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Peculiarities of Housing and Communal Services and the Difficulties of Implementing Energy-Saving Technologies: The Case of Kazakhstan

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Abstract: The article considers the problems arising in the implementation of energy-saving technologies in the housing and communal services sector of Kazakhstan, including the example of specific situations. Despite the global trend of energy saving and increasing the energy efficiency of production and service provision, there is almost no introduction of energy-saving technologies by utility companies in Kazakhstan. After reviewing the experience of the previous 10 years and the unsuccessful attempts of Western manufacturers to enter this market, we identified the reasons for this situation, namely, the need to identify the exact institutional need for implementation with reference to the Kazakhstan regulatory framework, the need to consider the financial effect of the projects, not according to the prices of the producing countries (which are usually Western countries, where utility bills are much higher) but the Kazakhstan energy prices and/or tariffs for the necessary resources, as well as the necessity to calculate the economic and/or social effectiveness of the project. The authors present the results of the analysis of public utilities of Kazakhstan as DMUs (decision-making units). Data envelopment analysis (DEA) was chosen as the method of analysis, which allows for a nonparametric evaluation of economic agents by several input and output parameters. The authors also propose aspects of technical policy aimed at the development of energy conservation in Kazakhstan.

Keywords: management; bridge consulting; energy-saving technologies; socially oriented tariffs; economics; financial; economic; social and institutional effects of implementation; Kazakhstan

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1. Introduction

In Kazakhstan, for at least 10 years, the idea has been advanced that energy-saving technologies are one of the key areas of energy policy development. At the same time, Kazakhstan's economy is characterized by high energy usage. Energy usage is a key indicator characterizing the sustainability of the development of both the country and the energy sector, and this indicator is also among the basic in most systems of sustainability indicators.

The value of the chosen theme is determined by the fact that in crisis conditions, the utilities switch to a survival strategy, and the introduction of energy-saving technologies in theory and in Western practice not only contributes to cost reduction, but also allows improvement in the process of service provision.

Despite the fact that a lot of works by foreign authors are devoted to the subject under consideration, some practical issues relating to the problems associated with using energy-saving technologies at utility companies have been studied only slightly, and there is little experience in the area of energy saving in Kazakhstan. Therefore, we believe there is a need to examine the reasons for the lack of implementation of energy-saving technologies by Kazakhstani enterprises and to develop measures to use them.

The expediency of developing the topic. Currently, a low degree of implementation of energy-saving technologies is observed at utility enterprises of Kazakhstan (as well as The Eurasian Economic Union, hereinafter EAEU, which represents an economic union of some post-Soviet states located in Eurasia [1]). The state takes certain actions to improve the energy efficiency of utilities, but the pace of development leaves much to be desired. Consequently, there are problems in the implementation of energy-saving technologies, which are insufficiently highlighted and formulated, and this complicates the process of their elimination.

The scientific novelty of the study consists of identifying the reasons for the low implementation of energy-saving technologies in the enterprises of the housing and communal services sector.

The purpose of the study was to identify and analyze the problems associated with the introduction of energy-saving technologies in utility companies.

The hypothesis of the study: Companies entering the market of Kazakhstan with an offer of energy-saving technologies should consider the specifics and prices in the domestic market.

The object of the study is the enterprises of the housing and communal services sectors of Kazakhstan.

The subject of the study is to identify problems of implementation of energy-saving technologies in the work of utility companies and the development of practical recommendations to address key energy-saving issues.

Methodology and research methods. General scientific approaches—dialectical and systemic—which allow for consideration of the processes under study in development, determine the driving contradictions of the processes under study, as well as identify the content and form of the phenomena under study, were used as methods of research in the work. The complexity of managing the housing and communal services sector is based on its systemic nature. The system features of the housing and communal sector include:

- a set of constituents interrelated sub-sectors;
- unity of the main objective of all components—provision of housing and communal services to consumers that meet regulatory requirements;
- availability of a complex hierarchical structure;
- availability of external and internal factors of influence;
- existence of a management system.

As housing and communal services comprise a system, one has to use a systematic approach to study this sector and its system attributes.

Experimental, empirical and heuristic methods are used as special methodological tools in the study, to analyze the factors and identify problems in the application of energy-saving technologies.

DMUs (decision-making units) operating in the field of energy supply, gas supply, water supply and sewerage (wastewater disposal) in the regions of Kazakhstan were considered for the analysis. The purpose of the analysis was to find the most efficient DMU from the point of view of the consumer—that is, the DMU that serves the maximum number of people at a minimum tariff and staff. Data Envelopment Analysis (DEA) was chosen as a method of analysis, which allows for the nonparametric evaluation of economic agents by several input and output parameters. In our case, DEA solves an optimality problem: the minimization of input parameters for actual output parameters (input-oriented model).

The World Bank report (2012) notes that “the development economy has not yet come to a well-formulated institutional theory suitable for a world full of heterogeneous economies with a colorful history, at various stages of development” [2].

Cornillie and Fankhauser, conducting a study of the energy intensity of transition economies, concluded that energy prices and progress in enterprise restructuring are important factors for improving energy efficiency (Cornillie, Fankhauser, 2004) [3].

Pan X. et al. note that it is industrialization that has a direct positive impact on the energy usage of GDP. In the case of individual impacts, only industrialization has a positive effect on the energy usage of GDP, while trade openness, economic growth and technological innovation have an indirect but negative effect (Pan, Uddin, Saima, Jiao, Han, 2019) [4].

There was also a study by Chepel (Chepel, 2017) of the energy usage of GDP in the CIS countries; according to the results, it was noted that the CIS countries have a high potential to improve their energy efficiency. According to the author, this requires building the capacity of state institutions, limiting the shadow economy and more intensively counteracting corruption, focusing on the development of competitive energy markets and the introduction of energy audits [5].

