The Journal of Social Sciences Research
ISSN(e): 2411-9458, ISSN(p): 2413-6670
Vol. 4, Issue. 12, pp: 509-514, 2018
URL: https://arpgweb.com/journal/journal/7
DOI: https://doi.org/10.32861/jssr.412.509.514

Academic Research Publishing Group

Original Research Open Access

Kazakhstan's Energy Efficiency Policy Via Dea Approaches

Arsen Tleppayev *
Department of Economics, Kazakh German University, Kazakhstan

Saule Zeinolla
School of economics and business, Al-Farabi Kazakh National University, Kazakhstan

Saltanat Abishova
School of economics and business, Al-Farabi Kazakh National University, Kazakhstan

Abstract

In modern conditions of managing important task is to increase energy efficiency and energy efficiency as one of the priorities of economic policy. The purpose of this paper is to develop a theoretical and methodological approaches and practical recommendations aimed at the implementation of evaluation and monitoring of energy efficiency policy instruments. Methods of research are analysis and mathematical modeling. Implementation of the system of energy efficiency indicators will increase the efficiency of the proposed measures; compare the current status in various sectors to global peers. In this article we used the method of data analysis - Data Envelopment Analysis (DEA) to estimate the effectiveness of energy efficiency indicators in comparison with those of other countries. DEA technique allows a comparative analysis of energy efficiency indicators, which is based on a comparison of the values of the individual groups of indicators with each other. However, the use of this technique in a Kazakhstan limited lack of statistical information of many indicators and series of the dynamics of the existing indicators.

Keywords: Energy efficiency; Energy consumption; Indicators and Energy savings.

1. Introduction

To achieve the goals of sustainable development is necessary to ensure the improvement of energy efficiency of country's economy. Energy efficiency is one of the most important areas in the complex of measures to stimulate economic growth and strengthen the international position of the companies. In modern conditions, energy conservation and energy efficiency is one of the priorities of the economic policy of many private companies and government agencies, focused on the rapid development, both in terms of reducing the cost of production of goods and services, and in accordance with the general thrust of government programs aimed at reducing energy intensity of the economy.

Nowadays, important problem for Kazakhstan is creation an effective and efficient model in the field of performance management of energy intensity of GDP. It is important to have a clear idea of how to relate to the world's and Kazakhstan's energy intensity of GDP.

At the present stage, Kazakhstan's economy is characterized by the absence of a system of indicators and insufficient energy indicators, which depend on industry development. For example, in Kazakhstan, energy efficiency problems are related to the following main sectors:- Industry is one of the sectors where energy efficiency policies are very limited. Problems relate exclusively to energy audits and lack of experience of long-term (5-12 years) target energy efficiency agreements between the government and energy-intensive industrial holdings. - In the housing sector is completely lacking policies to promote passive houses and houses with zero energy consumption, reducing energy consumption appliances. The State Statistics does not collect data on the average of the energy consumption, or average power, or the class of energy efficiency of household appliances that greatly complicates monitoring the effectiveness of measures to improve the energy efficiency of household appliances. - In the transport sector, government has not mandatory standards for the fuel efficiency and CO2 emissions; policies on energy-efficient driving, the use of biofuels, hybrid vehicles and electric vehicles. - Utility companies do not have the energy efficiency policy among consumers; do not use the experience of developed countries using flexible tools.

For monitor the degree of energy efficiency in all sectors should be a system of indicators of energy efficiency and energy savings. Such accounting systems are developed and implemented in different countries and groups of countries. They allow to quantify the impact of various factors on the dynamics of energy consumption and energy intensity in selected sectors and to identify the effectiveness of measures to improve energy efficiency policy

To assess the effectiveness of energy efficiency indicators in comparison with those of the countries or global benchmarks can apply data convolution method - Data Envelopment Analysis (DEA). However, this method is used for estimating the efficiency of very complex objects - any institutional units such as banks, schools, hospitals, universities, industrial enterprises, individual economic sectors, regions and even countries of the world. Relative performance indicators of the objects defined in terms of rational use of available resources to achieve the results.

