To the Question of Development Perspective of Kyrgyz Republic Electric Power Industry with Using of New Innovative Renewable Energy Technologies

Alaibek Obozov, Ruslan Isaev and Arystanbek Omuraliev
Scientific Research Institute for Energy and Economics, Ahunbaeva Str. 119, Bishkek, Kyrgyzstan
obozov-a@mail.ru, ruslan.isaev81@yandex.com, oarstan@mail.ru

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Abstract: This paper shows the possibilities of renewable energy application in Kyrgyz Republic. Among them are solar, wind, biomass, etc. Scientific studies show that existing power industry has already exhausted its resource. Kyrgyz system is economically inefficient. The fundamentally new approach to the organization of power supply technology, based on the use of modern IT technologies is proposed. In the future, the creation of such systems is very promising, especially for countries with large territories or mountainous countries. Today it is necessary to seriously consider the future development of the power supply system, taking into account advanced renewable energy technologies. To solve the set tasks and implement them, it is necessary to provide these studies with finances and investments. In this regard, the Kyrgyz Republic has developed and adopted a Law on Renewable Energy providing for certain preferences for investors and ensuring the return on investments. The paper suggests reducing of energy losses, increasing of transparency and parallel development of RES in Kyrgyz Republic.

1 INTRODUCTION

The intensive direction of searching for additional energy sources in the background of reducing the reserves of traditional energy resources like oil, gas, coal, etc. and global environmental problems has led in recent decades to the use of new innovative and environmentally friendly technologies of renewable energy (RES) conversion (solar, wind, biomass, etc.).

Already today we can say with confidence that the future of energy is renewables. The practice of recent years shows that the pace of the introduction of new capacities for energy supply using renewable energy sources is at the most advanced positions in the world [5, 6, 10]. In recent 5-10 years, there has actually been a revolutionary transformation in the issues of receiving and transmitting energy using renewable energy sources, which leads to the need for a fundamental revision of modern power supply technologies and building networks entirely on new innovative principles.

2 CURRENT ENERGY SITUATION IN KYRGYZSTAN

Scientific studies of scientists in the field of electric power industry show that modern electric power industry, as a way of centralized production, transmission and distribution of energy, has already exhausted its resource and in its development comes to a standstill [1, 2]. As known, the existing centralized power supply systems for reliable customer support are based on increasing the generating capacity taking into account the peak power coverage. This can be well demonstrated by the example of the functioning of the Kyrgyz energy system. Total installed capacity of all generating stations of the Republic is 3940 MW, while the average annual output is 14,7 billion kWh. In fact, to generate such a quantity of electricity, the installed capacity of 1700 MW is sufficient. This says that the utilization rate of generating stations does not exceed 43 %, i.e. unused reserve is 2240 MW. Of course, in such situation, there is no need to talk about the economic efficiency of the system. That is, such a system is not consistent already in the near future.

Of course, with all this we must not forget that this is due to the need to ensure the reliability of the supply of electricity to the consumer. So the seasonal change in electricity consumption in some years exceeded 2 or more times [7, 9]. The main electricity generation in the Republic is mainly carried out at the expense of hydropower stations, and their mode of operation is closely related to water resources, and they, in turn, are related to the provision of agricultural land with water, not only our Republic, but also neighboring countries like Uzbekistan and Kazakhstan. With this in mind, the functioning of the existing power supply system of the Republic is experiencing even greater difficulties. From this we can conclude about the need to find new ways to provide consumers with electricity, eliminating the shortcomings of the existing system.