The issues of economic development and energy security, taking into account regional characteristics, have been repeatedly considered in the works of economists and sociologists. (Anson et al., 2004; Boronenko & Lavrinenko, 2015; Clarke, 2018; Tvaronavičienė, 2018; Shevyakova et al., 2019; Petrenko et al., 2017) [6–11].

The applied aspects of energy efficiency have been described in more detail, for example, in the works of American researchers [12–20]. In terms of territory, population density and settlement density, and concentrations of population in cities and urban areas, the American experience is in direct correlation with the Kazakh experience. For an example, see New Horizons for Energy Efficiency: Major Opportunities to Reach Higher Electricity Savings by 2030 (York D. et al., 2015 [12]).

2. Main Part

Analysis of statistical data shows that the world economy has a pronounced tendency to reduce energy usage; for example, since 1990, the gross domestic product (GDP) has more than doubled, while total energy consumption has increased by less than 60% [21–24].

The energy usage of the national economy is often used as an indicator of energy efficiency, because of the availability of baseline data for calculation [25,26]. This indicator takes into account the energy required to meet the demand for national energy services.

To determine the economic efficiency of fuel and energy resource consumption in the production of GDP for the Republic of Kazakhstan as a whole, the energy usage of GDP is calculated as the ratio of the gross consumption of fuel and energy resources for all industrial and nonindustrial needs in tons of oil equivalent to the amount of GDP. The dynamics of energy usage in Kazakhstan's GDP are presented in Table 1 and Figure 1.

Table 1. Dynamics of the energy usage of Kazakhstan's GDP for the period 2014–2020.

Years	2014	2015	2016	2017	2018	2019	2020 *
Energy usage of GDP, (tons of oil equivalent per thousand U.S. dollars in 2015 prices)	0.36	0.30	0.34	0.34	0.37	0.35	0.32

* Preliminary data. Source: composed by the authors according to the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan [27].

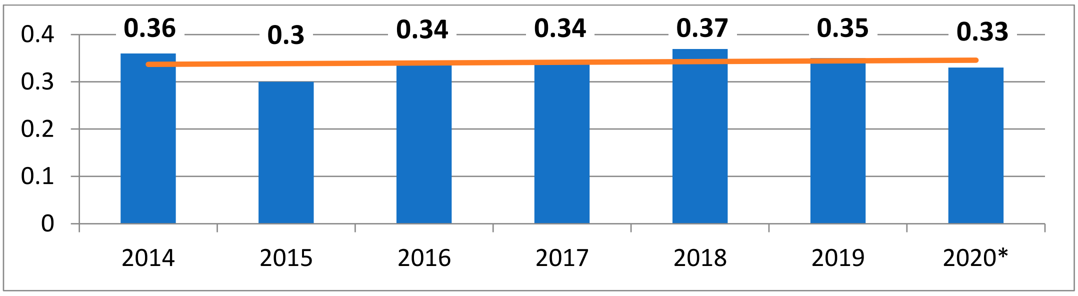

Figure 1. Energy usage of GDP (tons of oil equivalent per thousand U.S. dollars in 2015 prices). * Preliminary data. The orange line is the average value for the period 2014–2020.

Necessary measures, repeatedly considered and introduced in foreign practice, to ensure energy savings are:

- Elimination of technological backwardness of the industry;
- Supply of the enterprises with of new energy-saving equipment;
- Modernization of the housing and communal services sector;
- Introduction of energy-saving technologies;
- Attracting the necessary investments for energy saving;
- Working with the population to improve consumer literacy.

Additionally, the main direction to replace traditional fuels in the future is the transition to energy-saving technologies using renewable energy sources, which include solid biomass and animal products, industrial waste, hydropower, geothermal energy, solar energy, wind energy, and the tidal energy of sea waves and ocean.

This gives not only a significant reduction of energy costs, but also has great environmental benefits. Energy-saving technologies in Western practice with relatively simple methods of state regulation allow to significantly reduce the burden on state and local budgets, curb the growth of tariffs, increase the competitiveness of the economy, increase labor market supply.

In Kazakhstan, the housing and utilities sector is understood as a multi-sectoral complex that provides a wide range of services and includes utilities networks, equipment, buildings, structures, etc. The housing and utilities sector maintains life sustenance (existence) of people and settlements, as well as creates amenities and comfort for residence and activities of citizens. This is the area, the proper functioning of which directly affects not only the health, safety, and social well-being of the population, but also the successful development of the economy and the normal vital activity of the state. Therefore, the housing and utilities sector in Kazakhstan, a country with active intervention of the state into the economy, has traditionally been the responsibility of the state. This situation is also relevant for other EAEU member countries.

In Kazakhstan, the industry is represented by two main interrelated sectors:

- The housing sector, which includes multi-family residential buildings (MFBs) and individual households, which are the main consumers of utility services;
- the utilities sector, which includes networks and facilities (systems) that provide water, heat, gas and electricity supply, sewage, landscaping, and cleaning services.

The housing and utilities sector is a sector of the economy that provides the infrastructure of settlements. According to the Ministry of Economy of the Republic of Kazakhstan, it includes:

- the housing stock (105,000 apartment buildings);
- electricity supply system (199,500 km);
- heating networks (11,700 km);
- water pipelines (60,900 thousand km)
- gas pipelines (27,300 km) [28].

The situation in Kazakhstan's housing and utilities sector is similar to many post-Soviet countries: high wear and tear of networks and equipment, up to 70–80% in some places (e.g., trunk and intra-block networks), obsolete technologies, socially oriented tariffs and insufficient financing of housing and utilities projects.

