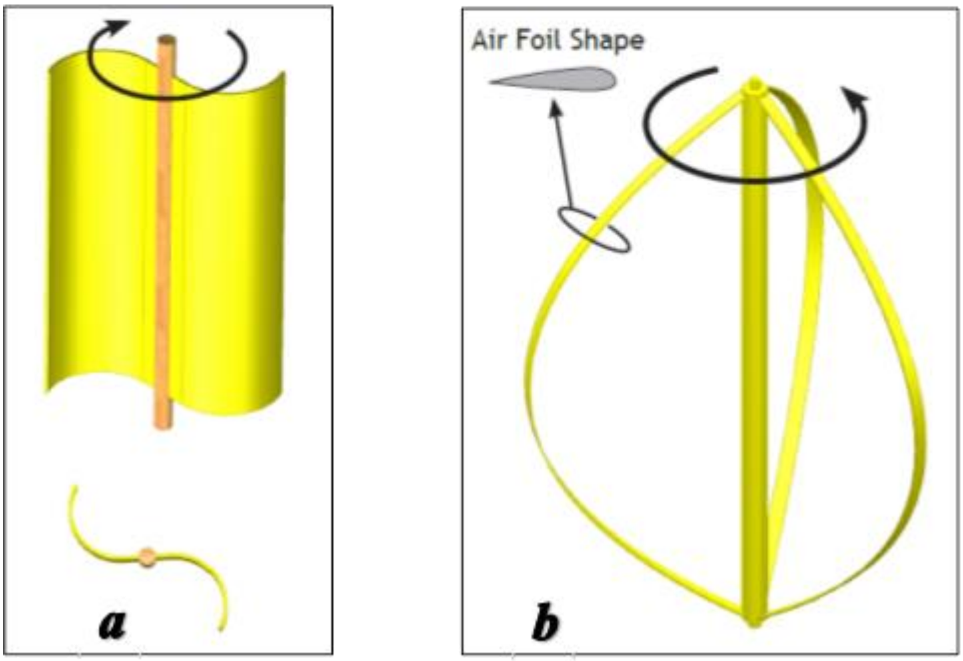


Figure 3 Structure of rotors of The Savonius turbine (a) and The Darrieus turbine (b) [4]

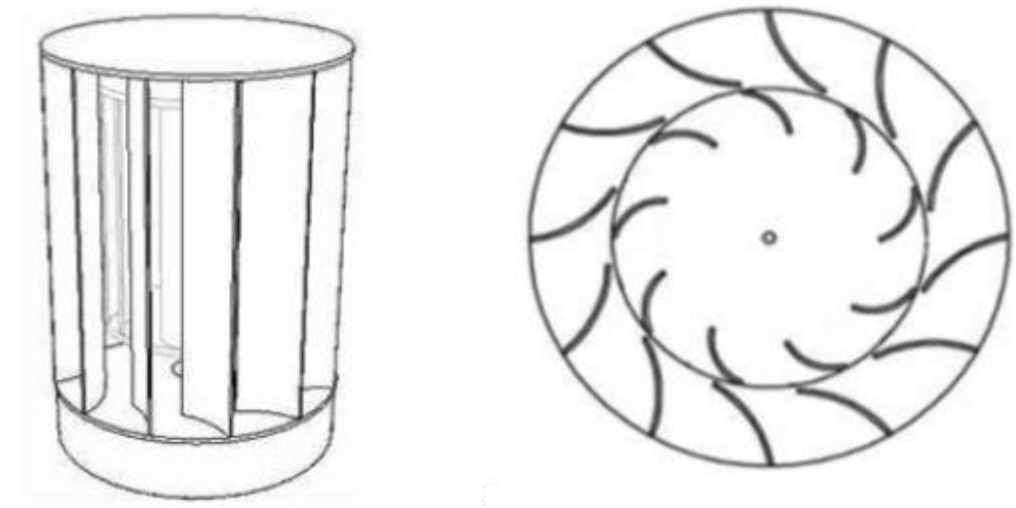
There is another modern type of VAWT desighned in Kazakhstan and named after its inventor Albert Bolotov a Bolotov turbine. One of the most significant features of this type of turbine is its combination of a wing and the principles of sail. Vertical - axis wind turbine consists of a stationary external part - the stator and a rotating rotor located inside, whose blades form active and reactive stage turbine. The guide vane has a plates, evenly spaced around the perimeter, the rotor blades also equally spaced around the perimeter.

Operation of the turbine does not depend on wind direction. With respect to the incident from either side of the air flow turbine has two sides: lee – an active turbine stage and windward - reactive turbine stage. In the turbines stator on the active side the air is compressed by the guide unit and sent to the rotor blade.