3 SMART GRID APPROACH

In recent years, the so-called smart micro grid systems have been actively developing in the world. This is a fundamentally new approach to the organization of power supply technology, based on the use of modern IT technologies using self-restoring smart grids, built not on increasing capacity, but directly on supplying the consumer with the necessary electrical energy. The construction of such systems has become possible due to the development of renewable energy technologies that ensure the most efficient operation of the electrical network with distributed parameters. It is a network with small generating capacities, interconnected to local and centralized networks, providing not only production, but also energy consumption. Moreover, the whole system is connected into a single intellectual, self-organizing and controlled network, providing the most efficient and reliable supply of electricity to the consumer. Such a system ensures maximum utilization of generating stations, due to minimum distances for energy transmission, minimizes technological and technical losses in grid, ensures the most efficient and optimal system operation due to the presence of consumer and producer feedback, through the use of computer control software and modern adaptive monitoring-measuring equipment equipped with elements of artificial intelligence.

In the future, the creation of such systems is very promising, especially for countries with large territories or mountainous countries, where there is a rather low density of consumers. The location of consumers in remote foothill and mountainous areas, where their provision of electricity by building traditional power lines is an unjustified luxury.

The Kyrgyz Republic is related to such type of mountainous country. Therefore, today it is necessary to seriously consider the future development of the power supply system, taking into account advanced renewable energy technologies.

Elements of such “Smart Grid” systems are already piloted in practice in the USA, Japan, Western Europe and other developed countries [1, 3]. The use of power supply technologies with the use of renewable energy allows to take into account the daily load of each individual consumer, up to the individual appliance, which provides a more efficient power supply. Here, the criterion of reliability is not the input power, but the total daily need for electricity.

Such systems provide a balance between production and energy consumption by virtue of the above structural control of the system in automatic mode. It should be noted that the synchronization system of generating devices of different types by their nature is being simultaneously solved. That is, it is possible to simultaneously connect to work as solar installations, micro hydro, wind turbines or other generating devices [1, 2, 4].

The presence of low density of electricity consumers, territorial dispersion, economic inefficiency of providing them with electricity, by laying lines of electric transmissions, especially in the foothill and mountainous terrain of our Republic, makes it very relevant to conduct scientific research in this area and develop practical recommendations for building the development strategy of the Republic’s fuel and energy sector.

In addition to the above objective reasons for the development of the use of renewable energy in the Republic there is another reason. This is non-proper extraction of traditional energy resources like coal, oil, gas, which we are forced to import from other countries for currency. Kyrgyzstan is rich in RES resources [8], whose potential is able to provide more than 50 % of the country's energy needs in the fuel and energy sector. The accumulated practical experience of using these energy sources shows that the solar installations, the energy of small mountain streams, and the energy of biomass, wind power and others can be used quite effectively in the Republic to obtain both thermal and electrical energy [8].

However, it should be said that for a successful integrated solution to the problem of power supply, the availability of new technical solutions and the introduction of new innovative technologies that use the most advanced IT technologies and automatic control systems are not enough. As modern practice shows, these are necessary but not sufficient conditions. To solve the set tasks and implement them, it is necessary to provide these studies with finances and investments.

4 REDUCTION OF LOSSES

Today in the world there are a lot of financial institutions, various funds of public associations, government agencies, large corporations ready to invest in promising renewable energy projects. But they all want one - guarantee return on investment and the availability of relevant legislation in the country.

In this regard, the Kyrgyz Republic has developed and adopted a Law on Renewable Energy (2012) providing for certain preferences for investors and ensuring the return on investments [11].

Unfortunately, practically adopted law did not work. Over the past 7 years, not a single project in the field of renewable energy with the attraction of foreign investors has been implemented. As a pilot project, only the Small Hydropower Project implemented by a local entrepreneur was implemented. But unfortunately, this experience was not successful. So when concluding an agreement between a supplier and a distribution energy company, there were disagreements related to the payment of the difference in the cost of electricity to the supplier.

Energy companies spoke in favor of the impossibility of financially covering this difference at the expense of their activities and initiated in the Parliament of the Kyrgyz Republic a review of the Law on Renewable Energy Sources and the establishment of other incentive coefficients.