Over the last 10 years, five large programs with budgets ranging from KZT 54 billion to KZT 5.3 trillion (at the official exchange rate of the National Bank of the Republic of Kazakhstan for 2021 from 0.107 to 10.518 billion euros [29]) have been developed in the sector of development and modernization of the housing and utilities sector. Each new project was launched before the previous one came to its logical end.

In 2010 the Program of Modernization of Housing and Communal Services until 2020 was adopted. However, in fact, it was already null and void in April 2011, six months after its approval [30]. Unfortunately, the program did not have a sufficient level of detail. The authors of the program were going to drastically improve public satisfaction with the quality of services provided by the housing and utilities system (from 50% to 70%) and reduce the number of accidents. It was planned to allocate 54 billion KZT (0.107 billion euro) for this purpose. The program has not existed long enough to achieve any results. However, it had an "ideological successor"—the Program of Modernization of the Housing and Utilities Sector for 2011–2020 [31]. This program was not fulfilled up to the end; it was closed in 2015. Although the goals of the two programs were identical, the "updated model" required 877 billion KZT (1.74 billion euro) of investment, or 16 times more than the previous one. The second program was supposed to solve the problem of emergency housing. It was possible to achieve the planned indicators, although with a delay. The share of condominium facilities requiring overhaul reached 22% not in 2020, but in 2021.

The third document, which also addressed the development of the housing and utilities sector, was the state anti-crisis program of infrastructure development "Nurly Zhol" for 2015–2019 [32]. It was planned to allocate 2.2 trillion KZT (4.336 billion euro) for the entire program, of which 150 billion KZT (0.298 billion euro) were supposed to be invested in reducing the wear and tear of heating and wastewater networks. Through loans and subsidies in 2015–2018, Nurly Zhol allocated 229 billion KZT (0.454 billion euro) for the implementation of 398 projects for the construction and reconstruction of 3376 km of heating, water supply and sanitation networks, as well as 89 units of water facilities. Investments were partially justified: depreciation of heat, water, and wastewater networks from 2015 to 2019 decreased from 65% to 57%, while the indicator value at the end of the period was 53%.

The "successor" of "Nurly Zhol" In terms of development of the housing and utilities sector was the "Nurly Zher" program, designed for 2020–2025 [33]. Under "Nurly Zher", adopted in December 2019, investments of 5.3 trillion KZT (10.518 billion euro) were planned to take place. Five target indicators are expected to be achieved by 2025: an increase in the annual volume of housing commissioned from all sources of funding to 20.7 million square meters; housing provision—26 square meters per resident; public access to water services in towns and villages at 100%; reduction of the wear of heating, water supply and water disposal networks to 47%; reduction of the share of condominiums requiring major repairs to 18.1%.

In October 2021, the national project "Strong Regions—Driver of the Country's Development" was adopted [34]. It involves investments of 7.6 trillion KZT (15.083 billion euro), of which 1.4 billion are direct investments in the housing and utilities sector. By the end of the project period in 2025, it is planned to provide 100% access to water supply services in towns and villages, 100% sewage treatment in cities, and the construction of more than 1500 engineering infrastructure projects in new areas.

Nevertheless, utilities are extremely reluctant to implement energy-saving technologies, and this is due to the following reasons:

(1) Lack of access to information for enterprise managers due to the current energy accounting system. Kazakhstani enterprises rarely perform department metering of energy consumption, or the metering procedure is done on an enterprise-wide basis,

and only one out of ten utility companies have an automated energy consumption metering system. This leads to the fact that the management of the enterprise does not see the potential for cost reduction and to difficulties in determining which equipment has the potential to save energy.

(2) Insufficient information about modern energy-saving technologies that can contribute to saving energy costs. Information on energy saving equipment that is distributed through specialized exhibitions does not always reach the management of utility companies.

(3) Managers and specialists of enterprises do not possess sufficient information about energy saving opportunities. Many managers are convinced that reducing energy consumption will have no effect on the cost of their products, as opportunities for reducing energy consumption are negligible or economically unprofitable, while international practices suggest that it is quite realistic to reduce energy consumption by 20–30%. To date, the state has not been able to coordinate the actions of all market participants, and therefore measures to improve energy efficiency depend on the desires and motivation of business leaders. This has occurred despite the existence of the Law of the Republic of Kazakhstan dated 13 January 2012, No. 541-IV "On energy saving and improving energy efficiency" (as amended on 29 June 2020) [35]. It should be noted that this is focused more on the construction of new facilities that consume energy and water resources than the modernization of existing ones.

(4) Lack of own funds to implement energy efficiency projects. As a result of many years of inspections of utility companies, the following project disadvantages have been highlighted:

- Long payback periods for energy saving and energy efficiency projects;
- Low (socially oriented and acceptable) utility tariffs in Kazakhstan (see data in Tables 2–4);
- Therefore, the lack of own funds for the implementation of projects that have a high level of investment costs.

Table 2. Average electricity tariff for households by utilities.

Provider	City/Region (The Number at the Beginning of 2022, Thousand People)	Tariff, KZT (Eurocent) per 1 kW· Hour, Including VAT	Tariff Effective Date
AlmatyEnergoSbyt	Almaty (2024.86)	18.88 (3.75)	1 September 2021
Astanaenergosbyt	Nur-Sultan (Astana) (1239.74)	15.22 (3.02)	1 September 2021
Energopotok	Shymkent (1112.46)	15.13 (3.00)	1 June 2021
Shygysenergotrade	East Kazakhstan region (1356.39)	13.45 (2.67)	2 November 2021
Kostanay EnergoCenter	Kostanay region (857.85)	26.62 (5.28)	1 June 2021
KaragandyZhyluSbyt	Karaganda region (1371.91)	12.81 (2.54)	1 September 2021
Sevkazenergosbyt	North-Kazakhstan region (537.04)	13.91 (2.76)	5 August 2021

Source: composed by the authors.