The force is under the influence of pressure on the concave surface acts on the rotor blade, creates in sail mode a torque of turbine and providing a high starting torque of the rotor.

A lift force appears on the convex surface of the blade is perpendicular to velocity vector of vane, airflow rotates blade in a circle.

From the design considerations, the height of the turbine is divided into separate "modules" height of 2-3 meters. Installation of modules to each other is provided in accordance with the specific wind conditions to obtain the required power [11].



A B

Figure 4: General view of a turbine (a) and stator section having 12 blades and a rotor having 9 blades (b) [11]

Wind farm with vertical-axial turbines have a large number of advantages compared with propeller turbines:

- No dependence of producing power on the wind direction
- Ability to work in conditions of gusty and hurricane winds;
- The generator connects directly to the rotor and has no complicated gears;
- The ability to use several rotors in one generator;
- The presence of the guide unit increases the power density of rotor up to 2,5 times in comparison with the open rotor;
- No external moving parts.

Besides the above advantages, in result of a combination of principles of wing and sail, the Bolotov turbine has a small starting torque, which allows this construction to work at small and large wind speed in the mode of sail and wing respectively.

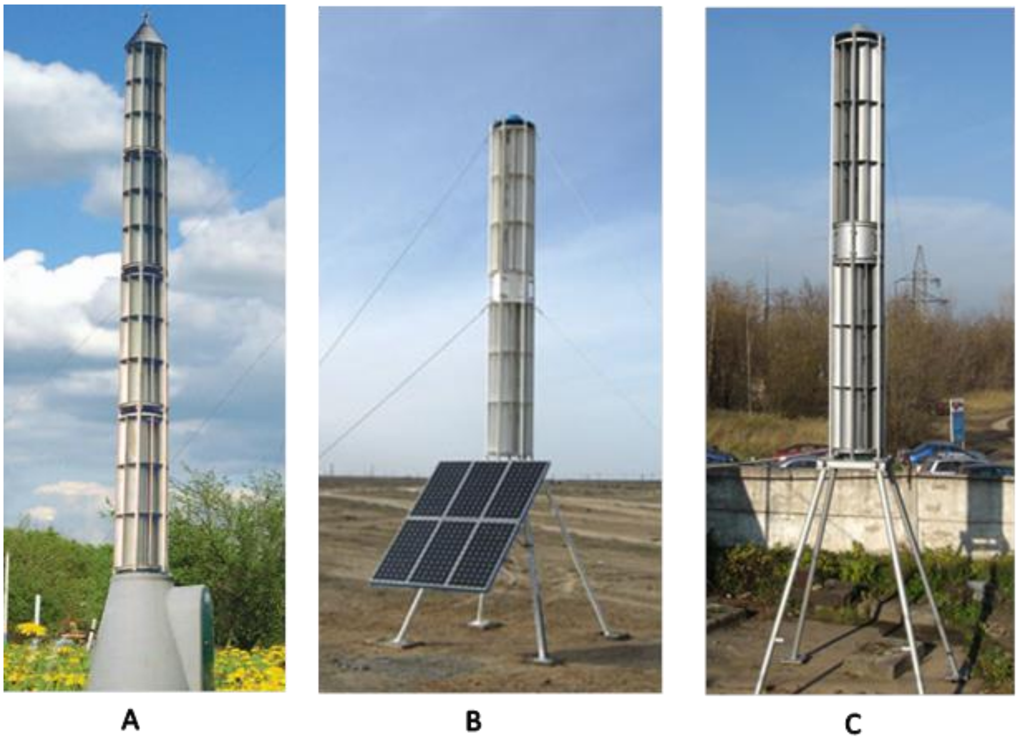
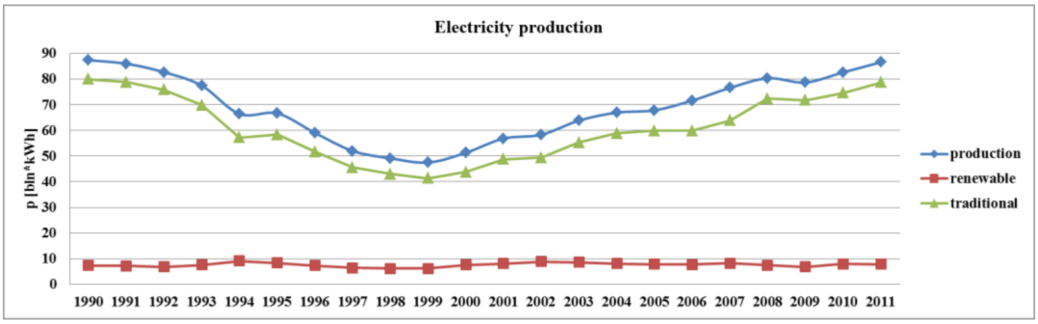


