PROBLEMS OF DEVELOPMENT OF RENEWABLE ENERGY FACILITIES IN RURAL REGIONS ON EXAMPLE OF KAZAKHSTAN

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Abstract. This manuscript presents an overview of the difficulties and problems with the development of the renewable energy sources in the rural regions of Kazakhstan. At the beginning a brief overview of the available renewables and their potential evaluation based on the publicly available tools in the rural regions of Kazakhstan is presented. Problems of the development of the renewable energy facilities in the rural regions can be divided into two groups: organizational and technical. The first group is more connected with renewable energy (RES) development programs and strategies. Kazakhstan's programs and strategies for the renewables development, their benefits and lacks are analyzed in the paper as well. One of the most important technical issues with the renewable energy development and wide application in rural regions can be identified as a grid connection barrier and unit commitment problem. The origin of this problem is based on the nature of the renewable energy facilities – variable generation. The technical solutions of the problem are analyzed in the article and can be classified into three groups: precise choosing of the type of the renewable energy facility; using electrical energy storage systems; solving the unit commitment problem and overcome grid connection barriers. We showed that there is a possibly of a significant growth of the renewable energy development and production in the rural area of Kazakhstan and there are several ways of breaking the "wall" of technical issues.

Keywords: renewable energy, rural regions, grid connection, unit commitment, energy storage.

Introduction

Kazakhstan's energy system still remains as a part of the United Energy system which was formed during the Soviet era. In 1990's heavy industry started to decrease the energy consumption because of some difficulties in the economy of Kazakhstan. Funding from the state was reduced, electricity prices rose, and investment in industry is increasingly lacking. As a result, it slowed the renewal of fixed assets of electric power, and increased wear to the mid-1990s (the time of the reforms) reached 50 %. This has no doubt influenced agricultural development and rural living standards [1].

In the recent years, the electric power industry of Kazakhstan has undergone radical transformation: forming a new legal and regulatory framework, changing the structure of the industry, gradually forming a competitive electricity market.

As a result, the power sector reform could solve some economic problems of the country, in particular, refuse to subsidize the sector from the state budget, to generate market prices that reflect the real cost of electricity, which contributed to the establishment of parity prices for goods and services to other industries [2].

At the same time, many of the problems of electric power sector are not resolved and in particular the following. There are significant territorial differences in the availability of energy sources. Coal deposits are concentrated mainly in northern and central Kazakhstan, placed there with the largest generating capacity. Accordingly, these regions are fully secured sources of electricity and potentially energy surplus. The South Kazakhstan does not have enough primary energy and electricity based on imported fuel: coal and gas. Part of the electricity needs covered by its imports from Kyrgyzstan. The Southern regions of the country are most attractive for the development of agriculture, livestock. The most rational is the RES usage which can cover energy shortages in rural areas. In Kazakhstan, there is a real possibility of using wind energy, solar energy, geothermal energy, energy of small rivers (small hydro) in rural regions.

The nature of RES generation can be described as non-stable. This creates some difficulties in connecting RES to the electrical network. Nowadays this is seriously restraining the wide usage of the renewables. One such task is to overcome technical barriers when integrating RES into the energy system in cases where their share in the total generation capacity becomes noticeable. In this case, we must decide on the coordinated operation of existing generation capacity with renewable energy sources, or in other words, to solve the unit commitment (UC) problem with the renewables [1].

1. Materials and methods

1.1. Kazakhstan's renewable energy sources potential summary

There are different opinions and evaluation results of the renewables potential in Kazakhstan. But no doubt, the potential is very high (Table 1.) [3]. Wind can be used as a primary energy source for Kazakhstan and theoretically cover all energy needs not only at present time but in the future also. Nowadays hydropower is represented in Kazakhstan with big hydro power plants. This type of energy can be considering as renewable as well. The rest types of RES are not widely used [1].

Table 1

Potential of renewable energy resources in Kazakhstan

Type	Value, billion kWh per year
Wind	929–1820
Solar	2.5
Biomass energy	35
Small hydro	7.5

Biomass energy is also one of the most perspective types of renewable energy which can cover the energy demand in Kazakhstan (Figure 1).