Table 3. Average tariff on gas for households by housing and public utilities (including the tariff for the transportation of marketable gas through gas distribution systems).

Provider	City/Region (The Number at the Beginning of 2022, Thousand People)	Tariff, KZT (Eurocent) per 1 m^3, Including VAT	Tariff Effective Date
KazTransGas Aymak	Almaty (2024.86)	31.73 (6.30)	1 April 2022
	Nur-Sultan (Astana) (1239.74)	38.78 (7.70)	
	Shymkent (1112.46)	38.78 (7.70)	
	East Kazakhstan region (1356.39)	10.88 (2.16)	
	Kostanay region (857.85)	24.35 (4.83)	
	Karaganda region (1371.91)	40.80 (8.10)	
	Mangistau region (740.89)	11.08 (2.20)	
	Atyrau region (668.09)	5.26 (1.04)	

Source: composed by the authors. The cheapest gas in Kazakhstan is in regions where natural gas fields and production are located.

Table 4. Tariffs for water supply and sewage services.

Provider	City/Region (The Number at the Beginning of 2022, Thousand People)	Tariff, KZT (Euro) per 1 m^3, Including VAT	Tariff Effective Date
AlatauComService	Almaty (2024.86)	216.35 (0.43)	1 March 2020
water supply		84.56 (0.17)	
sewage and wastewater treatment		131.79 (0.26)	
SUE * "Astana Su Arnasy"	Nur-Sultan (Astana) (1239.74)	92.24 (0.18)	1 January 2022
water supply		51.86 (0.10)	
sewage and wastewater treatment		40.38 (0.08)	
Vodnye resursy-Marketing	Shymkent (1112.46)	133.17 (0.26)	1 July 2021
water supply		95.22 (0.19)	
sewage and wastewater treatment		37.95 (0.08)	
Oskemen Vodokanal	East Kazakhstan region (1356.39)	111.88 (0.22)	1 September 2021
water supply		50.24 (0.10)	
sewage and wastewater treatment		61.63 (0.12)	
SUE "Kostanay-Su"	Kostanay region (857.85)	112.39 (0.22)	1 January 2022
water supply		63.2 (0.13)	
sewage and wastewater treatment		49.19 (0.10)	
Karagandy Su LLP	Karaganda region (1371.91)	192.02 (0.38)	1 January 2022
water supply		101.24 (0.20)	
sewage and wastewater treatment		90.78 (0.18)	

* State communal enterprise. Source: composed by the authors.

It should be noted that almost all public utilities in Kazakhstan are unprofitable and are subsidized by the state, but they artificially maintain low tariffs for the population.

(5) Lack of a system of motivational measures for employees of housing and utilities companies, to encourage them to save energy and implement energy efficiency. The system of motivation of the chief power engineer service developed at the enterprise,

designed to stimulate the total interest of the service personnel in the reduction of total energy consumption is of great importance.

However, it is impossible to say that the housing and utilities sector is not involved in the relevant work. The housing and utilities sector (according to data from the Bureau of National Statistics) consumes 14–18% of electrical energy and 40–50% of thermal energy, and the share of thermal energy consumed in the last 5 years has increased from 42.23% to 58.47%.

For 2017–2021:

- the level of meter usage in Kazakhstan increased from 48% to 71% and more than 19 thousand metering devices for heat, electricity, hot and cold water, and gas were installed;
- the level of wear and tear of networks decreased to 53% (but remains relatively high);
- Budgetary investments of 272 billion KZT (0.54 billion euro) in total were allocated to repair and build new networks between 2015 and 2021; 3587 km of networks were built and replaced.

The greatest attention in the enterprises of housing and communal services deserves to be given to the operation of equipment, lighting of shops, water and gas supply, heating of production and other premises of the enterprise, such as air conditioning. They are the most expensive items in the enterprise. It can be seen in Table 5 as to what energy-saving technologies can be implemented in most enterprises of housing and communal services in Kazakhstan and their approximate payback period (according to manufacturers).

Table 5. Energy-saving technologies for the housing and communal services sector.

Energy-Saving Technologies	Description of Technology	Efficiency	Payback Period (According to Technology Manufacturers)
Installation of heat pumps	The device can give heat using alternative energy, for example, consuming 1 kW of electricity, it gives from 2 to 5 kW of thermal energy. Can work not only for heating, but also cooling.	25–30%	From 5 years or more, depending on the intensity of use
Secondary energy resources	Use any materials previously to be discarded—sludge, sawdust, wood chips.	30%	From 2 years
Insulation	Sealing and elimination of heat loss through windows, doors, ventilation and other engineering communications	30–70%	From 2–4 years
LED lighting	Installation of LED lights and LED strips (for lighting, for example, stairwells, basements, blind rooms of small size)	Reducing electricity consumption by a factor of five 9–15 months	From 2 years

Source: composed by the authors.

3. Results

Considering the Kazakhstan practice of introducing energy-saving technologies in the housing and communal services sector, we would like to note that at the initial stage the need for implementation is determined by four groups of factors presented in Table 6 in the form of a roadmap.

Table 6. A roadmap of the measures for introducing energy-saving technologies in the housing and utilities sector, as well as countermeasures.

