Central Asian Journal of Economics and Management
ISSN: 2181-4228

CAJEM
- SCIENCE

QAYTA TIKLANUVCHI MUQOBIL ENERGIYA HAQIDA ILMIY VA NAZARIY QARASHLAR

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Received: 02 February 2025; **Accepted:** 20 March 2025; **Published:** 25 March 2025.

Abstract. The article presents scientific and theoretical views on renewable alternative energy. The opinions of foreign, CIS and republican scientists on renewable alternative energy issues are presented. A classification of renewable energy sources into three groups is presented.

Keywords. renewable alternative energy, energy strategy, innovation wave period, anthropogenic evolution of energy, renewable energy strategies, solar, wind, biomass energies, «green» energy.

In the context of the rapid development of industrial civilization, the last two decades of the last century have formed a new paradigm of energy development. The growth rate of energy consumption per capita, which until then had doubled every 50 years, has decreased worldwide, as in developed countries [9, -C.15]. The energy crisis of 1973 stimulated development in the field of alternative energy, as a result of which the use of renewable energy sources began, and this area has become a priority area of the national energy strategy of many developed countries.

World experience shows that there is a fairly cyclical change of dominant energy resources in the energy sector. On average, every 30-50 years, due to the introduction of innovative sources of energy, this energy source replaces the remaining energy sources and its share in the energy balance reaches 70 percent, and will remain the leader for the next 15-20 years. During the second wave of innovation, which was noted by Y. Schumpeter, that is, in the late 19th and early 20th centuries, coal dominated, and later oil and gas fossil fuels. Usually, this transition is accompanied by a global transformation of the energy system and its infrastructure. In the third wave of innovation (1900-1950), oil began to be used not only as fuel, but also as the main raw material for the chemical industry. In the fourth wave of innovation (1950-1980), the active use of biomass-based energy began, which marked the anthropogenic evolution of energy. This type of energy has been increasing in importance due to its low environmental impact and ecological purity compared to other energy sources. After the 1973 oil crisis gave impetus to the active use of renewable energy sources, the development of technologies with low energy intensity began, and a new branch of the fourth innovation wave began to take shape - renewable energy. Until this period, energy produced on the basis of renewable energy sources was considered a distant scientific and technological task, when traditional energy sources were economically or physically inferior [5, –P. 21]. Also, the production of sectors with high energy intensity, including steelmaking and the chemical industry, was reduced. During this period, industrial production in the USA decreased by 13%, in Japan by 20%, in the UK by 10%, in France by 13%, and in Italy by 14% [17, –P. 25.]. In a number of countries, in particular in Germany, industrial and scientific potential has reached a high level, and active development of renewable energy has begun [6, -c.86]. In the post-crisis period, long-term strategies for renewable energy using modern innovative technologies have begun to be developed.

Many studies have been carried out in foreign countries on renewable energy sources. In particular, J.W.Twidell, A.D.Weir, T.Johansson, S.P. Raghuvanshi, T. Jackson, M. Grubb, R. Hill,

C. Mitchell, V. Andrea, J.H.Wu, Y.H. Huang, U. Ulritz, M.G. Smith, J. Urpelainen, T.N. Sedash, B.V. Yermolenko, I.A. Grechukhina, M.V. Dakalov, A.O. Buchnev, I.S. Moga, P.P. Bezrukikh, A.V. Chernyshev and many other scientists have conducted in-depth research on this topic.

In particular, the Indian economist S.P. Raghuvanshi in his study "Renewable energy resources for climate change mitigation" (2007) assessed the impact of renewable energy development on climate change. In his opinion, renewable energy sources are a type of energy that does not affect the environment and climate change, and they are always replenished [12, –P. 13.]. The Swedish scientist T. Jackson in his study "Renewable Energy: prospects for implementation" (1993) highlighted the economic, institutional and environmental aspects of the use of renewable energy sources. He considered the issues of reducing technological costs in the field. In his research, he defined renewable energy sources as naturally renewable and environmentally friendly energy [10, – P. 45]. The English economist M. Grubb in his study "Renewable Energy Strategies for Europe" (1995) studied the strategies for developing alternative energy in the EU member states. The economist defines renewable energy sources as energy sources obtained from inexhaustible natural resources [4, –P. 12]. Also, in-depth research on the topic was conducted by Russian economists T.N. Sedash in his studies "Renewable Energy Sources: Promotion in Russia and Abroad" [15, -p. 12] and I.A. Grechukhina in his studies "Economic Mechanisms for the Development of Renewable Energy" [2, -p. 16]. These two scientists defined renewable energy sources as energy sources obtained from solar, wind, water and plant resources.