As practice has shown, despite the rather high stimulating factors adopted in the Law on Renewable Energy (for solar photovoltaic stations the multiplying factor was assumed to be 6), no investor was involved in the implementation of the project on renewable energy in the past period. This suggests that the coefficients in and of themselves do absolutely nothing and their changes, provided for in the new law in the direction of decreasing, absolutely will not change anything. Apparently the reason is still in the other. If we put aside all the technical issues, the lack of regulatory and technical documentation for connecting renewable energy generating stations to centralized networks, the lack of mechanisms for compensating the difference in electricity tariffs, etc., then we can see other more weighty reasons that exist in the existing system functioning of the Republic's fuel and energy complex, hindering the successful attraction of investments in energy projects of renewable energy sources. It is clear that one of the main reasons why investments in the energy sector are not attractive is low electricity tariffs.

The second reason is the low efficiency of the fuel and energy complex. Previously, we showed that the existing system, due to the prevailing circumstances and the existing technological scheme, provides only 43 % of the workload of generating stations, i.e. more than 50 % of the equipment is practically idle and does not bring any benefit.

Finally, it is quite a high losses of electricity for its transportation and distribution. In Figure 1 the diagrams of electrical losses in Kyrgyzstan are compared with other foreign countries are provided.

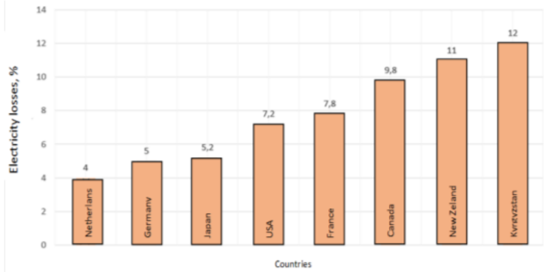

Figure 1: Diagrams of power losses.

As you can see, the percentage of losses is quite high and this is the Achilles heel, which radically negates the efficiency of the power supply system and the impossibility of its independent recovery from this situation.

Let us try to assess how this factor affects the attraction of foreign investments and why the position of electric companies is against introducing multiplying factors into the law. To do this, consider the current situation in the energy sector and analyze the objectivity of the approval of energy companies about the impossibility, with electricity tariffs, to repay the difference in the cost of electricity generated stations operating on renewable energy. If you follow the chronology of increasing the capacity of power plants in the Republic (Table 1), you can see that in almost 100 years from 1919 to 2019, the total capacity reached 3940 MW.

Table 1: The chronology of increasing the capacity of power plants in the Republic.

Years	Cap. (MW)
1917	0,485
1941	19,6
1951	61,9
1961	261,794
1971	908,149
1981	2770,65
1991	3075,65
2001	3315,65
2017	3940

And the most active period was the time interval from 1970 to 1991, i.e. during the period of the Republic in the USSR. Moreover, for these 21 years, the capacity was put into operation at almost 2,5 thousand MW, which is more than 62 % of the total installed capacity today. During the years of independent existence of Kyrgyzstan as a sovereign state (27 years), only 18 % of the total installed capacity was introduced, which is only 813 MW. What it says is that the pace of introduction of new capacities has decreased significantly and the reasons for this are the previously listed factors, including the fact that this industry is not attractive to investors. What can we say about the pace of implementation in the fuel and energy complex of new innovative technologies for the use of renewable energy? Earlier, we showed that during the whole period of existence of independent Kyrgyzstan, not a single industrially significant project on RES, and even when the law on RES was adopted, the situation has not changed.

Suppose that the pace of implementation of additional capacity will remain the same as over the past 27 years. Assume the growth of these capacities will be at the expense of the introduction of traditional generating stations and stations operating on renewable energy sources (20 %) Then you can easily calculate that on average about 30 MW of total capacity should be entered annually, of which the capacity of RES stations will be 6 MW. We intend to adopt an overestimated 20 % share of electricity generation at renewable energy stations, in order to further more clearly show the inconsistency of the assertion that it is impossible to cover the difference in tariffs of traditional stations with renewable energy stations. Actually, of course, given the experience of introducing renewable energy in recent years, most likely these values of the commissioned annual capacity of renewable energy stations will be significantly lower.