Group of Factors	Description of Impact	Necessity of Implementation	Reality in Kazakhstan	Countermeasures
Institutional (legal, environmental, etc.)	Requirements of legislation in force and/or change of requirements	Obligatory, failure to comply may result in penalties	In practice, the company compares, and it is often cheaper to pay, for example, a fine for exceeding emissions, than to introduce a new technology.	Damage to the company's reputation, coverage in social networks and the media, but it must be borne in mind that 96% of utilities in Kazakhstan are monopolists, and the consumer has no chance to change provider
Financial efficiency (direct effect)	Reduction of the cost of providing electricity, heat, gas, drinking water and wastewater services	Not obligatory, but declared as a goal	Practically unattainable with a forecast period of 20 years (e.g., negative NPV), see data in Table 5 on payback period given by technology supplier by calculating using current tariffs in the producing country (see Table 7) and not in Kazakhstan.	If the financial efficiency of the project is negative, economic (by calculating imputed and indirect revenues) and/or social efficiency can be achieved.
	Economic efficiency (indirect effect)	Positive effect	Not necessary, but declared as a goal Practically achievable with a forecasting period of 20 years (e.g., positive ENPV), but possible only when the calculation and assessment of the impact of indirect income and improving the image of the monopoly enterprise in the housing and utilities sector are included. It is also necessary to consider that funds for the modernization of the housing and utilities sector in Kazakhstan are usually allocated from the state and/or local budgets.	It is mandatory to consider in the assessment and calculation of the positive impact calculation of budget refunds (e.g., VAT in the cost of the project). It Is also possible to estimate: - An increase in revenues (including an increase in incoming taxes to the local budget) and in the city's population; - revitalization of entrepreneurial activity due to improved provision of public utilities.
	Social efficiency (indirect effect)	Positive effect		It is possible to estimate: - reduction of population morbidity due to improved sanitary and epidemiological situations when the project is implemented; - creation of new jobs during the implementation of the project at the construction stage; - improvement of the enterprise's reputation.

Source: composed by the authors.

Table 7. Average prices and tariffs for water supply and sanitation in Kazakhstan, end of year.

Name of Indicator	Unit of Measure	2014	2015	2016	2017	2018	2019
Average selling prices and tariffs for services for the population in Kazakhstan							
Hot water	KZT/m^3	178	199	218	234	240	262
Cold water	KZT/m^3	48	57	65	71	73	79
Wastewater disposal	KZT/m^3	31	37	43	46	48	54
Prices for communal services for industrial enterprises							
Steam and hot water (heat energy)	KZT/Gcal	4127	4446	5284	5435	6410	6807
Average annual exchange rate of the Euro	KZT/Euro	238.1	245.8	378.63	368.32	406.66	465.39
Average selling prices and tariffs for services for the population in Kazakhstan							
Hot water	Euro/m^3	0.75	0.81	0.58	0.64	0.59	0.62
Cold water	Euro/m^3	0.20	0.23	0.17	0.19	0.18	0.19
Wastewater disposal	Euro/m^3	0.13	0.15	0.11	0.12	0.12	0.13
Prices for communal services for industrial enterprises							
Steam and hot water (heat energy)	Euro/Gcal	17.33	18.09	13.96	14.76	15.76	15.74

Source: composed by the authors.

Consequently, to justify the need to introduce energy-saving technologies in the enterprises of housing and communal services in Kazakhstan, it is necessary to implement the following:

(1) If possible, to find exactly the institutional need, preferably with a clear reference to the article of the Law of the Republic of Kazakhstan dated 13 January 2012, No 541-IV "On energy saving and improving energy efficiency" [34] and/or the Code of the Republic of Kazakhstan dated 2 January 2021 No. 400-VI "Ecological Code of the Republic of Kazakhstan" (as amended on 27 December 2021) [36].

(2) To determine the financial efficiency of the project in real energy prices in Kazakhstan and/or tariffs for the necessary resources, which in most cases, unfortunately, obtains negative results. To confirm the conclusions about unreasonably low (socially oriented) tariffs for end users, such as water resources, the comparative data are shown in Table 7.

Unfortunately, the decline in the value of resources in euros is due to the devaluation of the local currency—tenge (KZT), rather than their real decrease.

At the same time, we should not forget that the Government's decision to raise gas prices from 50 KZT (0.10 euro) to 100 KZT (0.20 euro) in January 2022 caused a violent protest reaction from the population and a change of the Government. Therefore, a moratorium was introduced in the country until 1 July 2022, on the increase of tariffs for regulated utilities, namely water, wastewater, heat, gas, and electricity. The Committee on the regulation of natural monopolies of the Ministry of national economy of the Republic of Kazakhstan carried out appropriate work to contain tariffs for the population at the level of December 2021 for a period of 180 days [37].

Thus, tariffs of 103 monopoly entities were adjusted to the level of December 2021. The measures taken will make it possible to achieve an economic effect during the moratorium, which will have a positive impact on the income of the population, which will save about 3.2 billion KZT, including in the areas of:

- Heat supply—1442 million KZT (2.86 million euros);
- Electricity supply—839.7 million KZT (1.66 million euros);
- Water supply—367.6 million KZT (0.73 million euros);
- Water disposal—224.6 million KZT (0.44 million euros);
- Gas supply—318.7 million KZT (0.63 million euros).

(3) To try to bring the project to economic and/or social efficiency.

Utilities such as DMUs (decision-making units) operating in the field of energy supply, gas supply, water supply and sewerage (wastewater disposal) in the regions of Kazakhstan were considered as part of this analysis. The purpose of the analysis was to find the most efficient DMU from the consumer's point of view, i.e., serving the maximum proportion of the population with the minimum tariff and staffing. Data envelopment analysis (DEA) was chosen as a method of analysis, which allows for the nonparametric evaluation of economic agents by several input and output parameters. In our case, DEA solves an optimality problem: minimization of input parameters for actual output parameters (input-oriented model). As input parameters we considered tariffs and the number of employees, and as output parameters we considered the number of populations served. When calculating efficiency, we considered the hypothesis of variable returns on scale, since in the utility supply system there are technological constraints, and a constant proportional change in the input parameters is technologically and physically impossible.