Figure 5: General view of Bolotov wind stations. Power plant "Wind", 5kW (A); Power plant "Wind+Sun", 2 kW (B); Power plant "Wind", 1 kW (C) [18]

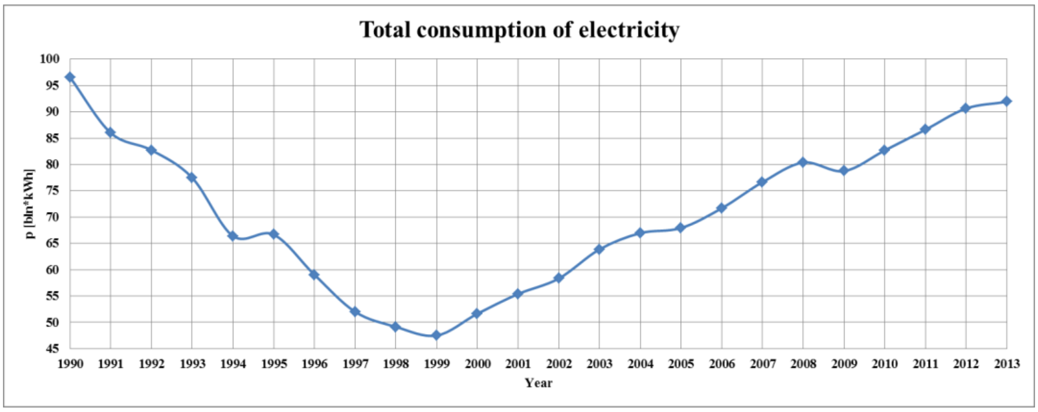
2.5 Modern situation of the energy and economic sectors of Kazakhstan

The energy sector is one of the most developed of the Kazakhstan economy. The Republic of Kazakhstan benefits from resources of fossil fuel, its reserves of which constitute 4% of the world fuel resources. In the year 2003 the total production of the energy resources in Kazakhstan formed about 105 millions toe, which exports amounted to 55 million toe and domestic consumption formed about 50 million toe. The share of coal in the consumption of energy forms about 67%, oil - about 21%, gas - about 12%. The main consumer of fuel in Kazakhstan is the production of energy and heat. Annual consumption of the fuel by this sector forms about 25 millions toe. In the structure of the fuel balance for electricity stations coal constitutes 75%, gas 23% and black oil 2%.

Kazakhstan currently produced a little less power than consumed. Such indicators are acceptable in the world. Graph 1 and 2 show the production and consumption of electricity in Kazakhstan in recent years.



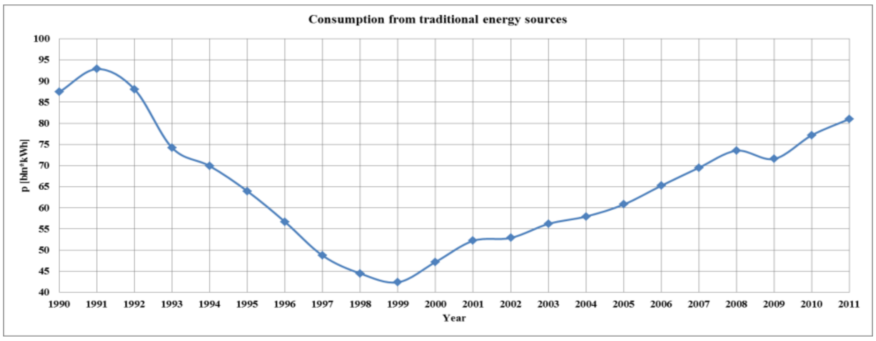
Graph 1 the dynamic of electricity production



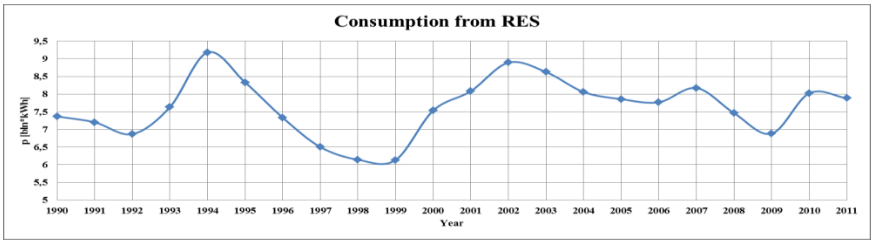
Graph 2 the dynamic of electricity consumption

Kazakhstan possesses significant resources of renewable energy in the form of hydro energy, solar energy and wind energy. The potential of hydro energy is assessed to be 170 million kWh per year and wind energy 1820 million kWh per year. However besides a small share of hydro energy in energy balance of the country (about 8 million kWh per year) these resources haven't achieved a wide application until the present time.