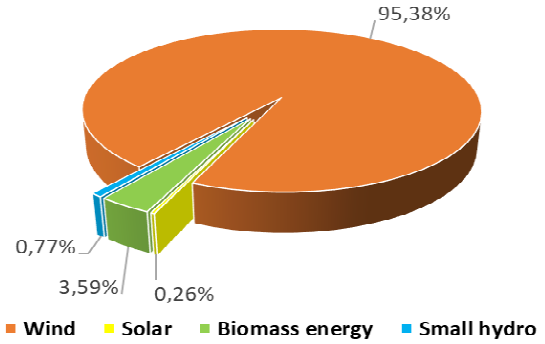

Fig. 1. **RES thearetical potential in the Republic of Kazakhstan**

1.2. Legal basement, current situation and programs of the renewable energy generation sources development in Kazakhstan

In general, the questions of electricity flows and electricity consumption and heat are governed by the Law of the Republic of Kazakhstan from July 9, 2004 No. 588-II "About the Electric Power Industry" [4].

In 2009, renewable energy sources began to be regulated by a separate law – the Law of the Republic of Kazakhstan "On Support for the Use of Renewable Energy Sources" from July 4, 2009 No. 165-IV [5].

Some questions related to the use of RES are regulated by other legislative acts such as the Land Code of the Republic of Kazakhstan [6], the Water Code of the Republic of Kazakhstan [7], Code of the Republic of Kazakhstan on Administrative Offenses [8], and Law on Natural Monopolies and Regulated Markets [9]. Issues that arise in the production and turnover of biofuels are regulated by a separate law – Law of the Republic of Kazakhstan "On state regulation of production and turnover of biofuels" [10]. To stimulate the RES development and the exchange of international experience in Kazakhstan acceded to the International Renewable Energy Agency which was started in Bonn 26 January 2009 and ratified its statute [11]. In August 2014, the functions of the authorized body in the field of public policy in the sphere of the use of RES were transferred from the Ministry of Industry and New Technologies to the Ministry of Energy [12]. For the development of renewable energy, the state provides some preferences, the most important of which are [12]:

- no license is required for renewable energy production;
- guaranteed access to points of connection to electrical networks;

- priority of electricity transmission from RES through electric networks;
- it is guaranteed to purchase the entire amount of RES energy at a fixed tariff for 15 years;
- predictable and long-term tariffs;
- investment preferences;
- exemption from customs duties;
- state natural grants;
- tax preferences;
- investment grants.

On March 19, 2010, the President of the Republic of Kazakhstan adopted the State Program on Forced Industrial-Innovative Development in the Republic of Kazakhstan for 2010-2014 [13]. Further, in August 2014, the State Program of Industrial and Innovative Development of the Republic of Kazakhstan for 2015–2019 [14] was approved. Both programs confirm the significant potential of RES, such as water, wind and solar energy in Kazakhstan in the short and long term. In particular, the program on Forced Industrial–Innovative Development in the Republic of Kazakhstan for 2010-2014 provided that by 2015 the share of RES in the total energy production should exceed 1 %.

On 30 of May 2013 the President of Kazakhstan approved the Concept for the transition of the Republic of Kazakhstan to the "green economy" [15]. According the concept, it is planned to establish a share of renewable energy in the country's total energy balance of about 3 % by 2020, which is in the amount of installed capacity of 1850-1900 MW in the country.

At the same time, the total share of alternative energy sources, including renewable sources, nuclear power plants and hydroelectric power plants, will grow to 30 % by 2030 and to 50 % by 2050.

The later adopted Concept for the Development of the Fuel and Energy Complex of the Republic of Kazakhstan until 2030 [16] confirms the previously accepted announcements and the terms for the introduction of renewable energy sources.

Kazakhstan President Nazarbayev's initiative "Strategy Kazakhstan – 2050" [17], involves the creation of pan-Eurasian energy system and the inclusion of Kazakhstan in the initiative united under the Green Euro-Asian Bridge initiative.

1.3. RES and Unit commitment

To the moment, the task of electricity accumulation in significant amounts still is not being solved. That means that to provide the stability of the energy system it is necessary to keep the balance of electricity production and consumption. To provide the stable functioning of the power system, we should have power lines and monitoring certain operating modes of electric power generators. Such kind of problem can be identified as a variant of the unit commitment problem [1].

Unit commitment problem can be described as an optimization problem used to determine the operation schedule of the generating units at every hour interval with varying loads under different constraints and environments [18].

There are plenty of methods and algorithms for the UC problem solution, which have been created by different authors and organizations: Priority List (PL), Dynamic Programming (DP), Branch-Bound, Mixed Integer Programming (MIP), Lagrangian Relaxation (LR) [19] and many others.

