POLITYKA ENERGETYCZNA – ENERGY POLICY JOURNAL

2024 ✦ Volume 27 ✦ Issue 1 ✦ 173–188

DOI: 10.33223/epj/171442

Aiganym Seidaliyeva[1], Sherniyaz Kabdushev[2], Saltanat Baipakbayeva[3], Eldar Kopishev[4], Ibragim Suleimenov[5]

The diversification of energy sources in Kazakhstan as a way to dampen the consequences of a predicted crisis

Abstract: It is shown that the predicted energy crisis in Kazakhstan makes the issue of small-scale energy and complementary civil society institutions more than relevant. This crisis, caused by the deterioration of heating networks built during the former USSR, can be more than large-scale, as evidenced by the events in the city of Ekibastuz, where a significant proportion of the population was left without heating in the winter of 2022/2023. It is proven that the development of small-scale power generation should be complex, i.e. in the foreseeable future, one should focus attention on a combination of renewable and traditional energy sources, which implies a gradual increase in the

✉ Corresponding Author: Aiganym Seidaliyeva; e-mail: aiganym.sva@gmail.com

[1] NJSC "Almaty University of Power Engineering and Telecommunications named after Gumarbek Daukeev", Kazakhstan; ORCID iD: 0000-0002-7314-182X; e-mail: aiganym.sva@gmail.com

[2] International IT University, Kazakhstan; ORCID iD: 0000-0002-2834-883X; e-mail: sherniyaz.kabdushev.hw@gmail.com

[3] International IT University, Kazakhstan; ORCID iD: 0000-0001-7251-0585; e-mail: saltanat.baipakbayeva@gmail.com

[4] L.N. Gumilyov Eurasian National University, Kazakhstan; ORCID iD: 0000-0002-7209-2341; e-mail: eldar_kopishev@mail.ru

[5] Academician of National Engineering Academy of RK, Kazakhstan; ORCID iD: 0000-0002-7274-029X; e-mail: esenych@yandex.kz

share of renewable energy. The expediency of using the concept of "energy freedom", at least in relation to the Republic of Kazakhstan, is substantiated. It is shown that the goal of the development of small green energy should be precisely the achievement of energy freedom for households, oriented towards the institutions of civil society. This implies, inter alia, the development of a wide range of non-trivial technical solutions that provide, for example, direct heat generation without an intermediate stage of conversion into electrical current. A specific example is considered, demonstrating the adequacy of the proposed approach. It is also shown that the primary measures to ensure the energy freedom of households can be implemented even when using equipment available on the market. Specific calculations are presented which prove that the transition to decentralized heat supply is economically feasible using available equipment.

Keywords: energy crisis, small-scale energy, downshifting, heating boiler, renewable energy sources

Introduction

The degree of depreciation of heat networks in some regions of the Republic of Kazakhstan exceeds 80% (Lisicyn 2022). Clear evidence of this is the number of significant accidents that took place on the territory of Kazakhstan in the second half of 2022. The accident in the city of Ekibastuz received the greatest public outcry, where, due to high wear and increased pressure in the direct and return pipelines of the heating network, it led to multiple cases of damage in the heating networks (Yazykova 2022).

There is no doubt that this problem is systemic in nature, and it is aggravated by the fact that those responsible for its solution are not fully aware of this.

Proof of this is the fact that the problem of providing the population of Kazakh cities with heat and electricity continues to be solved by purely administrative methods. Responsible persons, as before, refuse to understand that the solution of systemic problems requires, inter alia, scientific investigation. The fact that scientific organizations were not involved in solving the emerging problems speaks for itself.

There is every reason to believe that an energy crisis for Kazakhstan in the foreseeable future is inevitable. The degree of deterioration of thermal networks is increasing from year to year. Therefore, the average depreciation in the republic today is 54% (Lisicyn 2022). Political and administrative methods have obviously exhausted their resources, as well as the heating networks themselves, while in Kazakhstan, there are no mechanisms that would ensure the involvement of competent experts capable of generating non-standard ideas to solve such problems. Evidence of this is the fact that in Kazakhstan, there is a continuous increase in the cost of heating for households, including city apartments. Over the past twenty years, the cost of heating has increased by 55%, and this is despite the fact that most of the population of the largest cities of Kazakhstan is heated by water used at thermal power plants to cool equipment. Kazakh thermal power plants use Kazakh coal from such deposits as Ekibastuz, i.e., unlike many European countries, Kazakhstan does not depend on imports, and the increase in heating prices for the population is determined precisely by the state of heating networks. It is significant that it is the need to repair heating networks that is used by officials as an argument for the planned sharp increase in heating prices and the expected crisis (Kaliyev 2023; Altayev et al. 2022), i.e., the high degree of depreciation of heating networks is de facto confirmed at the government level. Consequently, there is every reason to pay close attention to the most independent energy supply of local communities, for example, individual sets of households or cooperatives of owners of several apartment buildings.

