Alexandr Pasternak[1]

INFLUENCE OF ELECTRICITY POWER GENERATING UNITS ON THE ENVIRONMENT IN KAZAKHSTAN

The article explores the issues of environmental pollution in Kazakhstan and energy production from renewables. In addition, the expediency of separating hydropower from renewables at calculating the total energy produced is considered. The analysis on the level of respiratory illnesses in the regions with the highest production of energy from heat power stations is carried out and the methods of more effective development of renewable energy sources are suggested.

Keywords: *Kazakhstan; renewable sources of energy; heat power stations; CO_2 emission; respiratory illnesses.*

Олександр Пастернак

ВПЛИВ ОБ'ЄКТІВ, ЩО ВИРОБЛЯЮТЬ ЕЛЕКТРОЕНЕРГІЮ, НА НАВКОЛИШНЄ СЕРЕДОВИЩЕ У РЕСПУБЛІЦІ КАЗАХСТАН

У статті розглянуто проблеми забруднення навколишнього середовища у Республіці Казахстан та виробництва електрики з відновлювальних джерел. Також представлено обґрунтованість відокремлення гідроелектроенергії при розрахунках загального виробництва альтернативної енергії. Наведено дані щодо рівня захворювань дихальних шляхів на прикладі регіонів з найбільшим виробництвом електроенергії тепловими електростанціями. Запропоновано методи більш ефективного розвитку відновлювальних джерел енергії.

Ключові слова: *Казахстан; відновлювальні джерела енергії; теплові електростанції; викиди CO_2; захворювання дихальних шляхів.*

Рис. 4. Табл. 7. Літ. 10.

Александр Пастернак

ВЛИЯНИЕ ОБЪЕКТОВ, ПРОИЗВОДЯЩИХ ЭЛЕКТРОЭНЕРГИЮ, НА ОКРУЖАЮЩУЮ СРЕДУ В РЕСПУБЛИКЕ КАЗАХСТАН

В статье рассмотрены проблемы загрязнения окружающей среды в Республике Казахстан и выработки электричества от возобновляемых источников энергии. Также рассмотрена обоснованность отделения гидроэлектроэнергии при расчете общей выработки от возобновляемых источников энергии. Приведены данные по уровню заболеваний дыхательных путей на примере регионов с наибольшей выработкой электроэнергии от тепловых электростанций и предложены методы по более эффективному развитию возобновляемых источников энергии.

Ключевые слова: *Казахстан; возобновляемые источники энергии; тепловые электростанции; выбросы CO_2; заболевания дыхательных путей.*

Problem setting. Kazakhstan is one of the former Soviet Union republics located in the Central Asia. This country has one of the mostly developed economies among the countries of this region. In 2017 Kazakhstan holds Exposition 2017 (EXPO 2017). The theme of the Exposition is referred to as the "Future energy". The main purpose of this event is to find solutions for the worldwide problems such as environmental pollution and scarcity of natural resources which currently are the major sources of energy in the world.

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Nowadays Kazakhstan works hard on the development of innovative technologies in the field of power energy. The priorities of this development are the reduction of carbon dioxide emission (CO_2) and the implementation of renewable energy sources. As for the renewable energy the process is still too slow and really this segment does not provide the expected level of energy production as it should have been. The main reason is that there are large reserves of petroleum and coal in the country. It is much cheaper to produce electricity using the methods that have already been used for a long time rather than produce innovations and wait when new technologies bring dividends. Heat power stations and state district power stations are the main power generating units in the country. These stations are also among the major sources of noxious gases and substances because they mostly use coal as a basic source of fuel. As a result, there is a high sickness rate of respiratory illnesses in the country because of strongly polluted air in most regions.

Latest research and publications analysis. Application of innovative technologies and the existing problems in electrical power sector were described by a number of scientists in Kazakhstan and abroad.

R.I. Kosmambetova states that "innovations are represented by the practical application of newly determined scientific and technological as well as economic decisions in any area of development. Innovations have a systematic character and they make changes in any technological and organizational opportunities of any process" (Kosmambetova, 2012: 254).

