DOI: 10.21122/1029-7448-2018-61-1-60-69

UDC 504.06:51-74

Ecological and Economic Efficiency of Traditional and Alternative Methods of Electrical Energy Production with the Features of the Islamic Republic of Iran

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Abstract. The problems of energy, environment protection and ecology play a major role in the development of economy strategy in any country. Most of the traditional power stations operating on organic fuels have a negative impact on the environment. Furthermore, there is a depletion of natural resources due to human activities. One of the ways to solve the problem of environmentally friendly energy production is to use alternative sources of energy. Based on the foregoing, the development of the strategy for the development of traditional and alternative energy must consider environmental and economic factors in a specific country. In the present work it was evaluated the environmental and economic efficiency of application of traditional and alternative energy with regard to the conditions of the Islamic Republic of Iran. The program packages RETScreen which is one of the most effective tools to accomplish the task was used. Calculations of cumulative cash flow from the operation of power plants using different types of primary energy are carried out using models of package RETScreen for assessing the input efficiency of various types of energy sources aiming to cover the intending growth in electricity demands and the environmental assessment with reference to different countries. The results of the study showed that the planning prospects of the development of energy systems in relation to the Islamic Republic of Iran to cover the expected growth in electricity demands it is advisable to use the alternative energy sources, and, first of all, the generating capacity based on solar and wind energy.

Keywords: traditional and alternative energetic, RETScreen, ecological and economic effectiveness

For citation: Mehdizadeh M. A., Kalinichenko A. S., Laptyonok S. A. (2018) Ecological and Economic Efficiency of Traditional and Alternative Methods of Electrical Energy Production with the Features of the Islamic Republic of Iran. *Energetika. Proc. CIS Higher Educ. Inst. and Power Eng. Assoc.* 61 (1), 60–69. DOI: 10.21122/1029-7448-2018-61-1-60-69

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Эколого-экономическая эффективность традиционных и альтернативных способов получения электрической энергии с учетом особенностей Исламской Республики Иран

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Реферат. Проблемы энергетики, окружающей среды, экологии играют большую роль при разработке стратегии развития экономики любой страны. Большинство традиционных энергетических установок, работающих на органическом топливе, оказывают отрицательное воздействие на окружающую среду. Кроме того, происходит истощение природных ресурсов вследствие человеческой деятельности. Поэтому все больше внимания уделяется учету влияния создаваемых объектов на экологическую обстановку. Один из путей решения проблемы производства экологически безопасной энергии – использование альтернативных источников энергии. Исходя из вышесказанного, при разработке стратегии развития традиционной и альтернативной энергетики необходимо учитывать экологические и экономические факторы применительно к особенностям конкретной страны. В настоящей работе выполнена оценка экологической и экономической эффективности использования традиционной и альтернативной энергетики применительно к условиям Исламской Республики Иран. При этом использовались пакеты программы RETScreen, которая является одним из наиболее эффективных инструментов для реализации поставленной задачи. На основе моделей пакета RETScreen для оценки эффективности ввода различных типов энергоисточников с целью покрытия предполагаемых темпов роста потребности в электроэнергии, а также экологической оценки были проведены расчеты совокупного потока денежных средств от эксплуатации энергоустановок, использующих различные виды первичной энергии, применительно для ряда стран Европы, Азиатского региона и стран бывшего СССР. Результаты исследований показали, что при планировании перспектив развития энергосистем применительно к Исламской Республике Иран с целью покрытия предполагаемых темпов роста потребности в электроэнергии целесообразным представляется преимущественный ввод альтернативных энергоисточников и в первую очередь генерирующих мощностей, использующих солнечную энергию и энергию ветра.

Ключевые слова: традиционная и альтернативная энергетика, RETScreen, экологическая и экономическая эффективность

Для цитирования: Мехдизадех, М. А. Эколого-экономическая эффективность традиционных и альтернативных способов получения электрической энергии с учетом особенностей Исламской Республики Иран / М. А. Мехдизадех, А. С. Калиниченко, С. А. Лаптёнок // *Энергетика. Изв. высш. учеб. заведений и энерг. объединений СНГ*. 2018. Т. 61, № 1. С. 60–69. DOI: 10.21122/1029-7448-2018-61-1-60-69

The energy problem, environmental protection and ecological problems have gradually become the focus of attention. Nowadays is characterized by the growth of energy consumption, which requires the increase of installations generating electricity. At the same time, most traditional power plants running on organic fuels have a negative impact on the environment [1]. Furthermore, there is a depletion of natural resources due to human activities. So, more attention is paid to consideration of the influence of newly created objects on the environment [2]. One of the ways to solve the production of environmentally

friendly energy is to use alternative sources of energy. Different countries seek for different solutions in the field of energy development in relation to their features. Based on the above, it is necessary to consider environmental and economic factors in relation to the specific country during the planning of a strategy for the development of traditional and alternative energy.