The emerging problems, in principle, cannot be solved in a centralized manner due to the fact that in Kazakhstan, there are no mechanisms for converting scientific and technical ideas into practice, at least at the political and administrative level. This is a systemic problem characteristic of Kazakhstani science in general. As shown in previous research (Aisin 2018), less than 0.1% of scientific developments carried out in Kazakhstan are put into practice, and most of the implemented innovations are in IT technologies. Consequently, the problem can be solved only through the self-organization of consumers who are aware of the need for the formation of civil society institutions.

At this level, systems of the so-called small-scale power generation may well be in demand, especially if the issue is approached in a comprehensive manner, i.e. to ensure the combined use of small-scale energy resources focused on the use of fossil fuels with developments in the field of renewable energy. This concept also clearly correlates with the idea of energy downshifting, i.e. moving away from the construction of large generation facilities towards low and medium power plants (Savchuk 2023; PwC Kazakhstan).

This article proves that the consequences of the imminent energy crisis in Kazakhstan can be largely dampened due to the fundamental rejection of the idea of centralized heat and power supply which was put into practice during the period of the former USSR (Zinger and Belevich 1999).

It is also provedn that this concept is nothing more than a consequence of ideological attitudes that correspond to the totalitarian past of Kazakhstan, which in no way corresponded to Kazakhstani realities (Basic socio-economic indicators 2023).

The authors sincerely believe that the formation of civil society institutions should be based, inter alia, on economic grounds. The energy independence of consumers in the current conditions is more than an important factor in this respect.

The overall goal of this work is to justify the need for the most complete introduction of downshifting in the Republic of Kazakhstan and is supplemented by a gradual transition to the fullest possible use of renewable energy sources, as well as a humanitarian component based on the fact that in the modern world the term "freedom" should also include "energy freedom".

The specific purpose of this work is to prove that such a transition can indeed be made gradual, and at the first step, the energy independence of households can be ensured even with the use of equipment that is mass-produced and presented on the market.

We emphasize that this issue is also important from the point of view of the integrated sustainable development of Kazakhstani regions, since it somehow affects almost all aspects of life (Mazhitova et al. 2018; Tashmukhambetova et al. 2017).

1. Formulation of the problem: socio-economic prerequisites for the accelerated development of small-scale power generation in Kazakhstan

Analysis of the situation with energy supply in Kazakhstan requires a comprehensive consideration of both socio-economic and technical factors. There is no doubt that the critical situation in the Kazakh energy sector is due to primarily historical reasons.

Currently, Kazakhstan has the following facilities that provide the population with heat and electricity.

CHPPs (combined heat and power plants) occupy a significant share in generation – they are concentrated in the largest cities of Kazakhstan and provide their population with heat (JSC «Halyk Global Markets» 2020).

All Kazakhstan CHPPs were built during the existence of the USSR (Mussin and Mussina 2023), and the nature of their use corresponded to the principles of a planned economy (Yavlinsky 2005). In particular, in Almaty, the largest city of Kazakhstan (the population is about 10% of the country's population as a whole), more than 90% of the population is provided with heat from thermal power plants. Specifically, warmth is a kind of by-product in the production of electricity (Semenov 2012).

In the conditions of a planned economy, the use of such specifics of thermal power plants looked justified in many respects. However, at present, this approach no longer seems justified. In particular, mechanisms related to competition between heat and electricity suppliers to the market remain unrealized (Mussin and Mussina 2023).

In addition, Kazakhstan has a very low population density (8 people/km^2, Kazakhstan). This leads to the need to build very long communications to transfer heat to small towns and villages, many of them do not currently have a sustainable heat supply, including because of the fact they are not connected to gas mains (Nurbay 2022).

Obviously, there is a critical length of heating mains, over which the use of the above approach ceases to be profitable. More precisely, this approach can demonstrate profitability when calculating indicators related to a large state, but when analyzing the profitability of individual heating mains, directly opposite results can be obtained, especially when it comes to serving a large area with a low population density.

The objectives of this work include a comprehensive analysis of the adequacy of the existing policy, including scientific and technical aspects, in the field of energy supply to the population of Kazakhstan, taking into account the factor of low population density.

The above data on the nature of the supply of the population of Kazakhstan with heat and electricity, as well as the data of work (Mussin and Mussina 2023), show that the market in question in Kazakhstan is completely controlled by monopolies which can afford to raise prices, including by arguing that it is needed to upgrade communications.

Moreover, energy industry in Kazakhstan remains non-transparent for civil society institutions. Even major accidents, such as those that occurred in the city of Ekibastuz, did not affect the transparency of decision making (Lisicyn 2022).

We are aware that social problems cannot be solved by technical means. However, the formation of civil society in Kazakhstan requires the creation of complementary technical solutions. In order for civil society institutions to become effective, they must have the appropriate tools at their disposal. In modern conditions, the real freedoms of the citizens of Kazakhstan imply, among other things, "energy freedom", i.e. the maximum achievable independence from the centralized supply of heat and electricity. This becomes especially relevant for such countries as Kazakhstan, which, we emphasize once again, is associated with the factor of a vast territory with a low population density.

The objective of this work is to analyze the possibility of realizing "energy freedom" for the population of Kazakhstan, based on the integrated use of renewable energy sources and autonomous fossil fuel energy sources used as a reserve.