The DEA results are presented in Tables 8–10 (Envelopment Model Input-oriented). The analysis was performed in the MaxDEA 8 Basic software environment.

As the data in Table 8 show, out of the seven DMUs operating in the energy supply sector in Kazakhstan three DMUs (AlmatyEnergoSbyt, Shygysenergotrade, KaragandyZhyluSbyt) in 2022 were at the border of efficiency: their tariffs and staff are in an optimal (in this case minimum) ratio with the number of populations served compared to the other four DMUs. The remaining four DMUs (Astanaenergosbyt, Energopotok, Kostanay EnergoCenter, Sevkazenergosbyt) are not efficient in terms of input parameters (tariffs and number of employees), although they are quite close to the efficiency boundary. For each of the inefficient DMUs, a benchmark DMU is recommended, which, due to the detected nonparametric dependencies, can serve as a benchmark in activity (Benchmark graph in Table 8). Similarly, for each of the inefficient DMUs, the DEA results recommend specific rate values and number of employees to reach the efficiency frontier.

Table 8. Envelopment Model Input-oriented results for 2022's energy supply.

Provider (DMU)	Score	Benchmark	Tariff, Eurocent per 1 kW·Hour, Including VAT		Number of Employees, People		The Number at the Beginning of 2022, Thousand People	
			Actual	Projection	Actual	Projection	Actual	Projection
AlmatyEnergoSbyt	1.000	AlmatyEnergoSbyt (1.00)	3.75	3.75	521	521	2024.86	2024.86
Astanaenergosbyt	0.841	KaragandyZhyluSbyt (1.00)	3.02	2.54	600	385	1239.74	1371.91
Energopotok	0.847	KaragandyZhyluSbyt (1.00)	3.00	2.54	749	385	1112.46	1371.91
Shygysenergotrade	1.000	Shygysenergotrade (1.00)	2.67	2.67	243	243	1356.39	1356.39
Kostanay EnergoCenter	0.829	Shygysenergotrade (1.00)	5.28	2.67	293	243	857.85	1356.39
KaragandyZhyluSbyt	1.000	KaragandyZhyluSbyt (1.00)	2.54	2.54	385	385	1371.91	1371.91
Sevkazenergosbyt	0.976	Shygysenergotrade (1.00)	2.76	2.67	249	243	537.04	1356.39

Source: composed by the authors.

The results of the DMU analysis on gas supply (Table 9) show that only three of the eight regions (Almaty, East Kazakhstan region, Atyrau region) were at the efficiency boundary in 2022: their tariffs and staff are in an optimal ratio to the number of populations served compared to the other five regions. Of the five inefficient regions, one of the five inefficient regions, (Mangistau region) was halfway to being efficient whereas the other four were much further from being efficient. Inefficient regions are located in different parts of Kazakhstan, so one cannot refer to the location as a reason for the regions' inefficiency in terms of gas supply. It is necessary to review the technological and/or business processes, as well as methods of management of these activities to improve the efficiency of personnel use and reduce tariffs in these regions. Table 9 shows recommendations for two benchmark regions for each of the inefficient regions in different proportions that need to be targeted to achieve an efficient state (Benchmark column). Additionally, for each of the inefficient regions, the DEA's results recommend the specific rates, number of employees, and potential population served to reach the efficiency frontier.

Table 9. Envelopment Model Input-oriented results for 2022's gas supply.

Regional Provider (DMU)/KazTransGas Aymak Division	Score	Benchmark	Tariff, Eurocent per 1 m^3, Including VAT		Number of Employees, People		The Number at the Beginning of 2022, Thousand People	
			Actual	Projection	Actual	Projection	Actual	Projection
Almaty	1.000	Almaty (1.00)	6.30	6.3	65	65	2024.86	2024.86
Nur-Sultan	0.276	East Kazakhstan region (0.971); Atyrau region (0.029)	7.70	2.13	54	15	1239.74	1336.48
Shymkent	0.229	East Kazakhstan region (0.646; Atyrau region (0.354)	7.70	1.76	852	48	1112.46	1112.46
East Kazakhstan region	1.000	East Kazakhstan region (1.00)	2.16	2.16	12	12	1356.39	1356.39
Kostanay region	0.390	East Kazakhstan region (0.755); Atyrau region (0.245)	4.83	1.89	94	37	857.85	1188.03
Karaganda region	0.278	Almaty (0.023); East Kazakhstan region (0.977)	8.10	2.26	125	13	1371.91	1371.91
Mangistau region	0.526	East Kazakhstan region (0.106); Atyrau region (0.894)	2.20	1.16	464	102	740.89	740.89
Atyrau region	1.00	Atyrau region (1.00)	1.04	1.04	113	113	668.09	668.09

Source: composed by the authors.

Table 10. Envelopment Model Input-oriented results for 2022's water supply and sewage services.

Provider (DMU)	Score	Benchmark	Tariff, euro per 1 m^3, Including VAT		Number of Employees, People		The Number at the Beginning of 2022, Thousand People	
			Actual	Projection	Actual	Projection	Actual	Projection
AlatauComService	1.000	AlatauComService (1.00)	0.43	0.43	34	34	2024.86	2024.86
SUE Astana Su Arnasy	1.000	SUE Astana Su Arnasy (1.00)	0.18	0.18	1971	1971	1239.74	1239.74
Vodnye resursy-Marketing	0.966	AlatauComService (0.092); Oskemen Vodokanal (0.296); SUE Kostanay-Su (0.612)	0.26	0.25	720	695	1112.46	1112.46
Oskemen Vodokanal	1.000	Oskemen Vodokanal (1.00)	0.26	0.26	1004	1004	1356.39	1356.39
SUE Kostanay-Su	1.000	SUE Kostanay-Su (1.00)	0.22	0.22	645	645	857.85	857.85
Karagandy Su LLP	0.659	AlatauComService (0.070); SUE Astana Su Arnasy (0.269); Oskemen Vodokanal (0.660)	0.38	0.25	1816	1197	1371.91	1371.91

Source: composed by the authors.