In many modern scientific and technical literature, in particular in the scientific works of the Russian scientist N.P. Kalashnikov, renewable energy sources include, in addition to solar, wind, biomass energy, the energy of sea level rise and fall, and the energy of sea waves [7, -c 27]. Also, in the studies of R.B. Akhmedov and Dzh. Tvaydel, low-potential thermal energy and geothermal energy are also included in renewable energy sources [1, -c.18;16, -c 14].

There are many discussions in the European Union and other developed countries about the efficiency of renewable energy sources and the period of their recovery of the invested funds [3, -c. 24; 13, -c 23]. Nevertheless, in many countries of the world, long-term large-scale programs for the introduction of «green» energy have been developed, as well as laws that encourage this type of energy and include obligations to save energy resources. From an ecological point of view, the expansion of the use of renewable energy sources is considered the optimal way to reduce the amount of harmful emissions into the atmosphere and the greenhouse effect resulting from the use of non-renewable energy resources. Therefore, interest in renewable energy sources has been growing in recent years.

The Russian scientist S.A. Podolinsky was the first to conduct in-depth research on the use of renewable energy in agriculture, namely solar energy. He studied the concept of labor in agriculture in relation to the efficiency of solar energy flow [11, -c 49]. The Austrian scientist E. Sacher was the first to conduct a comparative analysis of the use of renewable and non-renewable energy sources for Austria and Prussia. In this, he found that per capita consumption of cultivated plants and wood was 19 million kcal and coal was 9 million kcal [8]. In the course of his research, E. Sacher developed a thermodynamic picture of the world in which the crisis of industrial civilization and the limitation of natural resources were emerging, in which human economic activity and the biosphere were interconnected [14, -c 75].

In August 1981, the Conference on New and Renewable Energy Sources (CNERS) was held in Nairobi. This conference, attended by representatives of 125 countries, developed proposals for increasing international activity in the development of renewable energy sources [18]. The report of the conference was approved as a resolution at the 84th UN General Assembly (No. A36/PV.34). According to it, UN experts proposed the following classification of renewable energy: solar and wind energy; peat, biomass (taking into account renewable waste from agriculture, forestry, industry and the municipal sector); tidal energy (taking into account hydroelectric power plants with a capacity of

at least 1 MW).

The special report "Renewable Energy Sources and Climate Change Mitigation" [19], published in 2012 by the United Nations Environment Programme and the Intergovernmental Panel on Climate Change, emphasized that renewable energy sources have a lower negative impact on the environment than other types of energy and have a high potential to mitigate the effects of climate change.

The "Guidelines on Energy Statistics" published in 2007 by the Organisation for Economic Co-operation and Development (OECD), the International Energy Agency (IEA) and Eurostat define renewable energy sources as follows: renewable energy is energy obtained from natural resources and this type of energy is constantly replenished. Renewable energy sources include solar, wind, biomass, geothermal, hydropower, ocean energy, biogas and liquid biofuels [20]. Waste includes fuels formed from the burning of industrial waste, organizations, healthcare facilities and households. Waste is divided into solid or liquid, renewable and non-renewable, biodegradable and non-biodegradable waste.

The International Energy Agency divides renewable energy sources into the following three main groups:

Group 1 includes types of renewable energy sources used for electricity generation (hydro, wind, solar and tidal energy);

Group 2 includes types of renewable energy sources that are used for multiple purposes after production for grid consumption and end-use (geothermal and solar thermal energy). This group of energy sources cannot be stored due to their natural properties, and their reserves cannot be accounted for in storage;