2. Balance and electricity supply from the point of view of ensuring the energy freedoms of the population of Kazakhstan

For countries such as Kazakhstan, the development of green energy is of primary interest in terms of ensuring energy freedoms and the formation of relevant civil society institutions. Indeed, cities such as Ekibastuz, Ridder, Karaganda, located in the north of Kazakhstan (Fig.1), have obviously become hostages of monopolists, who, as current practice shows, are in no way interested in solving the everyday problems of citizens.

This conclusion is confirmed by the following facts. The city of Ekibastuz is supplied with heat from the Ekibastuz thermal power plant. This source is the only one for the city (kegoc.kz. 2022), so any major accident at this site leaves residents without heating, which was the case in the winter of 2022/2023. Similarly, the heat supply of many other Kazakh cities also depends on a single monopolist. This is why green energy for Kazakhstan is, inter alia, a means of ensuring real economic freedom of households.

Theoretically, the energy freedom of households can be achieved through the use of renewable energy sources. Obviously, a household that is completely focused on the use of photovoltaic panels as sources of electricity and independent sources of heat really becomes energy free. However, the current state of research in the field of green energy does not allow this problem to be solved in full, at least in the conditions of Kazakhstan, since the high cost of acquiring and operating photovoltaic panels or other renewable energy sources makes them unprofitable compared to traditional options (Dukenbayev 2002). Therefore, the transition to the use of renewable energy sources should be gradual.

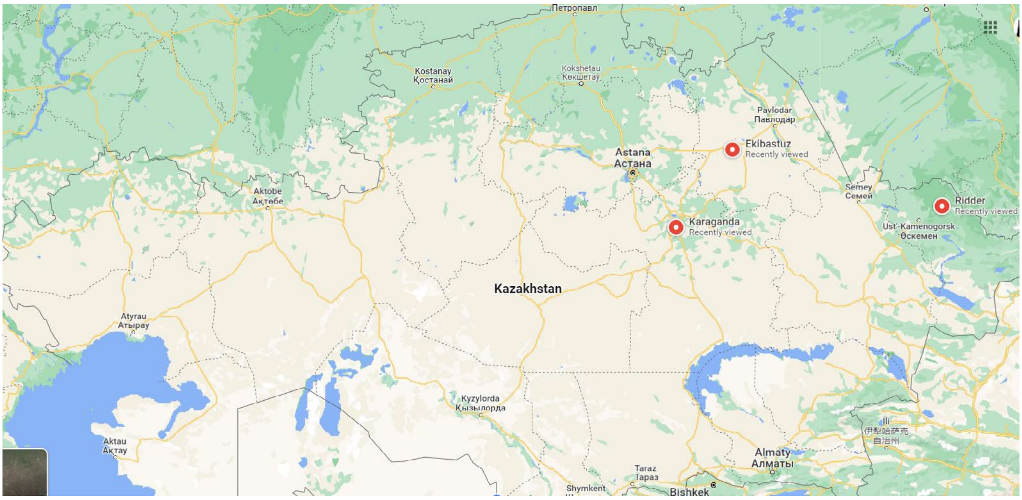

Fig. 1. Locations of the cities of Ekibastuz, Ridder and Karaganda on the map of Kazakhstan (Google Maps)

Rys. 1. Lokalizacje miast Ekibastuz, Ridder i Karaganda na mapie Kazachstanu

Such a gradual transition, among other factors, will create a certain demand, including the development of non-trivial heat supply systems. We emphasize that many non-trivial scientific ideas in Kazakhstan often remain unrealized precisely due to a lack of demand (Aisin 2018).

From this fact follows the basic formulation of the question used in this paper. There is a need for an integrated use of energy sources, both renewable and oriented towards the use of fossil fuels, and the criterion of efficiency in this regard should be the final costs of consumers.

Let us consider the possibilities for implementing a non-trivial approach to household energy supply. Thus, we want to emphasize that in the transition to the combined use of renewable energy sources with fossil fuels, there is a very wide range of different technical solutions. Of considerable interest in this regard is also the possibility of the direct use of renewable energy (Suleimenov et al. 2020).

As shown in previous work (Suleimenov et al. 2020), the unavoidable household demand for electrical energy is relatively low. More precisely, devices that cannot use the direct conversion of renewable energy into the energy consumed by households actually occupy only a small share of the electricity consumption structure (TVs, computers, etc.). Provided that the most energy-consuming devices (stoves, vacuum cleaners, refrigerators, etc.) are brought to the mode of the direct utilization of renewable energy, such systems can be connected, for example, to expensive photovoltaic panels, due to the fact that electric power consumption is reduced to a minimum. Therefore, the question can be posed as follows. A household can be oriented towards the direct use of renewable energy, without an intermediate stage of conversion to electricity. Any such process is accompanied by the release of heat, which can also be used to ensure the life of the household. The most illustrative example in this regard is the example of refrigeration units used for domestic purposes.

The principle of operation of household refrigerators is based on the action of a special gas, namely a refrigerant, i.e. a substance for which the boiling with isothermal expansion removes heat from the refrigerator chambers (Dhankar 2014). Therefore, the refrigeration unit (Fig. 2) can be directly connected to the wind power plant. The pumping of the refrigerant that ensures the functioning of the refrigerator (Suleimenov et al. 2020) can be performed by purely mechanical means without the use of an electric motor.