RES have variable generation profile that creates some difficulties with solving the UC problem. In most of the cases the generation level from the renewables cannot be modified and adjusted to the system needs. In addition, usually according the state police power system operators should accept all the energy from the renewable energy sources into the grid [1]. The solving of the UC problem can be critical for huge farms in the remote areas with a weak electrical grid connection.

2. Results and discussion

2.1. Kazakhstan's renewable energy sources potential summary

According to the analysis, the most promising renewable energy source is biofuel. Kazakhstan has a huge territory and agriculture potential as well (Table 2.) [20].

Table 2

Basic agriculture statistics

Physical areas	Year	Value	Unit
Area of the country	2009	272 490 000	ha
Cultivated area (arable land and area under permanent crops)	2009	23 480 000	ha
as % of the total area of the country	2009	9	%
arable land (annual crops + temp fallow + temp meadows)	2009	23 400 000	ha
area under permanent crops	2009	80 000	ha

In Kazakhstan, forests occupy an area of more than 10 million hectares, which is 4 % of the total territory of the country, of which 4 700 thousand ha are covered with saxaul. The volume of the waste timber for felling and wood on wood plants, and wood is used as firewood is nearly 1.3 million m^3 or 1 mill. tons. Thus, the energy potential of wood waste is more than 200 000 TOE.

By considering the 'biomass' renewable segment it can be concluded that straw of cereals is the most valuable energy source. Only by using one fifth of the straw produced amount more than 87 GW of the electrical energy can be generated. Biogas from livestock and poultry also can play the big role in energy production in Kazakhstan. The potential for methane production from cattle wastes is more than 85 thousand tons, or more than 52 thousand TOE. Due to the processing of agricultural waste, the country can annually receive up to 35 billion kWh of electric and 44 million gigacalories of thermal energy. The potential for methane production from municipal wastewater treatment is about 3 thousand tons or almost 1 800 thousand TOE [21].

2.2. Legal basement, and renewables support programs summery

There is no doubt Kazakhstan has a significant potential for the RES development. The plenty of programs and legislation acts which are going to support and force the development of the renewables were adopted in Kazakhstan. They provide some instruments and mechanisms for supporting the renewables. The most important can be identified such as: guaranteed access to points of connection to electrical networks; priority of electricity transmission from RES through electric networks; purchase the entire amount of RES energy at a fixed tariff for 15 years. However, unfortunately, not all the announced plans for the implementation of renewable energy sources are being carried out in full.

There is no special program for renewable energy development support in the rural regions. It should be taken into account the scale of the territory of Kazakhstan and lack of infrastructure in rural regions. In this support program also should be considered the disproportion of the economic development between rural and urban regions.

2.3. Overcoming the technical barriers for the renewable energy sources development in the rural arears

In order to overcome the difficulties connected with the variable generation from RES the energy storage facilities can be used. Such storages can eliminate the peaks of power generation and consumptions. Now it is the most promising direction for energy system development. To choose the proper source of the renewable energy source the analyzing of the renewable energy potential for the specific place should be done. It can be achieved by using the public available tools [22].

For solving the UC problem with RES were analyzed the features of RES as an energy source and elaborated the common approach for solving the UC with RES in a distributed electrical grid system [1].

According to the method, the following should be done:

- renewable energy sources impact factors should be identified;
- choosing the part of the electrical grid and input data analyzing;
- electricity output schedule from the available renewables predicting and identifying RES capacities in the specified region;
- choosing the software and mathematical methods for modeling;

- running the mathematical modeling and Unit commitment solving;
- selection of the optimal combination of the renewables and identifying the power storage capacity;
- getting the results from the Unit commitment simulation performing with variable conditions.

3. Conclusions

Kazakhstan has a great renewable energy potential, especially in the rural areas. The most promising is using wind and bioenergy. The share of wind energy potential among all renewables can reach more than 95 %, bioenergy 3.6 %. At present time the usage of bioenergy in the Republic is not developed because of weak infrastructure, some issues with biofuel production and using land for special crops. No doubt, with governmental support Kazakhstan can push the development of the bioenergy production and usage. This can solve not only the problem of the electricity deficit in some rural arears but waste disposal problem as well. Due to geographical features not in all rural arears the small rivers energy can be used but wind and solar energy available in almost all rural regions of the country.

Development of the renewable energy sources in rural regions should be supported by a special law or program. Unfortunately, at the moment Kazakhstan has no special support program for renewables in rural arears.

Technical issues can be solved by using energy storage facilities, proper choosing of the renewable sources combination and UC problem solving.

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