Table 10 shows the results of DEA for water supply and sanitation in Kazakhstan in 2022. Four of the six DMUs operating in this area (AlatauComService, SUE Astana Su Arnasy, Oskemen Vodokanal, SUE Kostanay-Su) were on the border of efficiency: their tariffs and staffing are in an optimal ratio to the number of populations served compared to the other two DMUs. Among the two inefficient DMUs, Vodnye Resursy-Marketing is closest to achieving efficiency, and Karagandy Su LLP is half the distance to the efficiency frontier. For each of the ineffective DMUs, three benchmark DMUs in different proportions are recommended that can serve as a benchmark for performance (Benchmark graph). Additionally, for each of the inefficient DMUs, the DEA results recommend the specific rates and number of employees to reach the efficiency frontier.

4. Discussion

Having considered all three types of utilities in terms of achieving an effective combination of resources and results, considering the value of the consumer (focus on reducing tariffs and staff maintenance) we can say that the most effective, "fair" formation of tariffs in Kazakhstan is observed in the energy supply, with slightly worse performance in water supply and wastewater disposal. A significant revision of gas supply activities is needed, both in the technological and/or business processes and in the management methods of utilities in a large part of Kazakhstan's regions.

In addition to the above, it is also necessary to consider the existing practice of the functioning of public utilities in Kazakhstan. For example, for SUE "Astana su arnasy" (as the leading enterprise in the housing and communal sector of Kazakhstan and the most easily financed by the state, given the status of the capital), various energy-saving technologies have been repeatedly proposed. Let us discuss below why specific technologies have not been used.

Situation 1. For sewage treatment plants, a technical solution of installing heat pumps in water treatment facilities was proposed. However, the existing scheme of sewage treatment, retention basins (primary and secondary) and water treatment facilities are of an open-air design (as in most wastewater treatment plants in other cities of Kazakhstan).

In terms of climatic characteristics, Nur-Sultan, as well as the whole of Northern, Central and Eastern Kazakhstan, is characterized by the following indicators:

- climatic region in terms of construction conditions—IB;
- The outside temperature of the coldest five days—31.2 °C;
- Average wind speed for the winter period—5 m/s;

The climate of the city is sharply continental. Winter is cold, long, with little snow and in some years is severe. The frosty period lasts 245 days, while the duration of winter is 5–5.5 months. Stable snow cover is formed usually in the middle of November for 130–140 days. The average temperature in January is −17 °C. Absolute minimum in some winters reaches −52 °C.

Decreases in the temperature in the water treatment facilities by one degree in the period from mid-October to late March leads to a complete stop of the biological treatment stage. The decision to implement the technology was not received with much enthusiasm. The case correlates practically with all wastewater treatment plants of Kazakhstan.

Situation 2. Use of secondary energy resources. For Nur-Sultan sewage treatment plant, a concession proposal was made to use sludge. However, according to Paragraph 5 of the Annex to the Decree of the Government of the Republic of Kazakhstan dated 6 November 2017 No 710 "On approval of the list of facilities not subject to transfer for the implementation of public-private partnership, including in the concession" (as amended on 13 March 2021) water management facilities (dams, waterworks and other hydraulic structures) of special strategic importance, except for water management facilities (water intake facilities, pumping stations, water treatment facilities) providing water supply, including to Astana, are not subject to transfer for implementation of public–private partnerships. Since the separation of the SUE "Astana su arnasy" a separate legal entity responsible only for the processing of sludge is not possible institutionally, financially, and technically; therefore, this proposal was also rejected. The case correlates with almost all the wastewater treatment plants in Kazakhstan.

The results of the SWOT-analysis of the development of the housing and communal services sector in Kazakhstan (considering the implementation of state investment programs) in terms of the introduction of energy-saving technologies are presented in Table 11.

It should be noted that even in the event of a threat to the solvency of the population and economic crises in Kazakhstan, the housing and utilities sector will function because of the inability to refuse services (centralized provision). The high level of market power of the housing and utilities enterprises reduces the threat of political manipulation and the threat of a significant impact of changes in legislation. Companies' losses may decrease due to implementation of opportunities to improve energy efficiency and full metering of all resources. Additionally, it is possible to increase efficiency of management through the use of IT technologies and Big Data technology.

Table 11. SWOT-analysis of the development of the housing and communal services sector in Kazakhstan.