*Corresponding Author

The essence of the DEA method is that by using mathematical modeling from a sample of the objects under study in the coordinates of the resource variables (inputs) and the output variables on the objects lying on the boundary of the set under consideration, a piecewise linear shell is built - the efficiency frontier (efficiency frontier) and on its basis the effectiveness of a particular object included in the set under consideration is estimated. To each object there corresponds a point in the multidimensional space G: "input-output". The solutions of the corresponding optimization problems of linear programming give the efficiency coefficients that determine the comparative efficiency of each object. The efficiency boundary is formed by analysis objects with the highest (equal to one or 100%) efficiency ratings. Segments of the effectiveness boundary create a "envelope" for the entire sample of analysis objects. The following types of efficiency are distinguished:- technical efficiency - the state at which the maximum output is achieved with a given set of resources.- structural efficiency or efficiency of allocation of resources (allocative efficiency) - a state in which the minimum expenditure of resources is achieved with a given output volume.- economic efficiency - a condition combining the two previous types of efficiency.

Authorship DEA method belongs Charnsu A., Cooper W. and Rhodes E., which was used to measure the performance of organizations machine linear programming.

The DEA has its origins in the work of Charnes *et al.* (1978) and Banker *et al.* (1984), both based on Farrell (1957), who proposed an empirical model to measure the relative efficiency. According to Farrell (1957), it is more advisable to determine the efficiency of a firm or an administrative unit, comparing it to the best level of efficiency observed, than to compare it to some unattainable ideal.

There are many studies worldwide identifying a wide variety of sector-specific indicators and cross-cutting energy efficiency improvement opportunities for economy. Significant numbers of energy efficiency measures is discussed in various studies by Ang *et al.* (2010`); Ang *et al.* (2015), Bashmakov (2013), Brun and Gereffi (2011).DeCanio (1998); Golove and Eto (1996); de *et al.* (2001); Filippini *et al.* (2014), Thollander and Ottosson (2008); Rohdin *et al.* (2007), Worrell *et al.* (2007), Tleppaev *et al.* (2016).

This paper aims to develop theoretical and methodological approaches and scientific and practical recommendations aimed at improving energy efficiency.

In accordance with this purpose we had the following research objectives:

1) construction a DEA model;

2) identify the difference between world and Kazakhstan's experience;

3) develop a recommendation

2. Results

Considering the energy intensity of GDP or industrial production sector as a functioning entity and all its activities as a set of processes, it is possible to determine the input parameters (workforce, investment in fixed assets, the amount of energy consumed and / or oil and gas and / or electricity), which define the energy consumption, and output (GDP or unwanted indicator - CO2 emissions).

Considering the totality of countries (countries can also be compared in terms of close climatic conditions), using the DEA method, it is possible to construct a performance boundary for a given set of countries and to calculate the level of efficiency for each "inefficient" country, and also to determine a set of reference values from effective countries. Thus, with the help of the DEA, it is possible to establish samples of the most effective activities, as well as to provide measurement of effectiveness on a selected scale and to give recommendations for its improvement.

The objective is to maximize the DEA efficiency rating for each country as the relative efficiency of unit j using only energy consumption as input is given by relative output value to relative input value

$$\frac{wy_i}{vx_j} \qquad (1)$$

We define the variables as follows:

w = relative output weight applied to country's GDP

y = amount of output (GDP) from unit j

v = relative input weight applied to country's energy consumption

x = amount of input (energy consumption)

j = unit/ country being measured.

In measuring energy efficiency, we used total energy consumption for each country without differentiating energy source types because all of these countries depend on fossil fuels, mainly oil.

For the analysis we used the time series data from 2006 to 2013: GDP based on purchasing power parity, the power consumption in tons of oil equivalent, indicators of labor and capital from the World Bank, European statistics, Russia, Belarus and Kazakhstan government database. The DEA methodology measure energy efficiency using three variable inputs (capital, labor, and energy consumption) and one output (GDP) (table 1 and table 2)

Table-1. Data used for measuring DEA

Indicators	Description
Power consumption	Energy Consumption (ton of oil equivalent), the World Bank
Capital	Gross capital formation (current US dollars.), World Bank
Work force	Total workforce, World Bank data
GDP	Gross domestic product based on purchasing power (PPP) assessment of the country's GDP (US $ bn. In current international dollars), the IMF