O.B. Antonov argues that "Kazakhstan has not achieved goals that had been stated by the "Strategy of Innovative Industrial Development of the Republic of Kazakhstan 2003–2015" as well as by the "Strategy of Becoming a More Competitive Country Among 50 Mostly Developed Countries Around the World" (accepted in 2006) in the sphere of industry and power energy sector" (Antonov, 2014: 5).

A.R. Karenov asserts that "economy in Kazakhstan has a specific feature – it is not open to innovative technologies and the reasons of that are complex and have not been studied thoroughly so far. In the mean time, science in Kazakhstan has made a lot of efforts to identify the real systematic reasons and factors stopping the development of innovations" (Karenov, 2010: 35).

L. Wang, Z. Chen, D. Ma and P. Zhao indicate in their article "Measuring Carbon Emissions Performance in 123 Countries: Application of Minimum Distance to the Strong Efficiency Frontier Analysis" that: "using cluster analysis, we have shown that nine countries, including Ukraine, Kazakhstan, Uzbekistan and Iraq, should take severe measures to save energy and reduce carbon emissions" (Wang et al., 2013: 5319).

An interesting research was made by R. De Jong, J. Verbesselt, A. Zeileis and M.E. Schaepman. They "detected major shifts in vegetation activity trends and their associated type (either interruptions or reversals) and timing. It appeared that the biospheric trend shifts have, over time, increased in frequency, confirming recent findings of increased turnover rates in vegetated areas. Signs of greening-to-browning reversals around the millennium transition were found in many regions (Patagonia, the Sahel, Northern Kazakhstan, among others), as well as negative interruptions – "setbacks" – in greening trends (Southern Africa, India, Asia Minor, among others)" (De Jong et al., 2013: 1117).

C. Schelly and J. Price in their article "Utilizing GIS (Geographic information system) to Examine the Relationship Between State Renewable Portfolio Standards and the Adoption of Renewable Energy Technologies" state that "in the United States, there is no comprehensive energy policy at the federal level. To address issues as diverse as climate change, energy security, and economic development, individual states have increasingly implemented Renewable Portfolio Standards (RPSs), which mandate that utility providers include a specified amount of electricity from renewable energy sources in their total energy portfolios" (Schelly and Price, 2014: 1).

As it often happens for new things to be implemented usually there are barriers and difficulties. The same is for the innovative technologies and/or renewable sources of energy. P. Lehmann et al. in their article "Carbon Lock-Out: Advancing Renewable Energy Policy in Europe" write the following: "as part of its climate strategy, the EU aims at increasing the share of electricity from renewable energy sources (RES-E) in overall electricity generation. Attaining this target poses a considerable challenge as the electricity sector is "locked" into a carbon-intensive system, which hampers the adoption of RES-E technologies. Electricity generation, transmission and distribution grids as well as storage and demand response are subject to important path dependences, which put existing, non-renewable energy sources at an advantage" (Lehmann et al., 2012: 323).

Other authors also underline the necessity of renewables' development. M.E.A. Farrag and G.A. Putrus in the paper "Analysis of the Dynamic Performance of Self-Excited Induction Generators Employed in Renewable Energy Generation" write that "increased price of energy resources and concerns regarding climate change and the need to limit greenhouse gas emissions are driving energy policy makers towards improved energy efficiency and renewable energy sources" (Farrag and Putrus, 2014: 279).

C. Koenigs et al. in the paper "A Smarter Grid for Renewable Energy: Different States of Action" state that "while renewable energy technologies like wind and solar have huge potential to reduce both greenhouse gas emissions and other negative environmental impacts from electricity generation, integrating these technologies into the electric power grid poses ongoing technological and institutional challenges" (Koenigs et al., 2013: 218).

Unresolved issues. In the area of electric energy production in Kazakhstan there are many research papers written. In most of them researchers write about the need for development of renewable energy sources. Many articles include data on the amount of energy produced from renewables but there is no a clear distinction between renewables sources and non-hydro renewables. A few articles disclose failures in the concepts and programmes developed before. In the statistical data there is no description of probable occasional and/or intentional distortion of information submitted by organizations all over the country. Therefore there is a need to make a double check, if possible, and find data from different official sources.