In the present work the environmental and economic efficiency of application of traditional and alternative energy with regard to the specific conditions of the Islamic Republic of Iran was evaluated. The program packages RETScreen which is one of the most effective tools to accomplish the task was used [3–5]. Calculations of cumulative cash flow from the operation of power plants using different types of primary energy are carried out using models of package RETScreen for assessing the input efficiency of various types of energy sources aiming to cover the intending growth in electricity demands and the environmental assessment with reference to several countries in Europe (Spain, Italy, France, Sweden), Asia (Armenia, Iraq, Iran, Turkey) and countries of the former USSR (Belarus, Lithuania, Russia, Ukraine).

Dependences of the values of the total cash flow from the operation of the power plants on the number of years of their operation as results of calculations were obtained.

All countries mentioned above can be divided into two groups according to the type of the total cash flow dynamics. The first group includes countries, where the cumulative cash flow from the operation of the generating facilities using various types of primary energy starts to grow since the introduction of the plant into operation according to a linear law (fig. 1). The second group consists of the countries, where the cumulative cash flow is characterized by a non-linear increase and can even delayed in time (fig. 2).

From the countries reviewed the first group includes France, Italy, Lithuania, Spain, Sweden and Ukraine, and the second one – Armenia, Belarus, Iraq, Iran, Russia and Turkey.

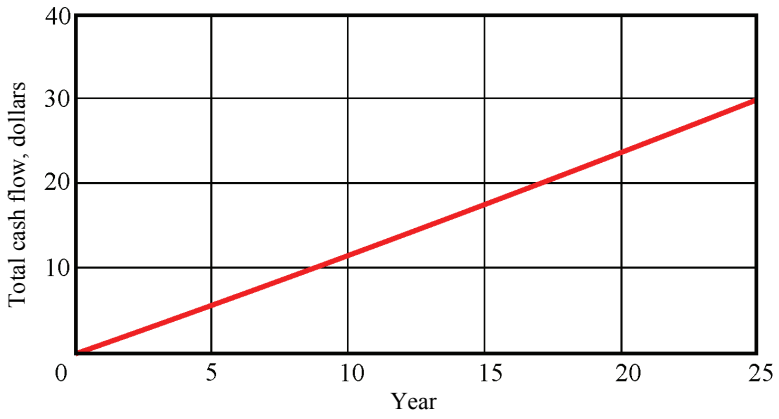

Fig. 1. The results of the calculation of the total cash-flow from power plants that use solar energy with regards to Sweden (RETScreen)

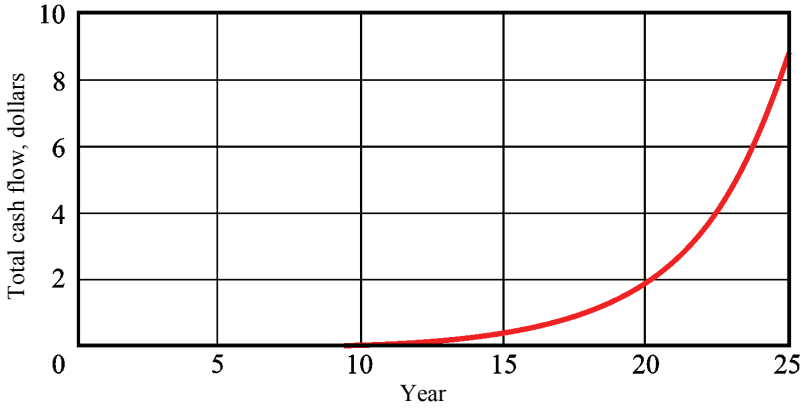

Fig. 2. The results of the calculation of the total cash-flow from power plants that use the energy of river runoff, for the Islamic Republic of Iran

To assess the economic efficiency of power-generating facilities, using various types of primary energy, different approaches based on the type of dynamics of formation of total income were used [6].

For the group of countries where the dynamics is linear, the total cash flow as the indicator of effectiveness was used. So, the increase in the total cash flow starting from the first year of operation can be described by the equation $y = ax$, where x is the sequence number of the operation year, a is a coefficient that defines the growth of aggregate cash flow during the year, which is a measure of efficiency and depends on the characteristics of a particular economy.