Source: Compiled by authors on the basis worldbank.org, imf.org

Table-2. shows the average energy consumption, labor costs, gross savings to GDP in selected groups of countries: the European Union and the Eurasian Economic Union

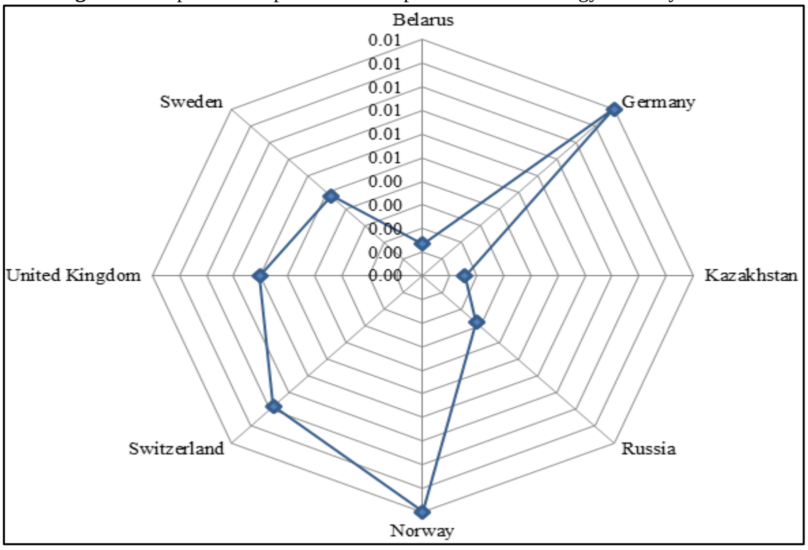
Table-2. Countries data

	Energy Consumption labor costs Gross GDP	Energy consumption labor costs Gross GDP	Energy consumption labor costsGross GDP	Energy consumption labor costs Gross GDP
Belarus	17,17	15,31	9,93	11,87
Germany	20,32	17,55	13,45	15,03
Kazakhstan	18,03	15,98	10,60	12,73
Russia	20,32	18,16	12,82	15,02
Norway	17,94	14,77	11,66	12,65
Switzerland	18,25	15,32	11,87	12,95
United Kingdom	19,95	17,28	13,02	14,65
Sweden	18,20	15,42	11,67	12,90

Source: Compiled by authors on the basis worldbank.org, imf.org

The simulation results are shown in Figure 1, and they show the relative backwardness of energy efficiency of Kazakhstan's economy by leading countries - Germany and Norway, which figures have been taken as the standard of 1 or 100%. This technique is applicable to industry performance, which requires the implementation of an information base as the basis, the above indicators in the Nordic countries of Europe.

Figure-1. Graphical interpretation DEA problem for the energy intensity of GDP



Source: compiled by the authors

In this study, the comparison between the countries was performed by constructing an efficiency index, usingthe DEA technique, which measured the efficiency of countries in gross fixed capital formation, workforce and energy consumption by economic growth. As a result, considering the variables used, this study showed that Kazakhstan had the lowest total-factor efficiency.

The objective of this study was to contribute to qualitative and quantitative information regarding the development of Kazakhstan to achieve economic growth without harming the environment and with the least amount of production factors.

It should be noted that the reduction of the GDP energy intensity can occur under the influence of a number of factors, in particular the structural changes in the economy (the redistribution of economic activity to less energy-intensive industries), changes in capacity utilization (eg, due to the economic crisis), weather and etc.

Improving energy efficiency means reducing the cost of energy resources per unit of useful effect (for example, output) or, in reverse formulation, increasing the beneficial effect of a unit of energy used.

It is clear that an increase in energy efficiency may be accompanied by an increase in energy consumption - if this increase is slower than the rate of increase in the useful effect. Energy efficiency in this sense is the reverse of energy intensity: the cost of energy per unit of output (or to create another good).

Reducing energy intensity is similar to increasing energy efficiency, and changing the energy intensity of GDP is one of the important factors of the energy efficiency of the economy.

But the decrease in the energy intensity of GDP can occur under the influence of a number of factors, in particular structural changes in the economy (redistribution of economic activity in favor of less energy-intensive industries), changes in capacity utilization (for example, because of the economic crisis), weather, etc.