Methodology. The goal of the paper is to analyze the situation in the power energy sector; identify how many and what kind of sources producing energy in different regions of Kazakhstan exist; what regions have a high level of CO_2 emissions, what are the reasons for that and how it influences the rate of respiratory diseases and what are the possible ways to overcome these problems.

Key research findings. Having obtained the data on the electric power produced by heat power stations and emissions from the consumption of coal we can identify how much it is interrelated. The analysis is demonstrated in Figure 1.

Table 1. **Total electric power produced, produced by heat power stations, and CO_2 emissions from coal consumption in Kazakhstan, 2007–2011**

	2007	2008	2009	2010	2011
Total electric power produced, mln kWh*	76,620.9	80,347.8	78,729.1	82,646.5	86,585.5
Electric power produced by heat power stations, mln kWh*	68,425.2	72,859.4	71,827.0	74,599.0	78,651.1
CO_2 Emissions from the Consumption of Coal, mln metric tons**	125	134	123	133	142

* Source: Agency of Statistics of the Republic of Kazakhstan, Industry of Kazakhstan and Its Regions, 2007–2011, Statistical collection, p. 49–50.
** Source: http://www.eia.gov.

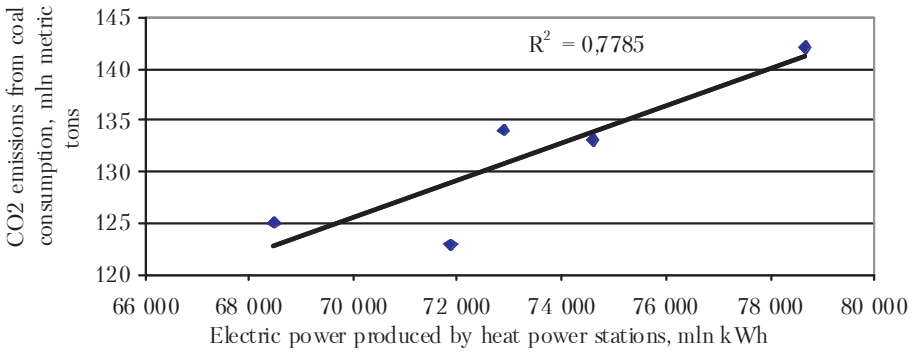

Figure 1. **Relationship between the production of electric power from heat power stations in Kazakhstan during 2007–2011 and CO_2 emissions from coal consumption,** *made by the author*

As we can from Figure 1 there is a reasonably fitted straight line, indicating that the more heat power stations produce energy the more CO_2 emissions occur.

Kazakhstan has developed several highly important for the country concepts, strategies and programs. For example, the concepts of "Green Economy", "Strategy 2050" and "Energy Saving Programme 2020" have been developed. All the programs and concepts reflect the strong necessity in developing highly technological and innovative ways for improving economic situation, reducing CO_2 emissions, developing renewables, and reducing losses in producing and transporting energy within the country. But, in fact, in some sectors the process is too slow and ineffective in practice. To confirm the fact let us consider the production of renewables energy as presented in Table 2.

Table 2. **Total Renewable Electricity Net Generation,** *bln kWh*

2007	2008	2009	2010	2011
8.09	7.386	6.811	7.943	7.805

Source: http://www.eia.gov.

The results presented in Table 2 seem to be quite good. But what if we separate hydro energy from the total energy produced from renewables. Although a question

arises of how much it is reasonable to make such kind of separation. The answer is the following. Hydro power stations have been constructed in previous years, mostly in the times of the Soviet Union. That is why this source of energy cannot be considered as completely new or alternative. Now let us see how the amount of energy from alternative renewables changes if we take into account the reasonable separation of hydropower sources of energy from the total energy produced by renewables. The results are presented in Table 3.

Table 3. **Wind Electricity Net Generation,** *bln kWh*

2007	2008	2009	2010	2011
0.001	0.001	0.001	0.001	0.001

Source: http://www.eia.gov.

Table 3 demonstrates that the results for wind energy are not so good. The reason for that is that technologies for wind energy are too expensive and the construction of wind power stations and putting them into operation is very slow moving. Investors are not eager to invest in wind energy projects since there is a long payback period. The cost of energy is higher in comparison with the cost of energy produced from traditional coal and gas heat power stations. In addition, there is a risk that balancing these wind power stations into the power grid of the country will take much time and many bureaucratic procedures. Now let us see how much energy is produced from other so called alternative renewable (Table 4).