Based on the assumptions made, we will calculate the possible generation of annual electrical energy when the solar power is set to 1 MW and then we will determine it by simple multiplication for a power of 6 MW.

Determine what percentage of the total annual output will be the production of PV station with a capacity of 6 MW with (1). It is known that the average annual duration of sunshine in the Republic varies between 2800 hours a year. Then PV station at the rate of 1 MW will generate

$$Q = N_{\tau} = 1 \cdot 2800 = 2800 \text{ MWh} \qquad (1)$$

For a power of 6 MW 16800 MWh respectively.

Of the total annual output of the fuel and energy complex 14,7 billion kWh the share of PV station output with a capacity of 1 MWh will be in percent 0,02 %, for 6 MW respectively 0,12%.

We have previously shown that, on average, in the Republic, the loss of electric energy in the networks is 12 %. Let's calculate how much electricity and money the energy companies lose as a result of this, if we take into account that the annual production of electricity amounts to 14,7 billion kWh, the calculations will be carried out with the established tariffs for electricity energy of 0,77; 2,16; 2,24 KG soms per kWh In this assessment, no division was made into categories of consumers paying for different tariffs, the calculation was made in the offer, when all consumers pay for different tariffs. This approach allows you to make a qualitative assessment of the potential losses of electricity and losses of income of energy companies, depending on the % of the existing electrical losses in the networks.

Table 2 shows the results of the calculations made.

The corresponding designations of the columns of the above-stated table means.

1 - Indicators of electrical losses in percent;

2 - The corresponding annual energy losses at various percentages, bln. kWh;

3, 4, 5 - Average annual losses of the electric power complex of the Republic, expressed in million soms with corresponding electricity tariffs of 0,77 soms; 2,16 som; 2,24 som. In other words, how many electric companies annually lose financial resources due to losses in the networks;

6 - This column shows what percentage of the corresponding total losses of the fuel and energy sector of the country is at a loss of 1 MW of installed PV power and 6 MW respectively (column 7).

Table 2. The results of calculations of losses of electricity and incomes of energy companies depending on the losses of electricity in networks.

Loss perc.	Electricity losses, billion kWh	Financial losses of companies, mln soms			Percentage of losses	
%		0,77 som	2,16 som	2,24 som	At 1 MW	At 6 MW
1	2	3	4	5	6	7
1	0,147	113	317	329	2,08	11,5
2	0,294	226	635	658	1,02	5,7
3	0,441	339	952	987	0,68	3,8
4	0,588	452	1264	1316	0,51	2,85
5	0,735	565	1586	1645	0,41	2,28
6	0,882	678	1903	1974	0,34	1,9
7	1,029	791	2220	2303	0,29	1,6
8	1,176	9,04	2537	2632	0,25	1,42
9	1,323	1017	2854	2961	0,22	1,26
10	1,47	1130	3171	3290	0,20	1,14
11	1,617	1243	3488	3619	0,18	1,03
12	1,764	1356	3805	3948	0,17	0,95

The data in Table 1 represented in the form of the corresponding diagrams (Fig. 2) and (Fig. 3).

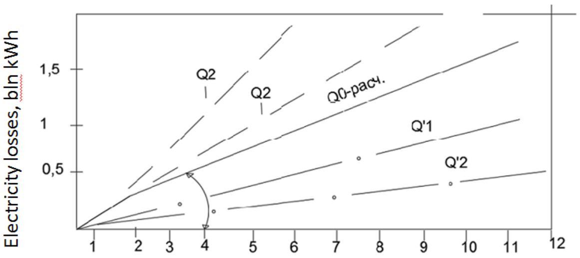

Figure 2: Diagrams of changes from different percentages.

From the obtained diagram it can be seen that the dependence of electric power losses in networks linearly depends on its percentage value.

Moreover, the intensity of losses is the higher, the greater the generation of electricity, i.e. in the zone where $Q_2 > Q_1 > Q_{0calc}$ losses will grow more intensively than in the zone where $Q_{0calc} > Q_1' > Q_2'$.