1. Strengths	2. Weaknesses
Kazakhstan as a whole	
1.1 Positive dynamics of urban population growth (and, as a consequence, increase in consumption of public utilities). 1.2 Significant share of the large cities Almaty, Shymkent, Nur-Sultan in the GDP of the country and increasing demand for water supply and sanitation (possible implementation of pilot projects for training and introduction of new energy-saving technologies in public utilities). 1.3 Positive development of services in large cities—Nur-Sultan, Almaty, Shymkent and Karaganda, including those provided by SMEs, hence increasing demand for water use by both enterprises and the population. 1.4 Stimulation of positive environment for development of modern (innovation) and "green" economy in large cities of Kazakhstan. 1.5 Transport accessibility of all regions, availability of developed road infrastructure in Kazakhstan, especially railways.	2.1 Low population density (7.1 people per square meter) and 80% of the population living in urban areas. 2.2 Lag behind developed countries in economic development and urbanization. 2.3 Relatively low competitiveness of the country on the global and regional (Eurasian) markets. 2.4 Regional disparities in quality of life indicators, as well as a significant gap in the provision of infrastructure for centralized water supply and sanitation services between urban and rural settlements. 2.5 Low level of economic diversification in mono and small towns and settlements.
Directly in the housing and communal services sector	
1.6. A continuous state support for the development and modernization of the housing and utilities system (possibility of financing the projects). 1.7. Already existing relatively high degree of coverage of the urban population with centralized water supply and sanitation.	2.6 Clear deficit and gradual retirement of qualified personnel in the housing and utilities sector (with university, technical and specialized education). 2.7 Underdevelopment and lack of practice-oriented education and training system with modern skills and competences for the housing and communal sector. 2.8 Low level of consumers' awareness and knowledge about tariff setting, advantages of new technologies, energy-saving technologies and consumption metering systems. 2.9 Gap between needs and capacities of engineering and social infrastructure, high wear and tear of water supply, sewage, heating and electricity networks, internal roads in settlements, especially in small and mono-towns and rural settlements. 2.10 Lack of alternative sources of financing for the modernization of urban engineering infrastructure (other than budget funds). 2.11 Low degree and speed of introduction of new energy-saving technologies in the housing and communal services system.

Table 11. *Cont.*

3. Opportunities	4. Threats
Kazakhstan as a whole	
3.1 Increase of personnel mobility in the labor market in large cities of Kazakhstan. 3.2 Growth of sales markets in agglomerations, large cities, including for water supply and sanitation services. 3.3. Implementation of strategies for the development of major cities until 2050. 3.4. Improvement of the quality of life through technological (innovative) development of large cities, mono, and small cities, and rural settlements in the implementation of a state investment programs.	4.1. Continued difficult sanitary and epidemiological conditions due to COVID and possible tightening of the sanitary and epidemiological regime. 4.2. Unrest in January 2022 and resistance to tariff increases from the population. 4.3. War between Russia and Ukraine. 4.4. Investment unattractiveness of small and single-industry towns and rural settlements remote from large cities. 4.5. Increased unemployment due to the shutdown of city-forming enterprises in small and single-industry towns, as well as in rural areas, and, consequently, a lack of funds to pay for utilities.
Directly in the housing and communal services sector	
3.5. Introduction of PPP mechanisms to increase the investment attractiveness of the housing and communal services sector. 3.6. Introduction of new technologies and digitalization in the housing and communal services sector to increase the service life of engineering infrastructure, reduce losses, and automate production processes. 3.7. Development of the education system to train qualified personnel with the required skills and competencies at all levels of education (possible implementation of pilot projects for training and introduction of new energy-saving technologies in public utilities).	4.6. Excessive strain on urban infrastructure. 4.7. Lack of a system of educational institution (universities, colleges, etc.) orders of specialists from operating organizations in training areas. 4.8. Lack of centers for professional development and competence development, both at the operating enterprises themselves, and in general in Kazakhstan. 4.9. Reduction of state support for the modernization of engineering infrastructure due to budget constraints. 4.10. Depreciation of the national currency, which will lead to higher prices for imports, including construction materials and equipment.

Source: composed by the authors.

5. Conclusions

The conducted research has shown that there is technical potential for the implementation of energy-saving technologies to improve energy efficiency in the enterprises of housing and communal services in Kazakhstan. However, it should be remembered that energy-saving activities are by no means a one-time event; this activity should be integrated into the management system of the organization.

To improve the situation, utilities need to introduce an energy management system, which as a management tool for the organization will allow to carry out:

- System analysis of energy consumption;
- Searching and analysis of information on increase of energy efficiency;
- Development and implementation of programs to improve energy efficiency;
- Searching for the most effective systems of financing;
- Development and implementation of staff motivation systems;
- Monitoring and evaluating the implementation of energy efficiency programs.

However, for such a system to work, an initial energy inspection must be conducted with the involvement of specialized organizations—energy auditors.

For communal enterprises, energy saving should be implemented on a legislative and contractual basis, which, through the introduction of energy-saving technologies, reduces energy and fuel costs in the cost of goods and services produced.

In Kazakhstan, a country with active state intervention in the economy, it is a state that should motivate consumers to make decisions on the efficient use of energy. Energy saving, as the main part of resource saving, stimulates real and social sectors of economy, investment and budgetary spheres, as well as business. Implementation of the state energy-saving policy principles in the regional legal support of energy efficiency projects should be based on the principle of obligation, which requires rational use and economical consumption of energy resources.

Major factors contributing to insufficient effectiveness of an energy-saving management system are low levels of governmental awareness of energy-saving's role in development of the Kazakhstan economy, a weak legal framework, poor financial support of energy efficiency activities, underdeveloped mechanisms for promoting energy-saving, imperfect prices and tariffs for energy resources, insufficient information, etc.

Technically, policy aimed at development of energy saving should be implemented, firstly through the system of working legislative and normative acts, which should establish common for all principal provisions, forming legal, economic, and organizational basis for implementation of measures, aimed at energy saving, i.e.,:

- The right of competition in the heating and electric power generation market;
- The right of producers of non-traditional energy and renewable energy sources to be connected to the networks of energy supplying organizations under the obligation to buy this energy;
- The right to receive various economic benefits (tax and credit, favorable tariffs, subsidies, etc.) for energy producers and consumers from new technologies, unconventional and renewable energy sources at the initial stage of establishment and adaptation in the market, and in the future when producing significantly more economical and environmentally clean energy;
- Rules of economic incentives for tangible results in the field of energy saving.

For more a rapid distribution of modern energy-saving technologies, according to many experts, it is necessary to create a directory of the most effective solutions that exist in foreign countries. This would help experts assess the possibility of using certain technologies, as well as the costs of their implementation.

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