Table 4. **Solar, Tide and Wave Electricity Net Generation,** *bln kWh*

2007	2008	2009	2010	2011
0	0	0	0	0

Source: http://www.eia.gov.

Indicators presented in Table 4 are even worse. As for tide and wave electricity it is quite understandable for this time. These technologies are not advanced so much all over the world and development and practical implementation is at the beginning stage in developed countries as well. In addition, Kazakhstan has only one large sea in the West of the country – Caspian Sea. The sea is far removed from the most manufacturing regions of the country and it would take additional costs on the energy transportation to those regions. On the other hand, tide and wave energy producing would be useful for the local consumers of energy as it is closely located and clean with regard to CO_2 emissions. As for the solar energy, the zeroes are not as much justified as the tide and wave electricity production. Kazakhstan has a big potential in applying solar power stations. But, again it is expensive to put into operation and maintain them.

Now let us have a look at the total non-hydroelectric renewables. It includes geothermal, wind, solar, tide and wave, biomass and waste sources of energy (Table 5).

Table 5. **Total Non-Hydro Renewable Electricity Net Generation,** *bln kWh*

2007	2008	2009	2010	2011
0.001	0.001	0.001	0.001	0.001

Source: http://www.eia.gov.

On the basis of the data presented in Table 5 and analyzing the data in Tables 2–4 we can conclude that the single source of energy from alternative renewables in Kazakhstan is the wind energy. Even though it is too low, there is still a belief that it

will proceed in further development and will be applicable in greater scale in the near future.

But the "dreams" may not come true. The reason is that the construction of two more heat power stations is expected. The first one is a project on construction of Balkhash Heat Power Station. It is expected to be a 2640 (Samkaliev, www.kazenergy.com) MW heat power station with a primary purpose to cover energy deficit in the South region of the country. The second project is a construction of a heat power station in Astana, Heat Power Station-3, with the expected power of 240 MW (Samkaliev, www.kazenergy.com). The construction of these stations will significantly increase amount of CO_2 emissions and negatively affect the ecological situation in that regions and in Kazakhstan as a whole.

Now let us see what regions in the country have the most powerful heat stations, how much energy these stations produce and what effect on the environment and the rates of respiratory diseases over the regions are. The data for the highest amount of electrical power produced from heat power stations are presented in Table 6.

Table 6. **Regions and cities with the highest level of energy production from heat power stations,** *mln kWh*

	2007	2008	2009	2010	2011
Pavlodar Region	31,850.2	33,904.3	33,796.5	36,493.9	38,952.8
Karaganda Region	11,697.9	11,122.7	11,836.7	11,784.5	11,563.8
Mangystau Region	3,729.0	4,146.2	4,051.3	4,325.8	4,506.3
Almaty Region	2,685.7	3,342.5	3,175.6	3,218.8	3,507.0
Astana city	2,041.5	2,209.0	2,349.1	2,304.2	2,375.1

Source: Agency of Statistics of the Republic of Kazakhstan, Industry of Kazakhstan and Its Regions, 2007–2011, Statistical collection, p. 160.

Table 6 evidences that the highest level of energy production from heat power stations is in Pavlodar Region which is on the North of the country. The reason of such a high output is the largest heat power stations in Kazakhstan located in that region – Ekibastuzskaya and Aksuiskaya State District Power Stations. As we can see from Figures 2 and 3 there is a strong relationship between the rates of respiratory illnesses in Astana and Pavlodar Region and the amount of electrical power produced by heat power stations. The respiratory diseases data are presented in Table 7.

Table 7. **The rate of respiratory diseases in the regions and cities with the highest level of energy production from heat power stations**

	2007	2008	2009	2010	2011
Number of sick people per each 100,000 of population					
Pavlodar	29,269.6	30,337.9	33,391.2	34,287.1	33,420.7
Karaganda	24,104.7	25,143.6	26,429.4	24,531.0	25,394.8
Mangystau Region	18,026.1	17,492.5	17,806.8	18,735.5	21,253.1
Almaty city	28,216.8	29,645.9	31,676.5	30,271.1	28,633.3
Astana city	22,708.9	24,148.1	26,692.2	27,803.7	26,819.1

Source: Agency of Statistics of the Republic of Kazakhstan, Preservation of the Environment and Sustainable Development of Kazakhstan, 2007–2011, Statistical collection, p. 16.