The total installed capacity of electricity stations is about 18.5 GWe. Thermal power stations form 15.42 GWe, or 87% from the total capacity, the share of hydro stations is about 12%, and others about 1%. In Graphs 3 and 4 located below we can see the difference between the consumption of electricity from traditional energy sources and RES.



Graph 3 Consumption of electricity from traditional energy sources in Kazakhstan



Graph 4 Consumption of electricity from renewable energy sources in Kazakhstan

The main installed generation capacities of Kazakhstan are concentrated in the central part of the republic, in the Karaganda, East Kazakhstan and Pavlodar provinces. They are the main power suppliers. Therefore, some regions of the country still import electricity since it becomes more reasonable in terms of economical and technical factors. A surplus of generated electricity is exported to the neighboring countries throughout the interconnected grid systems.

According to the Ministry of Industry and New Technologies (MINT) of the Republic of Kazakhstan to the territory of Kazakhstan are the most promising renewable energy sources following [12] :

- wind energy (929 billion kWh per year);
- energy of water (total hydro - 170 billion kWh per year technically possible to implement - 62 billion kWh per year , of which about 8.0 billion kWh per year - the capacity of small hydropower plants) ;
- solar (photovoltaic systems and solar collectors , solar energy potential is estimated at 2.5 billion kWh per year; promote the development of solar energy in the world 's largest reserves of silicon feedstock (85 million tons)) .

The total potential of renewable energy is very significant and valued at more than $ 1 trillion. kWh per year.

One of the issues, concerning all Kazakhstan regions, is of the supply of energy to remote rural consumers. The large scale of the territory of Kazakhstan and low the density of population in rural area means that significant rural transmission lines extension is necessary, which currently forms about 360 thousands km. Maintenance of the power circuits for such an extension, as well as significant losses (25-50%) of energy transmitted will greatly increase energy cost. Analysis shows that the real cost of power transported to remote consumers with small capacity may reach up to 5 cents/kW/h, which makes energy supply of remote small consumers economically unfeasible.

An economic alternative for power supply to remote consumers would be distributed small scale generation using renewable sources of energy. However, this potential remains unrealized.

3 Theoretical analysis

3.1 Regional climatic conditions of Kazakhstan

The climate of Kazakhstan is temperate continental, relatively dry. Air temperature varies during the whole day and year. The average annual rainfall approximately 100-500 mm per year. Continental climate is manifested in a number of features. These include: large amplitude between winter and summer temperatures, dry air, a small amount of precipitation in most parts of the country, long harsh winters and short summers in the north and a short winter and long hot summers in the south. Kazakhstan's geographic location in relation to latitude corresponds to the Mediterranean countries, have a humid subtropical climate, as well as the countries of central Europe with a temperate continental climate. Since Kazakhstan is located in the center of the vast continent of Eurasia, at considerable distances (thousands of kilometers) from the oceans and seas, their moderating influence on the climate is negligible.

The country is in the temperate zone . In summer the weather is hot, mostly rain and cold winters with little snow . The country clearly expressed 4 seasons. Winter in Kazakhstan on average begins in November and lasts until April. Air dry and cold winter. Basically is a clear frosty weather and blowing wind. The invasion of Arctic air masses come frosts to - 50°C. In this winter thaw possible. Spring in the country begins in mid-April and ends in May. In this spring weather is very changeable. In just a few days warm, clear weather can turn cold snap. The temperature difference may be 10 °C or more. Summer begins in late May and lasts until mid-September. Summer air dry subtropical climate of Central Asia invading country sets hot, dry weather, and the temperature can rise up to 40 °C. While, as the humid warm air masses of the Indian Ocean are being blocked mountain systems of the Tien Shan, Pamir, Himalayas, and the Iranian plateau. Autumn starts in late September and lasts until the beginning of November. Autumn the weather is more stable than in the spring.

3.2 Wind power potential

Kazakhstan is exceptionally rich in wind resources. About 50% of Kazakhstan’s territory has average wind speeds about 4-5 m/sec at a height of 30m, the deminimus figure for good technical potential wind energy development. In some estimates the wind potential of Kazakhstan forms about 1820 billion KW/h per year spread over the significant territory of Kazakhstan.