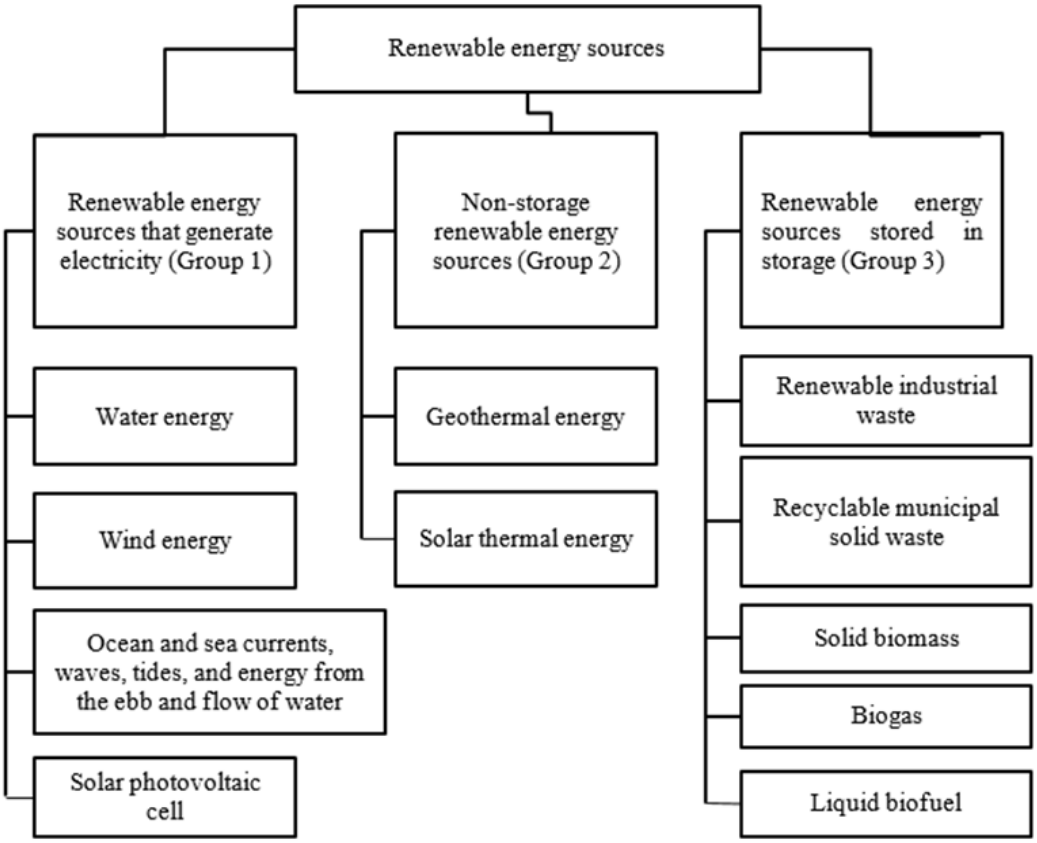

Figure 1. Classification of renewable energy sources into three groups [20]

Group 3 includes types of renewable energy sources that are used for multiple purposes after production for grid consumption and end-use (renewable waste, wood, biogas and liquid biofuels). This group of energy sources can be stored according to their natural properties, and their reserves in storage can be calculated (see Figure 1).

There are several controversial discussions about the definition of municipal solid waste. Municipal solid waste is considered waste collected from households, commercial organizations, healthcare and other institutions, and is divided into biodegradable and non-biodegradable waste. According to the International Energy Agency and the European Union methodology, biodegradable types of municipal solid waste are included in renewable energy sources. Some countries that are members of the International Energy Agency and the European Union include all types of municipal solid waste in renewable energy sources. In some other countries, in-depth studies are being conducted on this issue.

As a result, work is being done to reduce the share of non-biodegradable solid municipal waste based on the further expansion of waste disposal programs. If it is not possible to separate solid municipal waste into renewable and non-renewable groups, then the total amount of solid municipal waste can be divided into two equal groups.

We divide renewable energy sources into the following two main groups:

Group 1: Renewable energy sources that are rapidly renewable and have an intangible form. This group includes solar energy, wind energy, geothermal energy, ocean and wave energy, tidal energy, and water flow energy (Figure 2).