The highest level of energy produced from heat power stations is determined in Pavlodar Region. To see how it is interrelated with the number of people suffering from respiratory diseases we perform a regression analysis. The analysis is represented in Figure 2.

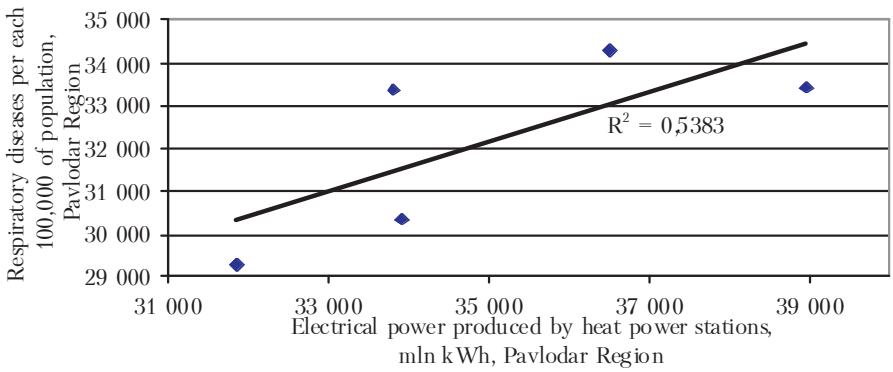

Figure 2. **Regression analysis for energy produced from heat power stations in Pavlodar Region and the number of people suffering from respiratory diseases in the region**

In addition, it is important to identify the same relationship in Astana. This is the capital of Kazakhstan and it will face Expo-2017 first. Figure 3 presents the regression analysis for the level of energy produced from heat power stations in Astana and the number of people suffering from respiratory diseases.

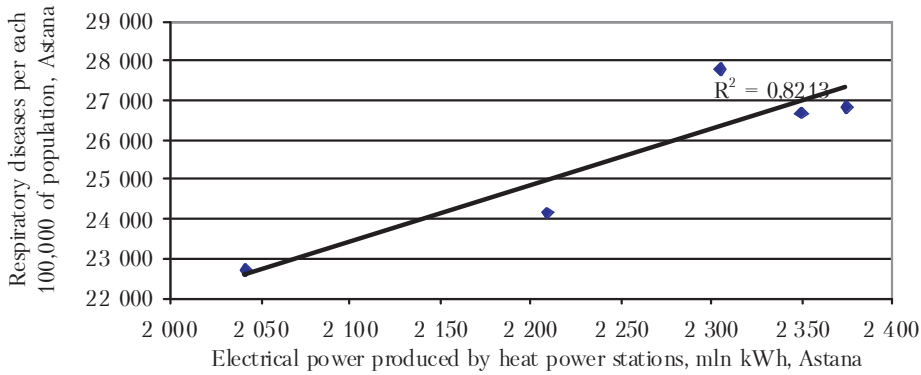

Figure 3. **Regression analysis for the levels of energy produced from heat power stations in Astana and the number of people suffering from respiratory diseases in the capital**

Figure 3 demonstrates a strict relationship between the amount of energy produced and the sickness rate.

The building of two additional heat power stations will increase the amount of CO_2 emissions from burning coal. As a result there is a high likelihood there will be an increase in the number of people suffering from respiratory diseases.

An emphasis should be made to the real development of renewable sources. It has to be supported by the government authorities and taken under its strict control.

There is a need to attract investors, providing them with favorable opportunities to work in this area, motivate them by relaxing some regulatory rules, and provide them with government support and promotion.

Development prospects. As for renewables we can say that it is much easier to produce energy using technologies that people got used to. Kazakhstan has rich natural resources, the energy sector is very inertial, people do not want to take high risks and invest in alternative sources.

In addition, there is a problem of high corruption level in the country hindering the development of this segment.