Sweden is characterized by a high level of economic development. As a result the profit from the input of the system can be obtained due to the significant volume of equity investment, lower rates on loans, long term lending, long-term investments and other economic factors associated with low levels of investment risks.

For a group of countries where the dynamics of income from the operation of the generating capacity has non-linear dependence the other approach are used. To define a function that describes this process the approximation of the data using the software complex Origin was carried out. For these countries the dynamics of the increase in total cash flow can be described as an exponential rate and almost perfectly described by the expression

$$y = ae^{\frac{x}{b}},$$

where x – number of years since the beginning of the project; a – coefficient, which is the base constant annual growth of aggregate cash flow and the coefficient b is a measure of the intensity of the increase of this flow.

The efficiency of the generating capacity in this case is directly dependent on the coefficient a and has the inverse relationship on the coefficient b.

A long payback period of projects in the Islamic Republic of Iran is due to the specific characteristics of schemes of financing construction and mainte-

nance of objects. First of all, there is the lack of own funds for investments in the projects implementation, high interest rates on loans, limitations on the ability for long-term loans and investment and other economic factors associated with high levels of investment risks. These factors are, primarily, the result of the U.S. and the European Union economic sanctions against the Islamic Republic of Iran (in particular, the embargo on oil supplies), which ran for 10 years and significantly reduced the level of economic development of the country.

Tab. 1 shows the values of annual income for generating capacity using different types of primary energy in the countries of the first group.

Table 1

The value of the annual income for generating capacity using different types of primary energy in the European Union countries and Ukraine (USA dollars)

Country	Wind	Gas	Solar	Hydro
Spain	2857143	69565217	1176471	88235294
Italy	3043478	75000000	1250000	93750000
France	2941177	75000000	1250000	93750000
Sweden	2857143	70000000	1162791	88235294
Lithuania	2926829	71428571	1219512	90909090
Ukraine	2890173	72463768	1250000	96000000
Mean value	**2919324**	**72242926**	**1218129**	**91813280**

The ratios of the primary economic effectiveness for generation capacity using different types of primary energy are presented in fig. 3. Clearly, the efficiency of hydropower and energy produced with natural gas is by orders of magnitude superior to the corresponding data for wind and solar energy (fig. 3).

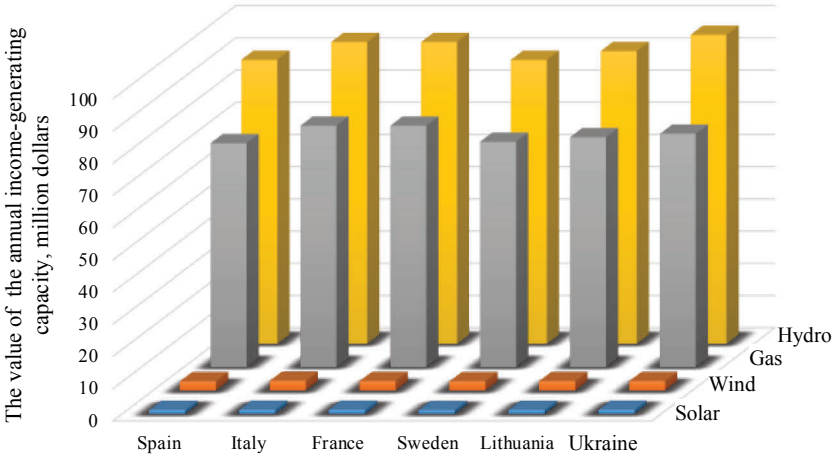

Fig. 3. The value of the annual income-generating capacity using different types of primary energy in the European Union countries and Ukraine (USA dollars)

For these countries with the nonlinear dynamics of operating income the annual income median is used as the performance indicator. Tab. 2 shows the va-

lues of annual income median for generation capacities that use different types of primary energy in countries of the second group.

Table 2

The annual income median for generation capacities that use different types of primary energy for countries of the second group (USA dollars)

Country	Wind	Gas	Solar	Hydro
Armenia	48070777	1584603752	27597597	2176739423
Iraq	49975034	1231159105	18513120	1492680219
Iran	59619502	1124817049	36072073	1762476522
Turkey	59267197	1459675015	32797896	1157424096
Belarus	11854195	2762525284	49461460	3750905577
Russia	96499620	2403639989	39751328	2895070364
Mean value	**54214388**	**1761070032**	**34032246**	**2205882700**

The ratios of the primary economic effectiveness for generation capacity using different types of primary energy are presented in fig. 4 and similar to countries of the first group (fig. 3). As well we see the superiority of gas and hydropower.