Kazakhstan belongs to the III and IV groups of wind speed values, and has more than ten locations with average annual wind speeds of 8-10 m/s, which are rich in "deposits" energy. Most windy sites are located in Caspian sea area in Atyray and Mangistay regions, in center of Kazakhstan in Akmola, Karaganda oblasts and some areas in the South of Kazakhstan. A country wide-wind atlas is available(Fig. 5). With a density of wind capacity about 10 MW/sq.km there is a possibility to install thousands MW of wind farms in Kazakhstan. For example, in Djungar Gates – wind potential is estimated as 525W/m2, in Chylyk corridor is about 240W/m2 accordingly. Power production of wind turbines in these places could achieve 4400kW/h/MW and 3200kW/h/MW respectively. The data confirm about excellent wind potential in Djungar Gates and good wind potential in Chylyk Corridor. Both sites are considered as very perspective for large wind farm construction[12].

The fundamental consideration of rational investors when assessing an opportunity is the nature of the risk-return balance. Crucial to controlling commercial risk is a stable, transparent and enforced policy, legal and regulatory framework which outlines the rights and responsibilities of actors, defines Government support and describes enforcement measures and penalties for non-compliance. Investors must be confident that laws and regulations upon which they base their decisions will be enforced this means that, to inspire investor confidence, the legal and regulatory framework must be attractive and the country must nurture a reputation of stability and legal enforcement. A fundamental document is the National Wind Power Development Program for Kazakhstan to 2015 with a perspective until 2030[3].

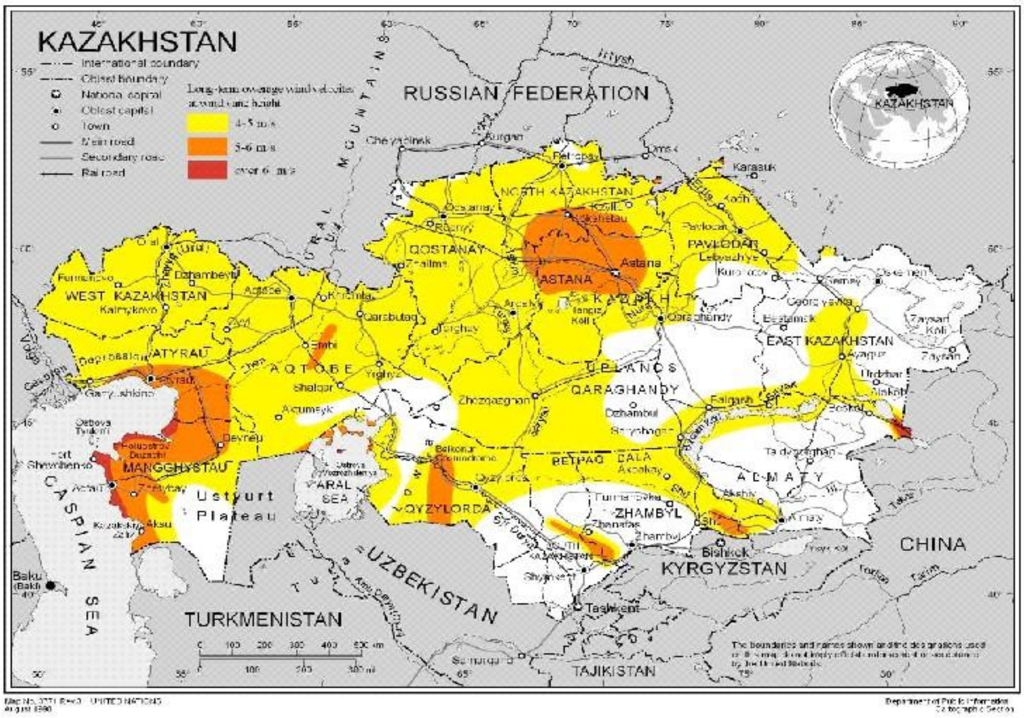


Figure 6: The wind atlas of the Republic of Kazakhstan

3.2.1 The National Wind Power Development Program

The Ministry of Energy and Mineral Resources (MEMR) and the UNDP-GEF Initiative prepared a National Wind Power Development Program for Kazakhstan to 2015 with a perspective until 2030 in 2008. It should be noted that the MINT took over responsibility for Kazakhstan's energy policy (excluding oil and gas policy issues) from the former MEMR during the course of this Project [12].

The objective of the Program is to achieve a target of 750 million kWh of electricity generation from wind energy in Kazakhstan by 2015 and 5 billion kWh by 2030. This production figure equates to approximately 250 MW and 2000 MW respectively.

The Program aims to achieve these targets by fulfilling the following goals:

- Development and implementation of legal and technical documentation for wind power sector development
- Designing and implementation of activities to install wind power capacities by 2015 with perspective until 2030
- Support of small-scale wind power generation
- Development of scientific, technical and industrial base of wind power sector
- International cooperation under Program of wind power development

The Program briefly outlines the three-stage approach to achieving these goals and what may be the expected outcomes of successful implementation of the Program. The Program is an ambitious first attempt to outline a clear national development program for wind energy. There were developed 3 Laws (2 pre-existing and one developed with the support of the Project) and 4 Rules that define the legal basis for wind farm development in Kazakhstan (shown in Table 1).