The proposed improvements, in a diagram form, are presented in Figure 2.

First of all, we actually need to start developing renewable sources of energy. They produce lower level of noxious gases in the atmosphere in comparison to traditional sources of energy such as coal, oil, and gas. To manage the barriers in achieving this goal, among other targets, the government needs to reduce significantly the level of corruption in the sector and in the supporting sectors of the industry.

Another point is that there should be an increase in the amount of investors attracted. For accelerating the process the most reliable guaranties need to be provided by the government. If it is really interested in promotion of renewable energy it will be trying to find all possible ways for improvement. But there is a main contra point here – building of new powerful heat stations. This will increase the amount of CO_2 emissions and as a result the rate of respiratory diseases among population. If the projects that had been already started cannot be overturned it should proceed but with an increased level of caution in terms of applying effective and modernized filters as much as it is possible. But, any way, the risk for the air to be polluted even more is still there.

Figure 4 presents schematically how renewables accelerated development can be achieved.

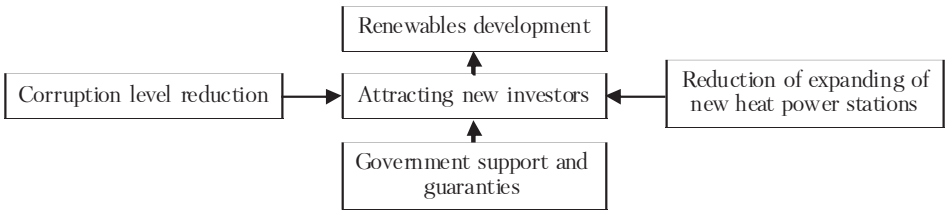

Figure 4. **Renewables development in Kazakhstan,** *as suggested by the author*

Conclusions. The government should implement control over the planned indicators in developing renewable energies. To have strategies and programmes without appropriate control and regulation is insufficient for effective development of the industry. To be consistent with the direction Kazakhstan has identified steps to reduce CO_2 emissions, developing renewable energy sources, and monitoring and accepting trends and developments in innovative technologies all over the world. Expo-2017 is expected to be a great event and it should be held in accordance with the "Green Energy" prospect.

References:

Антонов О.Б. Энергосбережение, энергоэффективность и энергоменеджмент в Казахстане. – Алматы, 2014. – 69 с.

Каренов А.Р. Проблемы и приоритеты перехода казахстанской экономики к индустриально-инновационному типу развития // Вестник Карагандинского университета.– Серия: Экономика.– 2010.– №2. – С. 35–39.

Космамбетова Р.И. Модель индустриально-инновационного развития национальной экономики. – Алматы, 2012. – 549 с.

Сатқалиев А.М. Перспективы развития электроэнергетического сектора // www.kazenergy.com.

De Jong, R., Verbesselt, J., Zeileis, A., Schaepman, M.E. (2013). Shifts in Global Vegetation Activity Trends. Remote Sens, 5: 1117–1133.

Farrag, M.E.A., Putrus, G.A. (2014). Analysis of the Dynamic Performance of Self-Excited Induction Generators Employed in Renewable Energy Generation. Energies, 7: 278–294.

Koenigs, C., Suri, M., Kreiter, A., Elling, C., Eagles, J., Peterson, T.R., Stephens, J.C., Wilson, E.J. (2013). A Smarter Grid for Renewable Energy: Different States of Action. Challenges, 4: 217–233.

Lehmann, P., Creutzig, F., Ehlers, M.-H., Friedrichsen, N., Heuson, C., Hirth, L., Pietzcker, R. (2012). Carbon Lock-Out: Advancing Renewable Energy Policy in Europe. Energies, 5: 323–354.

Schelly, C., Price, J. (2014). Utilizing GIS (Geographic Information System) to Examine the Relationship Between State Renewable Portfolio Standards and the Adoption of Renewable Energy Technologies. ISPRS Int. J. Geo-Inf., 3: 1–17.

Wang, L., Chen, Z., Ma, D., Zhao, P. (2013). Measuring Carbon Emissions Performance in 123 Countries: Application of Minimum Distance to the Strong Efficiency Frontier Analysis. Sustainability, 5: 5319–5332.

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