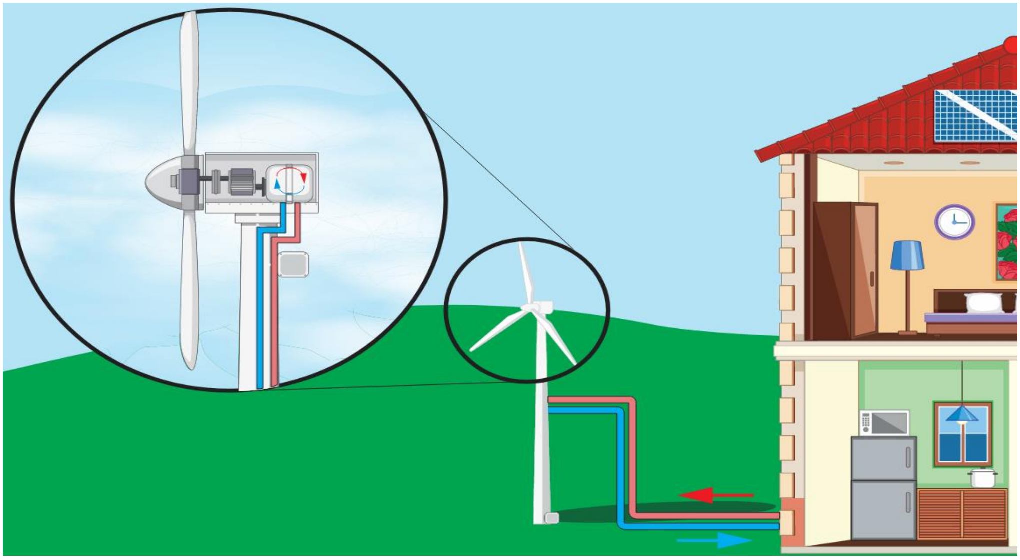

Fig. 2. Illustration of the principle of operation of refrigerators based on wind turbines

Rys. 2. Ilustracja zasady działania lodówek bazujących na turbinach wiatrowych

It is essential that heat is also generated, which follows from the fundamental laws of thermodynamics. This means that the wind power plant, which ensures the functioning of the refrigerating chamber, can also be used as a heat source. The rotational energy of the windmill blades in this case is converted into heat. Moreover, the existing types of refrigeration units were initially focused on maximum savings in electrical energy as they were built on the use of electric motors that pump the refrigerant. Provided that such an installation is also used for heat generation in parallel, lower performance refrigerants can be used. We also note that there are a number of additional possibilities for converting rotational energy into heat, associated, for example, with the use of viscous liquids of various nature. In this case, it is possible to control the viscosity over a wide range, for example, due to the formation of interpolymer complexes, including those with the participation of crosslinked polymer networks (Budtova et al. 1994; Dergunov et al. 2011).

Most significantly, with this approach to the use of wind energy, the question of the value of the coefficient of performance (COP), in essence, loses its meaning. Indeed, an efficiency value other than unity is usually due to the fact that a certain part of it is converted into heat, which is interpreted as unproductive losses. When using the proposed approach, this heat is also a beneficial effect. Therefore, the central issue in ensuring the energy freedom of households is the issue of providing heat. It is proved below that this problem is solvable even at the level of existing small-scale energy tools.

3. An example of calculating the heat supply for a set of apartment buildings

We will show that providing heat to local areas of urban development focused on energy independence in the conditions of Kazakhstan is cost-effective in the currently existing conditions. To do this, we will calculate the characteristics of heat supply using a clear concrete example using typical indicators.

As a specific example, residential buildings located in the city of Ekibastuz were selected, i.e. the city where in the winter of 2022/2023 there was the landmark accident mentioned above, which caused a wide public outcry. To specify the demonstration calculation, the following typical values of the parameters were chosen (plan for the elimination of the consequences of coal mining operations at the Ekibastuz coal deposit within the boundaries of the "Vostochny" open pit, 2020):

- the estimated air temperature of the coldest five-day period in Ekibastuz is – 33°C, the average temperature calculated for the entire heating period is – 8.4°C;
- the estimated duration of the heating period is 215 days;
- the number of residential buildings connected to the local heating system is 2.

This number of houses, united by a common local heating network, on the one hand, is sufficient to ensure the profitability of the operated systems. On the other hand, the number of inhabitants in them remains relatively small, which makes it possible to ensure civil self-organization.

It is also assumed that the houses have the same layout and typical architecture for the industrial cities of Kazakhstan: five floors with a total height of the house from 13 m and a total area of 510 m^2. This corresponds to the volume of one residential building of this type being 6,619 m^3. It is assumed that the number of residents for two houses is 400 people, which is also a typical value.