That is, in other words, if the angle of inclination of a straight line to the horizon is an angle α, then we can write:

$$Q_l = tg\alpha \cdot K, \quad (2)$$

where Q_l - losses of electricity, K - percentage of losses in the networks. The value of K is the value of the maximum average annual values of energy losses of the considering system (%).

Thus, it can be seen that for the case under consideration, when the annual energy production in the Republic is 14,7 billion kWh, the value of $tg\alpha$ will be 0,147, and it is a constant value, that is, taking into account the latter in general terms can be written (2):

$$Q_l = \frac{Q^y \cdot K}{100}, \quad (3)$$

where Q^y - the average annual electricity generation.

The dependence obtained allows us to determine the amount of electric power losses in networks with known values of its average annual output.

The diagram in Figure 3 shows the changes in the financial losses of energy companies, from the loss of electric power, due to the loss of electricity in the networks at the existing tariffs.

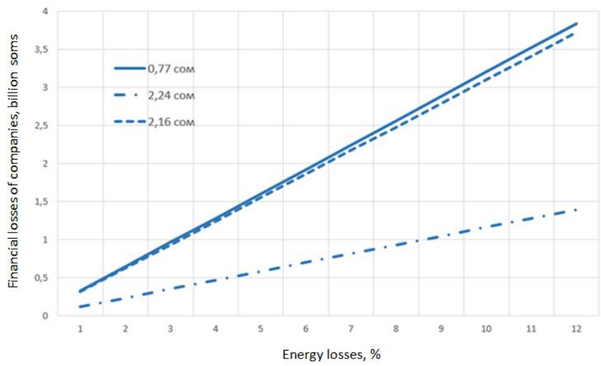

Figure 3: Diagram of financial losses of energy companies depending on losses in the grid.

From the obtained diagrams presented in Figure 3, it can be seen that the qualitative picture of the change in the financial losses of power companies depending on the losses in the networks is similar to the diagram shown in Figure 2. Therefore, analogously to (3), we can write down:

$$C_l = \frac{Q^y}{100} \cdot C \cdot K, \quad (4)$$

where C_l - is the cost of electrical losses, som; C - tariff for 1 kWh of electricity.

If we use (4), we can easily determine how much money an electric company can save, or in other words say, will get additional profit while reducing losses. Reduction of losses by 1% with appropriate rates are shown in Table 3 (column 3).

Now let's calculate what amount the energy companies should pay annually to the electricity supplier from PV, resulting from the difference in tariffs, determined by the adopted law of RES. Accordingly, for PV with an installed capacity of 1 MW the annual generation of electricity, as shown earlier, will be 2,8 million kWh. For 6 MW - 6,8 million kWh respectively.

The price of payment for traditional power plants, respectively, at different rates, with an installed capacity of 1 MW are given in Table 3 (column 3), and at 6 MW Table 3 (column 6).

Considering that we have not made a division of the number of consumers into the corresponding categories according to paid tariffs. For a qualitative presentation of the existing picture in the Table 3 shows the obtained values for the average tariff (1,72).

The value of the necessary payment for PV energy according to the Law of Renewable Energy should be considered with a factor of 6. Calculations for 1 MW are given in Table 3 (column 4), for 6 MW (column 7).

The annual value of payments of the energy company to the electricity supplier from the PV will be nothing more than the difference in the amount of payment received to the electricity supplier from PV with the value of payment to the traditional supplier at the established traditional tariff. The values of the calculations for 1 MW are given in Table 3 (column 5) and respectively for 6 MW (column 8).

Table 3: The results of calculations of the cost of electricity for the traditional system and PV.

#	Tariffs, Som	Cost of electric power tradition. at 1 MW (million som)	The cost of electric energy PV 1 MW, (million som)		Cost of electric power tradition. at 6 MW (million som)	The cost of electric energy PV 6 MW, (million som)	
			Δ	C		Δ	C^1
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	0,77	2,156	13	10,9	12,93	77,6	64,7
2	2,16	6,05	36,3	30,2	36,3	217	180,7
3	2,24	6,27	37,6	31,3	37,6	225,6	188
Av.	1,72	4,8	28,8	24	29	177,6	148

The data Table 3 for clarity presented in the form of histograms in Figure 4.