Such a decrease in energy intensity may not be accompanied by an improvement in technologies in individual industries - there is a "nominal" increase in efficiency as a whole without increasing the efficiency of individual industries and technological processes in them.

This situation leads to the transition to energy efficiency in a narrow sense - the technological effectiveness of individual processes of energy consumption in the economy. Such indicators are calculated in many countries.

A common method of calculating the energy saving potential by increasing the energy intensity is to compare energy costs across a wide range of industries with actual and potentially achievable energy efficiency parameters for individual industries, the production of specific products and the implementation of individual technological processes in these industries. Much depends on the "standard".

There are several categories of energy efficiency level for each typical technology:

- "Theoretical minimum" - the minimum possible in accordance with the laws of thermodynamics specific energy consumption, necessary for the performance of a certain work or transformation of materials;
- "Practical minimum" - the best practically achieved in the world indicators of specific energy consumption with the use of technologies that have proved their commercial effectiveness;
- "Real consumption abroad" - the most common indicators of specific energy consumption in other countries (corresponds to the "fashion" in statistics);
- "Average consumption abroad" - average specific energy consumption in other countries or groups of countries (depending on the choice of regions for comparison)

In this case, as a rule, three basic definitions of the potential for increasing energy efficiency are used:

- The technical (technological) potential is estimated on the assumption that all equipment is instantly replaced by the best samples corresponding to the "practical minimum" specific consumption. The technical potential shows only hypothetical possibilities of energy saving without taking into account costs and other restrictions on its implementation. Its magnitude depends not only on technological, but also on geographic factors, depending on which advanced (best available) technologies are considered: domestic or global. Here, awareness of foreign technologies and possible limitations for their effective application in a particular field are important.
- Economic potential is part of the technical potential that is economically attractive when using public criteria for investment decision making: discount rates, imputed energy prices (export price of natural gas), environmental and other additional costs and benefits (for example, carbon prices). The realization of this potential requires time, determined by the speed of replacement of the main energy-consuming equipment. The most important factor determining not only the size, but also the structure of the energy saving potential, is the structure of the economy.

This reduction in energy consumption cannot be accompanied by improvements in technology in certain industries - there is a "nominal" increase the efficiency of the whole without increasing the efficiency of individual industries and processes in them (table 3).

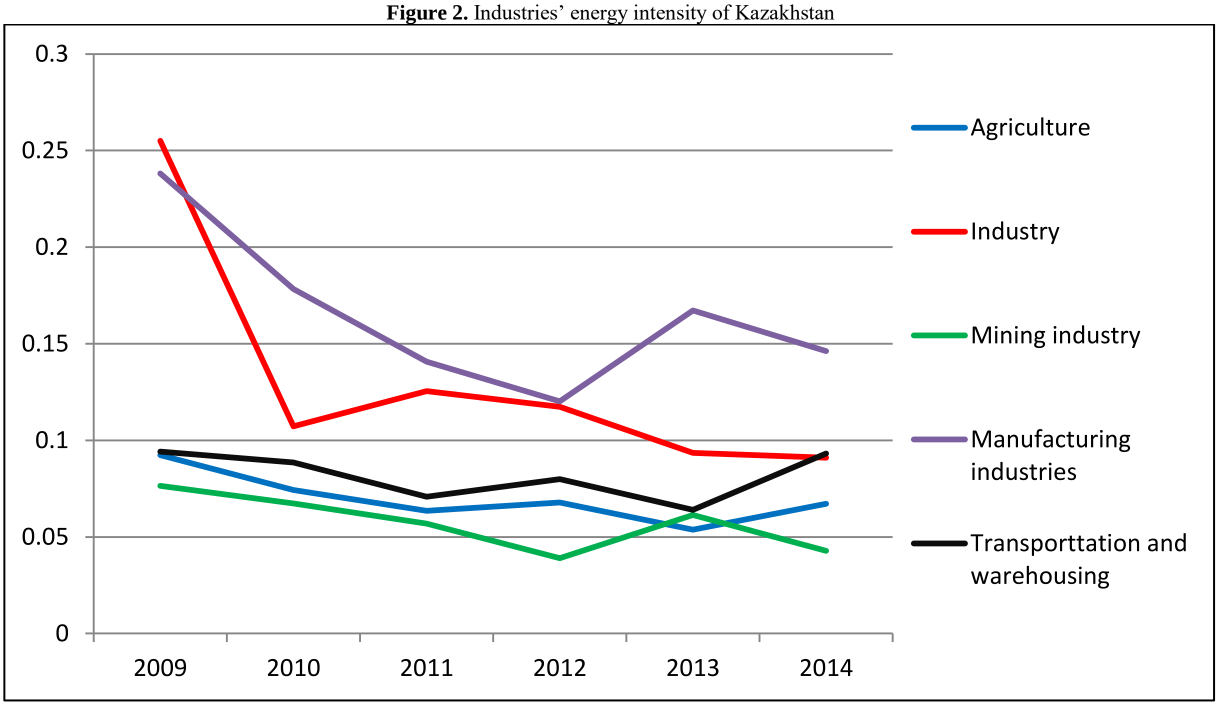
Table-3. Comparative average energy levels for some Kazakhstan's industry