To calculate energy consumption, there is a standard technique based on the calculation of thermal loads (Prokhorov 2018). In accordance with this, the heating load is determined from the calculation of the heat consumption of buildings Q_1 according to the following formula:

$$Q_1 = q_0 \cdot V \cdot (t_{in} - t_{out}) \quad [\text{kW}] \tag{1}$$

where:

- q_o – the specific thermal characteristic of buildings, the maximum heat flow for the needs of heating the building under conditions of a difference in external and internal temperatures of one degree Celsius. q_o = 0.41–0.46 W/(m^{3}K) (Mikhailov 1972),
- V – the volume of the building [m^3],
- t_{in} – internal air temperature [20°C],
- t_{out} – the calculated outdoor air temperature of the coldest five-day period (–33°C for the city of Ekibastuz).

With the selected values of typical parameters, calculated value of the considered indicator obtained by formula (1), is Q_1 = 287 kW.

In accordance with the standard methodology (Prokhorov 2018), the heat consumption for hot water supply of residential buildings Q_2 is determined by the following formula:

$$Q_2 = \frac{\chi_d \cdot \chi_w \cdot M \cdot R \cdot c \cdot (t_h - t_c)}{86{,}400} \quad [\text{ kW}] \tag{2}$$

where:

- M – the number of residents, taken to be 400 people,
- R – the rate of hot water consumption (110 kg/day per person),
- c – the heat capacity of water,
- t_h – the temperature of hot water (a typical value of 60°C is assumed),
- t_c – temperature of cold water (assumed to be +15°C in summer and +5°C in winter),
- χ_d – the coefficient of daily unevenness (assumed to be 1.7–2),
- χ_w – the coefficient of weekly unevenness (assumed to be 1.2).

For the selected typical indicators, calculations according to formula (2) give the following values Q_2 = 239 kW and Q_2 = 195.8 kW in winter and summer, respectively. The resulting energy consumption is thus 721 kW. Therefore, to provide thermal energy to the residential buildings under consideration united by a common network, it is sufficient to use two 400 kW hot water boilers. In particular, it is permissible to use boilers of the type BB-400 (hot water boiler from Buran Boiler), currently on the market (Buran Boiler LLP).

The boiler of this type is a fire-tube boiler, which also allows some improvements. In particular, it is possible to use a boiler with spiral inserts inserted into convective flame tubes, which, according to test results (Orumbaev et al. 2019), are more efficient than twisted tape inserts. The main indicators of this type of boiler are presented in Table 1.

The presented characteristics emphasize that a boiler of this type can indeed be operated by a local heating network. Thus, providing two houses with a body, which make up an energy-independent local segment of urban development, can indeed be implemented using boilers that are currently on the market.

Table 1. Main characteristics of the boiler BB-400 (Buran Boiler LLP)

Tabela 1. Główne cechy kotła BB-400 (Buran Boiler LLP)

Name of indicator	BB-400
1. Thermal power [MW]	0.423
2. Fuel consumption (diesel fuel) [kg/h]	35.1
3. Working pressure water [MPa]	0.4
4. Inlet water temperature [°C]	63.98
5. The same at the boiler outlet [°C]	72.87
6. Water temperature difference [°C]	8.87
9. Water consumption through the boiler [t/h]	41.06
10. Boiler furnace volume [m^3]	0.332
11. Radiant surface [m^2]	2.55
12. Convective surface [m^2]	10.79
13. Full surface of the boiler [m^2]	13.34
14. Boiler efficiency: at d.t. gas calculation. analysis	93.8(95)
16. Boiler weight [kg]	1,090

Let us show that the operation of this equipment is also economically viable.

In accordance with the standard methodology (RK EN 13941-2012) recommended for use in the Republic of Kazakhstan, capital investments for the construction of an autonomous boiler house can be estimated using the following formula:

$$W = \left(W_1 + W_2 + W_3 + W_4 + W_5\right) + W_6 + W_7 + W_9 \quad \text{[thousand tenge]} \tag{3}$$

where:

- W_1 – the cost of purchasing a boiler (3000 thousand tenge in 2022 prices),
- W_2 – pipeline construction costs,
- W_3 – the cost of the internal equipment of a residential building, including the cost of wiring a network of pipes for water heating and hot water, heating batteries, and hot water taps (we accept 20 thousand tenge for 1 apartment),
- W_4 – the cost of construction and installation work,
- W_5 – costs for the purchase of pumps (500 thousand tenge),
- W_6 – fuel costs,
- W_7 – wage costs,
- W_9 – current repair costs.

The cost of construction and installation work can be estimated as $W_4 = 0.2 \cdot (W_1 + W_3 + W_5) =$ $= 1{,}180$ thousand tenge.

It is assumed that heat pipes would be covered with mineral wool and foil and carried underground by two pipelines (RK EN 13941-2012). For local heat supply, the length of heating mains can be taken as being 65 m. $W_2 = 6000 \cdot 65 = 390$ thousand tenge.

To determine the cost of fuel (natural gas), we find the specific consumption of standard fuel for the generation of 1 Gcal of thermal energy for a boiler house in accordance with the methodology (Hilgers and Achenbach 2021). Immediately substituting specific parameter values, we obtain:

$$b_{spec} = \frac{143}{\eta_{boi} \cdot \eta_{reg}} = 161.9 \quad \text{[kg oe/Gcal]} \tag{4}$$

where:

$\eta_{boi} = 0.93$ – boiler efficiency,
$\eta_{reg} = 0.96$ – boiler load regulation efficiency.