Laws
The RES Law
Law on Investments (pre-existing)
Law on Power Industry (pre-existing)
Rules
Rules for the Purchase of Electricity
Rules for Connection to the Grid
Rules for Monitoring RES
Rules for Considering Feasibility Studies

Table 1: Main Legal and Regulatory Instruments

3.3 Possibilities of using different modern technologies according to the wind force in regions

According to research the centralized energy system of Kazakhstan has a balancing act. This facilitates the integration of wind energy as possible to ensure maximum effect of smoothing volatility of wind energy : the total wind power generating capacity used in Kazakhstan will rarely be above 80% or below 10% of total installed capacity .

Forecast scenarios for wind power generation provide about 250 MW per year in 2015 and about 2000 MW in the year 2030 level of integration of wind energy in the total power output will be less than 1 % of total electricity production in 2015 and about 4% in 2030 [17].

There are a lot of factors prompt a need for immediate actions including renewable energy development in Kazakhstan. Today or tomorrow, renewable energy aims to take a stable place in the energy balance of the Republic, before the time when all of its vast mineral resources will run out.

One of the most importunate problem are losses about 25-50% on the line because of the very large distances between power suply. The geographical position of the Republic of of Kazakhstan is in a wind zone of the northern hemisphere, and on large parts of Kazakhstan are sufficiently strong air flows, especially the northeast and southwestern directions. In some areas of Kazakhstan the annual average wind speed is more than 6 m/s, making these areas attractive for wind energy development. Research of wind energy potential in regions of Kazakhstan, carried out under the UNDP project on wind energy, show the presence of a good wind potential for the construction of wind farms in the southern zone (Almaty, Zhambyl, South Kazakhstan region), in the Western zone (Mangistau and Atyrau region), Northern Zone (Akmola region) and the central zone (Karaganda region). The construction of windfarms will provide electricity to remote areas, reduce the network load and decrease the losses on the line. In table below shown potencial localizations of offshore wind farms, average wind speed and a estimated productivy.

№	Site name	Region	Average yearly wind speed [m/s]	Recommended capacity of WF, [MW]
1	Zharminskaya	East-Kazakhstan	**5,6**	**40**
2	Yereimentau	Akmolinskaya	**5,4**	**35**
3	Seleyinskaya	Akmolinskaya	**5,9**	**40**
4	Balkhash	Karagandinskaya	**4,4**	**10**
5	Ulitau	Karagandinskaya	**5,4**	**10**
6	Arkalyk	Kustanaiskaya	**5,7**	**10**
7	Sakryl	West-Kazakhstan	**5,2**	**10**
8	Atyrau	Atyrausskaya	**4,4**	**40**
9	Akkystau	Atyrausskaya	**5,5**	**50**
10	Inder	Atyrausskaya	**5,4**	**20**
11	Prorva	Atyrausskaya	**6,2**	**40**
12	Fort-Shevchenko	Mangystausskaya	**6**	**40**
13	Kurdai	Zhambilskaya	**5,1**	**20**
14	Aralsk	Kyzylordinskaya	**4,9**	**10**
15	Karmakchinskaya	Kyzylordinskaya	**5,5**	**20**
16	Djungar Gates	Almatinskaya	**7,5**	**50**
17	Chylyk corridor	Almatinskaya	**5,8**	**100**

Table 2 The list of prospective sites for wind farms construction[17]

For HAWT wind farms the most suitable areas are Djingar Gates and Chylyk corridor, beacause both localization are natural wind tunnels. This characteristic means that there is a permanent direction of wind. Thus, in Chylyk corridor the average wind speed is about 5.8 m/s at the height of 10m with a generation potential of 240W/m^2 and in Djungar Gates – 7.5m/s and 525W/m^2 accordingly. Energy production from wind turbines in these places could achieve 3200kW/h/MW and 4400kW/h/MW respectively. The data confirm about excellent wind potential in Djungar Gates and good wind potential in Chylyk Corridor. Both sites are considered as very perspective for large wind farm construction. The UNDP project on wind energy continue carry out detailed wind study on most promised sites in Kazakhstan in order to prepare wind potential assessment and the Kazakhstan wind atlas. The data will be used for the feasibility study for wind farm construction and applying small wind installation [13]. Occurrences of extreme temperatures in winter below – 20º C usually require winterization of industrial equipment operated in Kazakhstan.