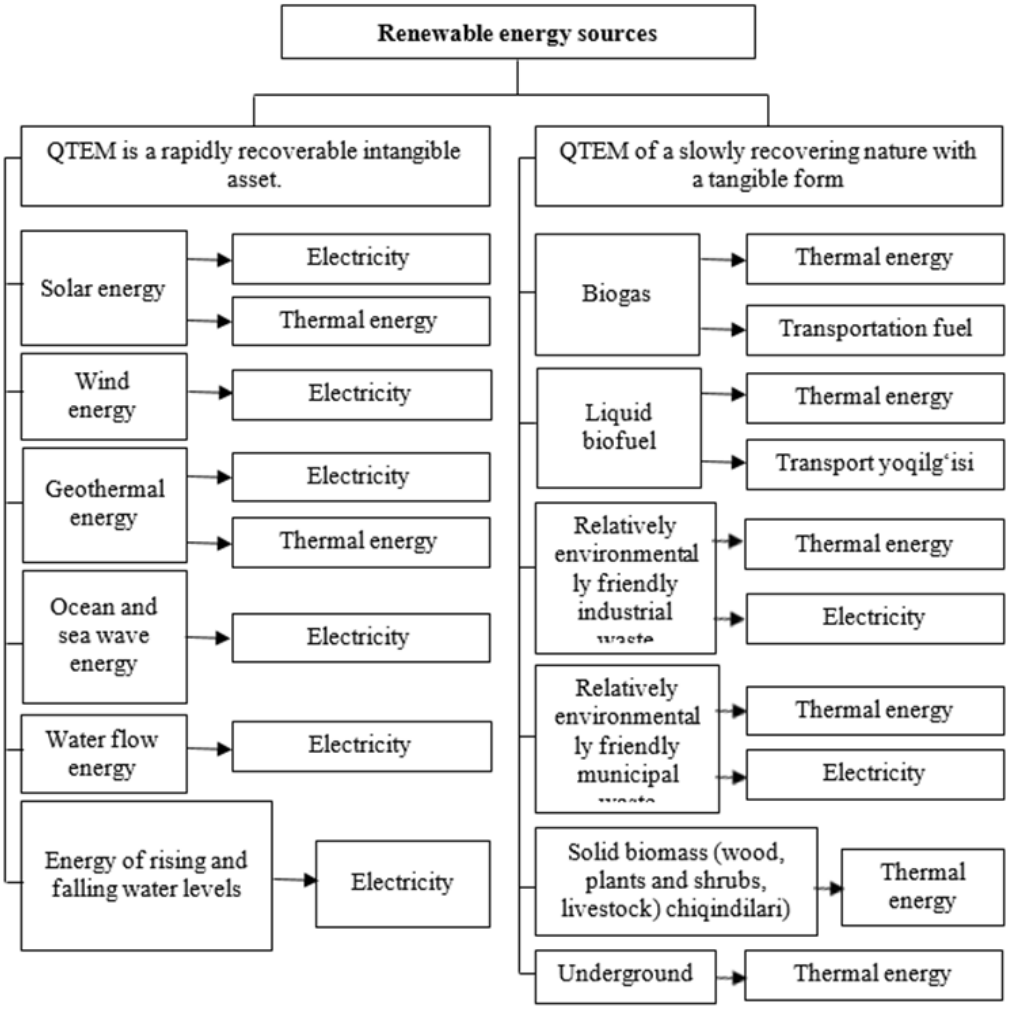

Figure 2. Classification of renewable energy sources into two groups.

Group 2: Renewable energy sources of slow renewal in physical form. This group includes biogas, biofuels, underground gas, relatively environmentally friendly industrial waste, relatively environmentally friendly solid municipal waste, solid biomass (wood, plants and shrubs, livestock waste and other agricultural waste).

When accounting for renewable energy sources and comparing them with each other and with other energy sources, some difficulties arise due to the units of measurement. For example,

solid municipal waste such as wood and wood waste is measured in cubic meters (m3) or in tons. Biogases are measured in cubic meters in volume, in thermoelectric units in kWh or kWh, and liquid biofuels are measured in liters in volume, in tons in weight and in joules, megajoules (JJ, MDJ). Renewable energy sources that generate electricity, such as hydroelectric power, solar power, tidal power, wave power, ocean currents, and wind power, are measured in units of electrical power (kWh, MWh, GWh).

The "Guidelines on Energy Statistics", published in 2007 by the Organisation for Economic Co-operation and Development (OECD), the International Energy Agency (IEA), and Eurostat, use the term "energy resources" interchangeably with terms such as "energy products" and "energy vectors" [20]. According to this, energy resources are divided into primary and secondary energy resources. Primary energy resources are energy sources that are directly extracted from natural resources. Such energy resources include energy sources such as oil, coal, and natural gas. All energy sources other than primary energy resources are secondary energy resources. Such energy resources can be produced from primary energy resources or from secondary energy resources. Some types of energy resources can be included in both primary and secondary energy resources.

The importance and scope of the use of renewable energy sources is determined, first of all, by their economic efficiency and competitiveness in relation to traditional energy technologies. The main advantages of renewable energy sources over traditional energy resources are their practically complete inexhaustibility, their availability in all regions, low fuel costs and the absence of a negative impact on the environment. It should be noted that the high capital intensity of renewable energy sources is the reason why this type of energy source has a low share in the total energy balance. Despite this, interest in the development and implementation of non-traditional and renewable energy sources is growing in most countries of the world.

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