In accordance with this, the total consumption of conventional fuel required to provide the considered local area of urban development for heating and hot water supply is:

$$b_c = b_{spec} \cdot Q_{heat} = 16.19 \cdot 593.9 = 9{,}6 \quad \text{[toe]} \tag{5}$$

Using the conversion factor K (calculator for converting natural fuel to conditional), which allows us to convert the consumption of conventional fuel, we find that the cost of fuel is $W_6 = 314.03$ thousand tenge. We will take the selling price for gas equal to 37.6 tenge/m^3, which corresponds to the prices of 2022 (gas tariffs for the population in Kazakhstan). Further estimates using standard methods give the following indicators:

- total wage fund (including taxes and fees with the number of employees two shift workers) – $W_7 = 2{,}150$ thousand tenge;
- depreciation deductions are accepted to be the amount of 8% of the total capital investments in the heat supply scheme of a residential building $W_8 = 0.08 \cdot (W_1 + W_2 + W_3 + W_4 + W_5) = 597.6$ thousand tenge;
- the cost of current repairs is accepted to be the amount of 15% of the depreciation deductions – $W_9 = 89.6$ thousand tenge in a year;
- other costs are determined by $W_{10} = (W_8 + W_9 + W_4) \cdot 10\% = 186.7$ thousand tenge;
- the required amount of capital investments $W = 10{,}023$ thousand tenge.

The amount of thermal energy for heating and hot water supply for the planned period is $Q_{heat} = 698$ Gcal/year and $Q_{hws} = 871.2$ Gcal/person·year, respectively.

Using these indicators, we obtain the following value of the cost of thermal energy when using a boiler house that provides a local segment of urban development:

$$S = \frac{W_8 + W_9 + W_6 + W_7 + W_{10}}{Q_{heat} + Q_{hws}} = 2{,}127 \quad \text{[tenge/Gcal]} \tag{6}$$

Let us compare the obtained indicators with the tariffs for thermal energy for the city of Ekibastuz. In accordance with the standards of the Republic of Kazakhstan, it is 3,337.64 tenge per 1 Gcal without a meter and 1,807.89 tenge per 1 Gcal with a meter (Heating tariffs in Kazakhstan).

It can be seen that the figures are at least comparable. Therefore, even with the operation of existing equipment and existing prices, there is every reason to switch to a local heat supply.

This approach seems justified for the following reasons.

Firstly, the risks associated with the instability of centralized heat supplies are reduced and preventive measures are being taken related to the predicted energy catastrophe caused by the deterioration of centralized heating networks and the lack of a clear scientific and technical policy in this area.

Secondly, there is a real platform for the formation of civil society institutions focused on the energy freedom of households.

Thirdly, the transition to local heating networks creates significant prerequisites for the use of renewable energy sources built on a variety of physical and physico-chemical principles as, for example, those described above. With a consistent transition to autonomous energy and electricity supply, fossil fuel heat sources acquire the functions of a reserve.

Finally, the transition to the concept of energy-independent local urban areas (or household associations) creates real prerequisites for the introduction of green energy systems. We emphasize that taken separately, they are not able to compete adequately with the existing sources of heat and energy, which are mainly focused on the use of hydrocarbon fuels. Local power supply systems, as shown in the materials of this work, can make them be in demand even at the current level of scientific and technical developments in this area. Here, their main advantage turns out to be in demand – flexibility and such a consumer advantage as ensuring energy freedom.

Conclusions

The concept of small energy, supplemented by the concept of green energy, is more than important for Kazakhstan. This conclusion is connected not with the "green transition" ideas only but with the predicted energy crisis that Kazakhstan will face in the foreseeable future too. This crisis is due to the deterioration of the heating networks inherited from the former USSR and the lack of a clear scientific and technical policy in the field of the fuel-energy complex.

The materials of the work show that the above risks can be significantly reduced by switching to local heating networks serving relatively small areas of urban development offline. The feasibility studies provided in the paper show that even with the use of existing equipment, it is possible to organize local heat supply, which, at a minimum, will be no more expensive than connecting to existing heating networks, the use of which is becoming more expensive for households.

The creation of such networks will, inter alia, contribute to the formation of civil society institutions, focused on ensuring the energy freedom of the population. In the modern world, the concept of "freedom" is inseparable from the concept of "energy freedom".

It is also significant that the transition to local heat supply networks inevitably creates competition in the corresponding market, limiting the ability of monopolists to dictate prices. This, among other factors, creates the prerequisites for progress in the development of non-trivial energy systems as there will be a corresponding demand.

References

Aisin, S. 2018. Five Chronic Problems of Kazakh Science (*Pyat hronicheskih problem kazakhstanskoi nauki*). [Online] https://online.zakon.kz/Document/?doc_id=36711333&pos=5;-108#pos=5;-108 [Accessed: 2023-07-12] (*in Russian*).

Altayev, A. 2022. Sad statistics on CHPPs in the regions – review (*Pechal'naya statistika po TEC v regionah)*. [Online] https://www.zakon.kz/6379596-pechalnaya-statistika-po-tets-v-regionakh--obzor.html [Accessed: 2023-07-08] (*in Russian*).