The temperature differences and fluctuations are high due to climatic conditions in Kazakhstan. Hence, air density changes significantly throughout a year. This factor may affect the operation of some wind turbine systems such as pitch settings. Therefore, it is necessary to give preference to wind turbine models designed to operate in big temperature ranges. SgurrEnergy suggested that the low temperature Vestas LT V 80 2 MW option may be suitable as it can normally operate at ambient temperatures ranging from -30 º C to 30 º C, while -40 º C is permissible for non-operational conditions. If temperature drops below – 20 º C, the turbine is equipped with separate heaters that can raise temperature inside the nacelle [15].

Bladed wind turbine (horizontal-axis) begins to produce current when the wind of 3 m/s on and off with the wind over 25 m/s. Maximum power is achieved at a wind of 15 m/s. Output power is proportional to the third power of wind speed at the wind increases twice from 5 m/sto 10 m / s, the power is increased by eight times .

The most efficient design for areas with low speed wind flows recognized wind generators, vertical rotation axis, so called. Rotary or carousel. The principal difference of the vane rotor of the generator is that the generator is sufficient vertical 1 m/sto begin generating electricity. Now more and more made of such plants as not all consumers living onshore, and inland wind velocity is generally in the range of from 3 to 12 m/s. In this mode, the efficiency of the wind vertical installation is much higher. It should be noted that the vertical wind turbines there are several significant advantages: they are virtually silent, and do not require absolutely no maintenance, a service life of over 20 years. Braking system, developed in recent years, guarantee the stable operation even under periodic squall gusts up to 60 m/s.

Because of changeable wind direction in a big part of country, the VAWT are very perspective in Kazakhstan as well. For private onshore energy production could be used the Bolotov wind turbine, which has a good advantages in compare with HAWT:

- High efficiency during low wind speed
- Independence of wind direction
- High starting torque
- Relatively good productivity in case of private objects

In case of offshore meteorological stations or agriculture farms a construction “Wind+Sun” of the Bolotov turbine usage is very perspective. Enterprises of the Republic of Kazakhstan and the Russian Federation are jointly developing, manufacturing and commissioning of complex IES energy systems with a basis on wind turbine rotor, model range 2 - 20 kW.

They are equipped with solar inverters and batteries, smart chargers, and protective equipment requirements for autonomous object, providing a reliable supply of energy to consumers [14].

3.4 Possibilities of future development of Wind Power in Kazakhstan

Using RES - a new technology in the energy sector of the Republic and all stations will be new.

To speed wind farm construction investment attractiveness is needed, it means that their equipment must be cheap. Hence, they should also be produced in the country. This has obvious advantages: saving the currency, develop and upload their own production, creates jobs, reduces the costs of shipping the equipment to the site. This reduces the cost and thus the price for electricity . All this reduces the risk of a financial crisis.

There are two ways for the production of equipment in the country - the license, or the use of domestic technologies. Preferably the second one and such possibilities are available.

For the most efficient development of suitable wind sites in Kazakhstan, it is necessary not only to use imported technologies, but also to develop and implement technical solutions that would be most responsive to their features and would be free from the above drawbacks. Such turbines should be characterized by a low cost, high capacity and performance, ease of construction, installation and maintenance, as well as accessibility to the production enterprises of Kazakhstan.

The development of such technological solutions will allow introducing a mass production of high power turbines for large-scale development of wind energy potential of the most perspective wind sites in Kazakhstan for the general industrial and private consumers.

Of course tower and wind turbines can be used in Kazakhstan. However, the high cost of imports and the need to subsidies of high tariffs can make green development uneconomical and unsustainable.

To successfully create a green industry in Kazakhstan should elaborate a strategy for the development, which would allow to achieve structural and price competitive advantage, enable you to create long-term benefits and added value for all stakeholders and society at large.

Despite the fact that wind power today belongs to the most economical sources of energy, it still needs government support. This support should be guaranteed in the procurement tariffs for this type of electricity. Established by law tariffs are necessary to banks agreed to allocate credits for the construction of new wind turbines.

Kazakhstan President Nursultan Nazarbayev outlined in Kazakhstan development Strategy for 2050 the main tasks for organization and content of EXPO 2017 exhibition and participation in its work of scientists and businessmen engaged in renewable energy industry as the energy of the future [16].

Large financially viable state funded investments into quickly erected and paid back inexpensive wind power stations must encourage implementation of such projects and enhance energy and ecological security of the country. Manufacture of renewable energy equipment in Kazakhstan will lead to growth of national GDP and create unlimited and reliable market for electric power. These measures will foster sustainable development and deter negative effects of global financial instability as well as contribute to the realization of Strategy 2050.

A victory in the struggle for the right to host the World Expo «EXPO- 2017 " is main event forcing of the development of RES and WP of Kazakhstan .