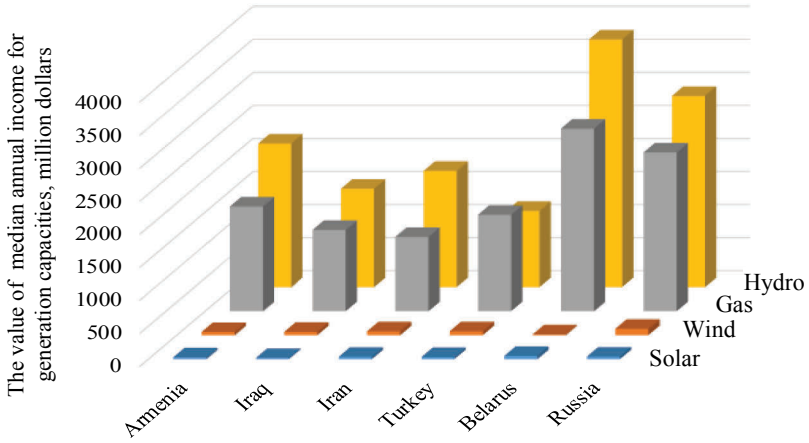

Fig. 4. The values of median annual income for generation capacities that use different types of primary energy for countries of the second group

With respect to Iran it can be noted that the energy complex allows annually producing 33000 MW of electricity. Moreover, 75 % of this amount gives natural gas, 18 % oil, 7 % hydroelectric power plants [7–9]. At the same time, there are prerequisites for efficient use of alternative energy sources [10]. Since Iran is devoted to the second group of countries, it is important to evaluate the efficiency of the alternative sources taking into account peculiarities of the country [11].

Despite the overall prevalence the total income can not fully characterize the ratio of the economic efficiency of power-generating facilities using various types of primary energy. In this case it is necessary to consider the costs that accompany a particular method of generating electrical energy and primarily construction costs and environmental damage.

Based on mentioned above the method described for evaluating the economic efficiency of generating capacity using different types of primary energy was

in a certain way modified. The modification consisted in accounting of specific costs of construction and indirect environmental costs associated with emission into the atmosphere of carbon dioxide for different types of generating capacities in terms of 1 MW [12, 13]. This approach allowed us to obtain the results displayed in tab. 3, 4 and fig. 5, 6.

Table 3

Specific values of annual income taking into account the construction cost and indirect environmental costs associated with emission into the atmosphere of carbon dioxide for generating capacity in the European Union countries and Ukraine (USA dollars)

Country	Wind	Gas	Solar	Hydro
Spain	2882.802	1783.063	2205.507	9166.219
Italy	2884.504	1796.074	2206.508	9197.299
France	2883.570	1796.074	2206.508	9197.299
Sweden	2882.502	1784.104	2205.321	9166.219
Lithuania	2883.438	1787.524	2206.093	9181.288
Ukraine	2883.104	1790.002	2206.508	9209.980
Mean value	**2883.320**	**1789.474**	**2206.07**	**9186.384**

Table 4

Specific values of the median annual income based on the cost of construction and indirect environmental costs associated with emission into the atmosphere of carbon dioxide for generating facilities in Armenia, Belarus, Iraq, Iran, Russia, Turkey (USA dollars)

Country	Wind	Gas	Solar	Hydro
Armenia	3295.848	5409.866	2564.969	20936.816
Iraq	3313.311	4563.766	2441.374	17081.528
Iran	3402.097	4309.873	2649.597	18000.798
Turkey	3398.212	5110.803	2635.719	15192.058
Belarus	2964.796	8229.654	2862.428	29808.656
Russia	3738.398	7370.530	2730.321	24985.256
Mean value	**3352.110**	**5832.415**	**2647.401**	**21000.852**

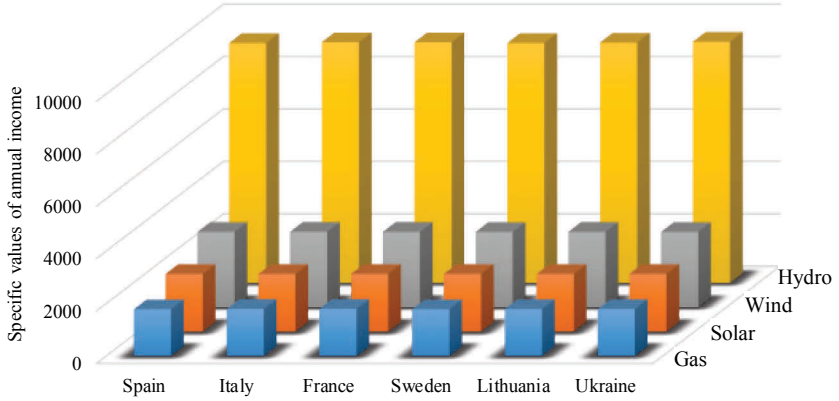

Fig. 5. Specific values of annual income, taking into account the construction cost and indirect environmental costs associated with emission into the atmosphere of carbon dioxide for generating facilities using different types of primary energy in the European Union countries and Ukraine (USA dollars)