Enlarged technology of production of goods, works and services	**Unit (consumption to volumeof production)**	**Specific consumption**	**Practical minimum**	**Real consumption abroad**
oil refinery	ktoe/t	156	53,9	75,1
gas processing	ktoe/ 1000 m3	NA	46,3	
ferrous metals production	ktoe/t	NA	31	68,0
aluminum	ktoe/t	NA	1599	1763
alumina production	ktoe/t	NA	324	410
manufacture of pulp	ktoe/t	597	404	485
papermaking	ktoe/t	NA	241	320
cement production	ktoe/t	NA	11	13
clinker production	ktoe/t	NA	99	145
glass manufacturing	ktoe/t	NA	132	NA

Source: compiled by the authors based on information of Agency of statistics Kazakhstan

Some of the above parameters, especially energy consumption for the industry, we calculated the some branches according to the fuel and energy balance and dynamics is shown in Figure 1. This figure shows a decrease in energy consumption per tenge of output on some sectors in 2009. However, in the period from 2012 to 2014 figures show the rise and fall that follows trends in the energy intensity of GDP. Overall power consumption reduction takes place, although dynamics reduction slows or tends to slow growth in past years due to the technological lag of industries and processes.

Figure 2. Industries' energy intensity of Kazakhstan



On the basis of specific energy consumption data for the production of goods, works and services, we made a comparison of the average energy efficiency and energy efficiency levels for only a few sectors.

For some of industries, we have not found data on the energy consumption of individual products and processes. Substantially, there is a significant gap levels of energy efficiency with the "actual consumption abroad" for all of the technology.

Another problem is improving the energy efficiency of buildings.The classification and normative values of the specific heat consumption for heating for residential and public buildings, the form of the energy passport of the building in standard RK 2.04-04-2011 are identical to Russian norms.

Table 4 shows the comparison of thermal efficiency, based on the level of thermal energy that must be supplied for heating 1 sq. m. area of the building. The heat efficiency differs for various typical building designs (see table 4).

It is worth noting that the level of requirements for thermal resistance of structures in Kazakhstan is substantially lower than that required in EU countries with similar climatic conditions. In general, the level of our backlog in terms of the degree of heat protection of newly constructed buildings is 15-20 years.

Table 4. Comparison of thermal efficiency

Specific reducible energy Wh. h. / (m2, oC. daily)	Russia	Kazakhstan (on the brick panel, estimated)	Germany
1986	100-150	144	95-126
1998	65-95	NA	47-63
Since 2000	50-80	NA	16-25
Perspective level	35-40	NA	6,5-12,5

Source: compiled by the authors based on UNIDO report

The results can be valuable, and can also be used as guidelines to determine public policies with appropriate strategies to improve the efficiency of countries considering the context of sustainability.

3. Conclusions

Comparing the methodology of DEA, as well as the methods used in its framework with other evaluation methods, there are several significant advantages.