The topic of the exhibition EXPO-2017 - "Energy Future " adresses one of the most urgent and important issues of our time, thrilling the entire world community sustainable use of energy. Achieving sustainable development, which is a healthy balance between development and the environment at the moment is an important goal for all countries of the world.

Astana will become a platform to showcase the worlds best developments and trends in the industry, that will atract world scientists and businessmans. An exhibition can give a powerful impetus to diversification of our economy, modernization of production capacities and knowledge base to attract investments to the country.

EXPO-2017 will open new horizons in the development of the domestic economy in the sectors of renewable energy and new technologies.

4 Conclusions

The Republic of Kazakhstan consumes large amounts of electricity to maintain stable industrial growth, per unit of Gross Domestic Product (GDP). Her irrational power consumption causes significant environmental pollution and decreases competitiveness of the country's economy. The environmental issues in Kazakhstan are many and this call for concern and her current electricity production is not sustainable.

The Government realizes this challenge and she has already began addressing it in several of her developmental programs. One of the solutions of sustainable development of Kazakhstan's energy sector is the introduction of environmental friendly technologies such as wind power. The oil and gas sector will play an important role in terms of increasing investments and improving the economy of the country. But the country does not want to rely solely on the development and production of oil and gas alone, but the revenue from oil and gas should help other sectors of the economy to develop and grow.

However under the current conditions of growing electricity deficiency and aging of the main generation plants in Kazakhstan, it is clear that the country has to introduce some new installed capacities in the near future. New power plants will be required to be designed according to modern environmental regulations that are stricter nowadays than they used to be when most of the old plants were built.

The share of coal power plants in the energy balance is very large, but is not sustainable in terms of environmental impact and life quality indicators. This could be partially replaced by renewables energy sources that would drastically reduce these factors to a minima level .

It is highly desirable to produce ecologically clean electric power with minima cost. This must be encouraged irrespective of the escalating price of fossil fuel energy sources, such as coal, gas and oil.

Due to the current environmental issues, such as global warming, air and land pollution, the growing consumption and the cost of traditional sources of energy,, there is increase in the challenge of achieving sustainable development, i.e. the most economical and efficient use of natural energy resources to meet our needs, now and in the future.

One way to achieve sustainable development is the use of alternative or renewable energy sources, such as wind, solar and hydro power, which is in abundance in Kazakhstan. Sustainability of economic development can only be achieved through the production of bulk products with high added value in the development and diversification of non-commodity export potential of the industry. Renewable energy sources available in Kazakhstan fully meet this criteria.

One of the most suitable kind of renewable energy sources is air flow. According to the MINT the annual potential of wind power in Kazakhstan is about 929 bln kWh. Kazakhstan's half territory has an average annual wind speed of 4-5 m/s and in some areas, the wind speed is 6 m/s or more, which means very good prospects for the use of wind energy in the country.

In Kazakhstan, the temperature could ranges from -40 ^{0}C to +50 ^{0}C in various regions. According to meteorological observations, the highest constancy of wind speed observed in the effective area of the city of Balkhash - 62 % (this equates to a total of 228 days in a year) . In Petropavlovsk - is 59.2%, or 220 days, Pavlodar - 50.6 %, Atyrau - 55.2%, Aktau - 51.5% and Astana - 48.2%. Wind energy development also involves real financial and technical support from the state. Currently, Kazakhstan has already begun work on the construction of wind farms. However, the installation of wind turbines requires a significant investment. In this regard, and the government is in full support of this project..

This year, President Nursultan Nazarbayev signed the Law "On amendments and additions to some legislative acts of the Republic of Kazakhstan on supporting the use of renewable energy." The new amendments create the conditions for the implementation of individual user's surplus of electric energy in the public network.

According to this document, the setting of fixed tariffs for the purchase of electricity from all facilities using renewable energy sources. Thus, the fixed tariff for electricity from wind power plants in 2014 was approved in the amount 19 kzt per 1 kW/h.

In order to develop and use renewable energy sources, the state reimbursed 50 % of the costs of RES installations not exceeding 5 kW for the individual user without having to connect to networks. This will greatly stimulate the production of renewable energy sources in Kazakhstan market and protect domestic producers.

Individual customers located in remote areas of the country , are provided with assistance in the form of compensation from the state, half of their acquisition costs for the use of renewable energy installations is taken care of by the Kazakhstan government.

This thesis analyzed the potential conditions of development of Wind Power in Kazakhstan, according to the climatic and economical views. The governmental will play a very big role in the support and development of the various sectors of RES. The laws and rules about RES adopted last year envisage good possibilities of the technological and economic development of an alternative energy market with WP in common, special attention should be paid to small wind farms construction. While large wind farms development and construction should also be in focus for a balance and stable energy in the country.

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