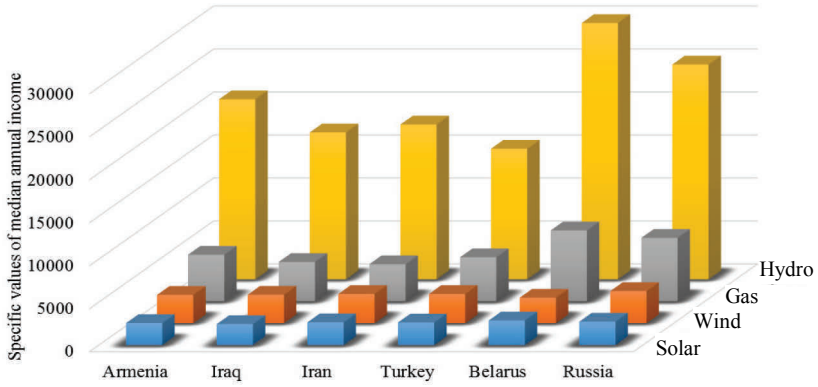

Fig. 6. Specific values of median annual income, taking into account the cost of construction and indirect environmental costs associated with emission into the atmosphere of carbon dioxide for generating facilities using different types of primary energy (USA dollars)

It is obvious that taking into account the specific costs of construction and indirect environmental costs associated with emission into the atmosphere of carbon dioxide, the ratio between generation capacities using conventional and alternative forms of energy varies substantially [14].

For the countries of the "European" group the "gas" power which is predominant in the absolute amounts of profits over the "wind" and "solar" ones but with the accounting environmental and economic efficiency is inferior to alternative methods of producing electrical energy (fig. 3, 5).

A similar effect is observed also for the countries of the second group. The ratio of economic efficiency of traditional and alternative methods of producing energy moves significantly towards the direction of the generating capacities that use energy of wind and Sun.

The degree of change in the ratio of the economic efficiency of generating facilities that use as primary energy renewable sources compared to the efficiency of facilities using the energy from the combustion of natural gas is presented in tab. 5, 6.

Table 5

Relative coefficients for the absolute annual profit and annual profit accounting specific cost of construction and minimization of the environmental impacts for 1 kW·h of energy produced (group 1)

	Wind/Gas	Solar/Gas	Hydro/Gas
1. Absolute profit	0.04	0.017	1.27
2. Profit accounting specific cost	1.60	1.200	5.10
2/1	40.00	70.100	4.02

Table 6

Relative coefficients for the absolute annual profit and annual profit accounting specific cost of construction and minimization of the environmental impacts for 1 kW·h of energy produced (group 2)

	Wind/Gas	Solar/Gas	Hydro/Gas
1. Absolute profit	0.03	0.02	1.25
2. Profit accounting specific cost	0.57	0.45	3.60
2/1	19.00	22.50	2.88

It is obvious that generating capacities that use as primary energy the Solar one have maximum environmental and economic efficiency in both groups of studied countries. The ecological-economic effectiveness of electricity production using solar energy will increase steadily with the prospect of reducing specific cost of construction solar-power stations in the next 30–35 years almost 2 times. This is true, in the first place, for the Islamic Republic of Iran, which has many sunny days and has little water reserves.

CONCLUSION

Analysis of the results has shown that ecological and economic efficiency of power generating installations using the energy of river runoff surpasses a similar indicator of the thermal power plants using natural gas by 3–4 times. Wind and heliostations surpass thermal installations in this indicator more than an order of magnitude. Hence, when planning prospects of development of power systems to cover the estimated growth of energy demand with respect to the Islamic Republic of Iran it is advisable to install units based on alternative energy sources, first of all, generating capacity using solar energy and wind energy.

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Received: 28 November 2017 Accepted: 22 January 2018 Published online: 29 January 2018

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Поступила 28.11.2017 Подписана в печать 22.01.2018 Опубликована онлайн 29.01.2018