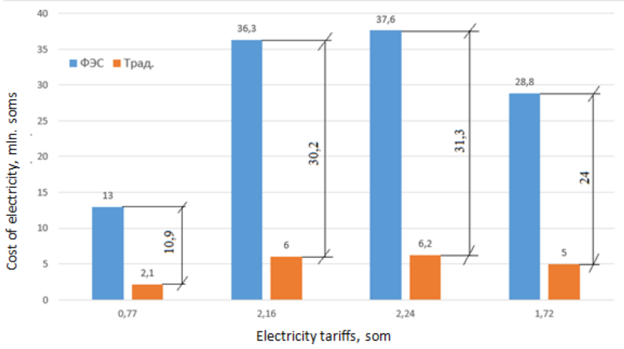

Figure 4: Comparative diagrams of electricity costs for traditional and PV grids at installed capacity of 1 MW.

Thus, from the presented data and diagrams, it can be seen that for an installed capacity of 1 MW, utility companies must pay the supplier annually, depending on the relevant tariff 10,9, 30,2, 31,03 million soms. If we take the average tariff, then, respectively, 24 million soms. For the chosen power of 6 MW, respectively, these values will be 6 times higher – 64,7, 180,6, 188 million som and 144 million averaged.

Previously, we raised the question at the expense of what means of the power company should cover this difference. To do this, go back to the Table 2. It can be seen that if the energy companies reduce their losses by at least 1 % per year, they will receive additional funds in the amount of 113 million soms (with 0,77) 317 million soms and 329 million soms, respectively, at tariffs 2,14 som and 2,24. At the average tariff of 252,8 million soms.

Then, taking into account the data Table 3 it can be calculated that energy companies, while reducing their electric power losses in the networks by 1%, can respectively compensate for the difference in tariffs for PV for about 10,5 years by receiving additional profit.

Thus, given the current situation in the electric power industry and existing tariffs, if we introduce PV with a capacity of 1 MW and reduce losses in general for all electric companies by 1% without any consequences, they can pay the difference in tariffs to the supplier of PV with the accepted ratio of 6 10,5 years and at the same time not a penny without raising the existing tariffs.

For the installed power of the PV of 6 MW, respectively, we get 1,7 years.

It should be said that all the calculations presented here are based on the electricity tariffs that exist today, the average annual output and in the proposal that the rate of increase in generating capacity will remain the same as the last 27 years, i.e. each year it is assumed to build up about 30 MW. Moreover, of these 30 MW, it is assumed that 20 % will be increased at the expense of PV, which accordingly amounted to 6 MW.

The above calculations were made for the case of a possible reduction of losses by only 1%. In reality, if you look at world experience, losses can be reduced to 6-8% as was done in developed countries like Germany, USA, Japan, i.e. for our Republic, this is approximately a reserve of 4-5 %, which makes it possible to cover the difference without increasing tariffs for a period of 7-9 years. Of course, this does not mean at all that everything will be exactly like this, but under the conditions we adopted, such an expected result is possible.

5 CONCLUSIONS

Thus, if we generally talk about the strategic development of the electric power industry of the Republic and its main implementation mechanisms, then the following should be said:

- The existing power supply system, which has a coefficient of utilization of power plants below 50% and is built on the principles of providing peak power to the consumer, is not consistent and is not economically justified;
- Already today, it is imperative to search for completely new innovative ways to provide consumers with electricity based on new grid design principles;
- The Kyrgyz electric power industry has rather large prospects in improving the innovative attractiveness of renewable energy projects and reserves in their financial support.
- At the first stages of improving the power supply system in the Republic, it is necessary to maximize the introduction and provision of parallel operation of generating stations on renewable energy sources with traditional centralized networks using the elements of the Smart Grid.

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