1. The absence of the need to define a strict analytical relationship between input and output parameters gives more possibilities for adapting the method to different contexts of its application.
2. Unlike efficiency estimation methods using various artificial weighting factors (rating approach), the DEA methodology uses the mechanisms for obtaining an estimate only on the basis of objective data on the amount of resources used and products released. Due to this approach, one can speak of a significant degree of objectivity of the evaluation obtained.
3. In contrast to statistical methods of performance evaluation, in which the efficiency norm is determined by

predicting output parameters on the basis of statistical dependence and taking into account the level of input parameters, the DEA methodology defines the efficiency norm as the level of the most effectively functioning real objects from the whole set of considered.

DEA technique allows a comparative analysis of energy efficiency indicators, which is based on a comparison of the values of the individual groups of indicators with each other. However, the use of this technique in a Kazakhstan limited lack of statistical information of many indicators and series of the dynamics of the existing indicators.

Based on the above analysis, it should be noted that the lack of tools, financing mechanisms and adapted predictive models in the framework of Kazakhstan's energy efficiency programs have a negative impact on energy efficiency. Changing this situation involves the implementation of a number of measures. For further analysis is required to develop a system of indicators of industries and comparative analysis

Acknowledgment

This paper is results by funding Committee of science Ministry of education and science of the Republic of Kazakhstan (project Improving energy efficiency of industry and housing in Kazakhstan using innovative technologies: standards and financial instruments).

References

Ang, B., Mu, A. and Zhou, P. (2010). Accounting frameworks for tracking energy efficiency trends. *Energy Economics,* 32(5): 1209-19.

Ang, B., Xu, X. and Su, B. (2015). 'Multi-country comparisons of energy performance, The index decomposition analysis approach. *Energy Economics,* 47: 68–76.

Banker, R. D., Charnes, A. and Cooper, W. W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science,* 30(9): 1078–92.

Bashmakov, I. (2013). Driving industrial energy efficiency in Russia. Available: http://www.cenef.ru/file/Idustry-eng.pdf

Brun, L. C. and Gereffi, G. (2011). The multiple pathways to industrial energy efficiency. *A Systems and Value Chain Approach*: Available: http://www.cggc.duke.edu/pdfs/DukeCGGC_EE-Report_2011-2-15.pdf

Charnes, A., Cooper, W. W. and Rhodes, E. (1978). Measuring the efficiency of dmus. *European Journal of Operational Research,* 2: 429-44.

de, G. H., Verhoef, E. and Nijkamp, P. (2001). Energy saving by firms, Decision-making, barriers and policies. *Energy Economics,* 23(6): 717–40.

DeCanio, S. (1998). 'The efficiency paradox, Bureaucratic and organizational barriers to profitable energy-saving investments. *Energy Policy,* 26(5): 441–54.

Farrell, M. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society, Series A,* 120: 253–81.

Filippini, M., Hunt, L. and Zoric, J. (2014). Impact of energy policy instruments on the estimated level of underlying energy efficiency in the EU residential sector. *Energy Policy,* 69: 73–81.

Golove, W. and Eto, J. (1996). 'Market barriers to energy efficiency, A critical reappraisal of the rationale for public policies to promote energy efficiency. *Lawrence Berkeley National Laboratory*: Available: http://eetd.lbl.gov/ea/emp/reports/38059.pdf

Rohdin, P., Thollander, P. and Solding, P. (2007). Barriers to and drivers for energy efficiency in the swedish foundry industry. *Energy Policy,* 35(1): 672–77.

Thollander, P. and Ottosson, M. (2008). An energy efficient swedish pulp and paper industry -exploring barriers to and driving forces for cost-effective energy efficiency investments. *Energy Efficiency,* 1: 21–34.

Tleppaev, A., Tovma, N. and Zeinolla, S., 2016. "Construction of kazakhstan's system of energy efficiency indicators for the development of industrial competitiveness." In *Proceedings of the 28th International Business Information Management Association (IBIMA), ISBN: 978-0-9860419-8-3, 9-10 November 2016, Seville, Spain.* pp. 2071-79.

Worrell, E., Price, L., Neelis, M., Galitsky, C. and Zhou, N. (2007). World best practice energy intensity values for selected industrial sectors. - report number: Lbnl-62806. Available: https://eaei.lbl.gov/sites/all/files/industrial_best_practice_en.pd