Basic socio-economic indicators, 2023. Bureau of National Statistics website (*Negizgi aleumettik korsetkishter*). [Online] www.stat.gov.kz [Accessed: 2023-04-19] (*in Kazakh*).

Budtova et al. 1994 – Budtova, T.V., Suleimenov, I.E. and Frenkel, S.Ya. 1994. Interpolymer complex formation of some nonionogenic polymers with linear and crosslinked polyacrylic acid. *Journal of Polymer Science/Polymer Chemistry* 32, pp. 281–284, DOI: 10.1002/pola.1994.080320208.

Buran Boiler LLP. [Online] https://buran.kz/ [Accessed: 2023-04-19].

Calculator for converting natural fuel to conditional. [Online] https://www.kotel-modul.ru/useful/table [Accessed: 2023-04-19].

Dergunov et al. 2011 – Dergunov, S.A., Mun, G.A., Dergunov, M.A., Suleimenov, I.E. and Pinkhassik, E. 2011. Tunable thermosensitivity in multistimuli-responsive terpolymers. *Reactive and Functional Polymers* 71(12), pp. 1129–1136, DOI: 10.1016/j.reactfunctpolym.2011.09.005.

Dhankar, P. 2014. A Study on Refrigeration. *International Journal of Science and Research* 3(5), pp. 1212–1220.

Dukenbayev, K. 2002. Energy of Kazakhstan. Conditions and mechanisms for its sustainable development. p. 453 (*in Russian*).

Gas tariffs for the population in Kazakhstan. [Online] https://bankchart.kz/spravochniki/indikatory_rynka/gas_tariff#google_vignette [Accessed: 2023-04-19].

Google Maps. [Online] https://www.google.com/maps/@48.8219131,66.8470636,5.48z?hl=en&entry=ttu [Accessed: 2023-07-13].

"Halyk Global Markets" 2020. Overview of the electricity market in Kazakhstan in 2020 (*Obzor rynka elektroenergii Kazakhstana v 2020 godu*). [Online] https://www.korem.kz/rus/press-centr/novosti_otrasli/?rid=9280&cid=0 [Accessed: 2023-07-11] (*in Russian*).

Heating tariffs in Kazakhstan. [Online] https://bankchart.kz/spravochniki/indikatory_rynka/tarify_na_otopleniye [Accessed: 2023-04-19].

Hilgers, M. and Achenbach, W. 2021. Fuel Consumption and Consumption Optimization. *Springer-Verlag GmbH Germany, part of Springer Nature* p. 56.

Kaliyev, A. 2023. Growth in utility services in Kazakhstan will be up to 30% – head of the Ministry of Economy (*Rost na komuslugi v Kazahstane sostavit do 30% – glava Minekonomiki*). [Online] https://

ru.sputnik.kz/20230426/rost-na-komuslugi-v-kazakhstane-sostavit-do-30-34300488.html [Accessed: 2023-07-12] (*in Russian*).

Kazakhstan. [Online] https://ru.wikipedia.org [Accessed: 2023-07-10].

kegoc.kz. 2022. Power industry of Kazakhstan: key facts. Power industry of Kazakhstan. [Online] http://www.kegoc.kz/ru/electric-power/elektroenergetika-kazakhstana/ [Accessed: 12.07.2023].

Lisicyn, P. 2022. The situation is critical: the wear of heating networks in the regions of Kazakhstan reaches 82% – Ministry of Industry (*Situaciya kriticheskaya – do 82% dohodit iznos teplosetei v regionah Kazakhstana*). [Online] https://ru.sputnik.kz/20230207/situatsiya-kriticheskaya-do-82-dokhodit-iznos-teplosetey-v-regionakh-kazakhstana---minindustrii-31842890.html [Accessed: 2023-04-19] (*in Russian*).

Mazhitova et al. 2018 – Mazhitova, G.Z., Janaleyeva, K.M., Berdenov, Z.G., Doskenova, B.B. and Atasoy, E. 2018. Assessment of the sustainability of landscapes of the North-Kazakhstan region to agricultural impact. *News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences* 3, pp. 90–95.

Mikhailov, F. 1972. Heating and basics of ventilation. M. Stroyizdat, p. 416 (*in Russian*).

Mussin, B. and Mussina, Z. 2023. Features of state management and regulation in the Kazakhstan energy supply system: opportunities and risks. *Polityka Energetyczna – Energy Policy Journal* 26(2), pp. 5–22, DOI: 10.33223/epj/162280.

Nurbay, R. 2022. Heat supply in Kazakhstan: problems and solutions (*Teplosnabzheniye v Kazakhstane: problem i puti resheniya*). [Online] https://www.inform.kz/ru/teplosnabzhenie-v-kazahstane-problemy-i-puti-resheniya_a3963511) [Accessed: 2023-07-10] (*in Russian*).

Orumbaev et al. 2019 – Orumbaev, R.K., Kassimov, A.S., Seidaliyeva, A.B. and Otynchiyeva, M.T. 2019. Investigation of spiral turbulators for the intensification of convective heat transfer of low power hot water boilers (*Isledovaniye spiralnyh turbulizatorov dlya intencifikacii konvektivnogo teploobmena vodogreinyh kotlov maloi moshnosti*). *Bulletin of the Almaty University of Energineering and Telecommunications* 2(45), pp. 20–27 (*in Russian*).

Plan for the elimination of the consequences of coal mining operations at the Ekibastuz coal deposit within the boundaries of the Vostochny open pit 2020 – JSC "Eurasian Energy Corporation" 2020, p. 113.

Prokhorov, V.I. 2018. Calculation method of heat consumption for buildings life support systems. *IOP Conference Series: Materials Science and Engineering* 365(2), DOI: 10.1088/1757-899X/365/2/022023.

PwC Kazakhstan, Energy Transition in Kazakhstan – Back to a Sustainable Future (*Energeticheski perehod v Kazakhstane – nazad v ustoichivoe budushee*), p. 66 (*in Russian*).

RK EN 13941-2012. (RK EN 13941:2009+A1:2010 Design and installation of preinsulated bonded pipe systems for district heating, IDT).

Savchuk, S. 2023. Kyiv is one step away from the global energy revolution (*Kiev v shage ot globalnoi energeticheskoi revolyucii*). [Online] https://ria.ru/20230105/energetika-1843092592.html [Accessed: 2023-04-19] (*in Russian*).

Semenov, V. 2012. Heat supply in modern market conditions. *Energy Council.* 2(21), pp. 24–25.

Suleimenov et al. 2020 – Suleimenov, I., Egemberdieva, Z., Bakirov, A., Baipakbayeva, S., Kopishev, E. and Mun, G. 2020. Efficiency Problem of renewable energetics systems in the context of «smart house» concept. *E3S Web of Conferences* 164, DOI: 10.1051/e3sconf/202016413002.

Tashmukhambetova et al. 2017 – Tashmukhambetova, Z., Aubakirov, Y., Shomanova, Z., Burkhanbekov, K., Safarov, R., Sassykova, L., Zhakirova, N. and Faizullaeva, M. 2017. The Effects of Pretreatment Methods of Carbon-Containing Wastes in Thermal Catalytic Recycling. *Oriental Journal of Chemistry* 33, pp. 2884–2890, DOI: 10.13005/ojc/330622.

Yavlinski, G. 2005. The planned economy of the USSR: Features, evolution, the cause of the collapse. *Economic science of modern Russia* 1(28).

Yazykova, T. 2022. Accident in Ekibastuz: Smailov turned to akims (*Avariya v Ekibastuze: Smailov obratilsya k akimam*). [Online] https://www.zakon.kz/6031528-avariia-v-ekibastuze-smailov-obratilsia-k-akimam.html [Accessed: 2023-04-19] (*in Russian*).

Zinger, N. and Belevich, A. 1999. Development of district heating in Russia. To the 75th anniversary of district heating", *Electric stations* 10.

Aiganym Seidaliyeva, Sherniyaz Kabdushev, Saltanat Baipakbayeva, Eldar Kopishev, Ibragim Suleimenov

Dywersyfikacja źródeł energii w Kazachstanie jako sposób na złagodzenie skutków przewidywanego kryzysu

Streszczenie

W artykule ukazano, że przewidywany kryzys energetyczny w Kazachstanie sprawia, że kwestia małej energetyki i komplementarnych instytucji społeczeństwa obywatelskiego staje się bardziej aktualna. Kryzys ten, spowodowany pogorszeniem sieci ciepłowniczych budowanych w czasach byłego ZSRR, może mieć więcej niż dużą skalę, o czym świadczą wydarzenia w mieście Ekibastuz, gdzie znaczna część ludności została zimą 2022/2023 pozbawiona ogrzewania. Udowodniono, że rozwój małej energetyki powinien być złożony, tj. w dającej się przewidzieć przyszłości należy skupić uwagę na łączeniu odnawialnych i tradycyjnych źródeł energii, co oznacza stopniowy wzrost udziału energii odnawialnej. Uzasadniona jest celowość stosowania pojęcia „wolności energetycznej", przynajmniej w odniesieniu do Republiki Kazachstanu. W artykule pokazano, że celem rozwoju małej zielonej energii powinno być właśnie osiągnięcie wolności energetycznej gospodarstw domowych, zorientowanej na instytucje społeczeństwa obywatelskiego. Oznacza to, między innymi, rozwój szerokiej gamy nietypowych rozwiązań technicznych, które zapewniają, na przykład, bezpośrednie wytwarzanie ciepła bez pośredniego etapu konwersji na prąd elektryczny. W artykule rozważono konkretny przykład wykazujący adekwatność proponowanego podejścia. Pokazano także, że podstawowe działania zapewniające wolność energetyczną gospodarstw domowych można realizować nawet przy wykorzystaniu dostępnych na rynku urządzeń. Przedstawiono konkretne obliczenia, które dowodzą, że przejście na zdecentralizowane dostawy ciepła jest ekonomicznie wykonalne przy użyciu dostępnego sprzętu.

Słowa kluczowe: kryzys energetyczny, energia na małą skalę, downshifting, kocioł grzewczy, odnawialne źródła energii