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## THE ROLE, PROBLEMS AND PERSPECTIVES OF ICT IN THE FORMATION OF GREEN ECONOMY

*The article interprets the need to form green economy and the reasons for the transition to it in the context of globalization and integration. The process of greening the economy is presented as a new stage in the economic development. The importance of ICT in greening the sphere of economic activity is grounded. The situation related to the formation of the green economy in the world, including in Azerbaijan is analyzed. Potential areas for greening the industrial economy based on ICT are shown. Suggestions on the development of appropriate evaluation models in connection with the transition to a green economy are given.*

**Keywords:** green economy, green thinking, greening technologies, green ICT.

### Introduction

One of the trends in sustainable economic development is the provision of long-term development based on natural resources and knowledge [1]. At present, economic development in most parts of the world is observed with adverse environmental phenomena, such as environmental imbalance, increased pollution, natural resource depletion, and climate change. The economy, which serves to improve the welfare of the person, hampers its well-being and damages its health [2]. Therefore, in the context of information society, the modernization should be oriented to innovative and advanced technologies that provide economic development. Furthermore, the modernization process should preserve and improve the productivity of environment. The concept of the formation and development of the green economy in this regard includes the resource-driven economy, environment economy, green technologies and many other trends [3].

Energy efficiency in Azerbaijan is directed primarily to the economic growth. The main goal is to improve the living conditions of each person. In this regard, the dependence on oil and gas resources should be eliminated and the non-oil sector in the country should be developed. Moreover, sustainable welfare conditions should be ensured for future generations. This issue necessitates the implementation of production and consumption across the country on the basis of ecological balance.

Humanity has created many products and services based on the traditional model of economy. However, the economy needs to be greened for sustainable economic development. Therefore, the signs of a new economic model based on green technologies in some countries are observed. Since ICT plays an important role in this process, it is important to explore its problems and perspectives.

### Analysis of the situation in Azerbaijan in the field of green economy formation

The UN Environment Program has identified the 10 key sectors that are essential for investing in green economy [4]. This program outlines the principles of green economy initiatives [5-7], based on which the recommendations on the transition to green economy and its terms have been developed [8-10]. The UN Climate Change Convention [11] can also have a major impact on the transition to green economy. Environmental restorations are also extensively used for Green economy [12].

The National Program on Sustainable Ecological Socio-Economic Development in the Republic of Azerbaijan was adopted in 2003 [13]. As a logical continuation of this program, one of the key targets of the National Strategy for the Development of Information Society in the Republic of Azerbaijan for years 2014-2020 [14] and the Strategic Road Map of the National Economy is to achieve ecologically sustainable socio-economic development, to minimize energy

consumption for each unit of GDP, to increase the share of renewable energy sources in the country's energy balance, and to create an environmentally efficient management system based on the protection of the ecological balance.

Over the last ten years, the energy efficiency consumed for the production of each unit of GDP in Azerbaijan has increased by more than 300%. At present, the energy efficiency in Azerbaijan is higher than the average for the world. According to international statistics provided by the World Bank in 2013, the average value of GDP produced in the world from 2003 to 2011 has increased from 4.93 USD to 6.19 USD per kilogram. In Azerbaijan, according to the same sources, these figures amounted to 2,26 USD (2003) and 7,22 (2011) USD respectively. This dynamics indicates the consistent implementation of the policy in the field of energy efficiency in Azerbaijan [21].

There is a basis for a perfect environmental policy in Azerbaijan. In accordance with the Rio + 20 and Johannesburg Summit Decisions, Azerbaijan is improving the environmental policy and legislation [16]. Environmental measures include the adoption of state programs and laws, the introduction of new governance principles, the expansion of the national parks, and the further improvement of the water provision of the population, the waste management and the environmental protection.

The basic principles of the legislation in the field of environmental protection in Azerbaijan envisage the development of the green economy. The government provides subsidies for agriculture, leasing services, preferential loans, and implements comprehensive melioration and irrigation. Azerbaijan has a great potential for the development of the green economy.

There are positive and negative sides in the evaluation concept on different criteria of each innovation. In this aspect, the green economy is no exception. Since the initiatives and programs for transition to the green economy can damage or benefit any country. Prior to the implementation of the initiatives, a proper assessment should be made and opportunities should be created for the rapid adaptation of the people. The negative impacts of transition to the green economy can be typically observed in the developing countries and the countries rich in natural resources. Principally, transition to the green economy does not imply that all other problems are positively solved. There are problems the solution of which can only be possible through a comprehensive approach.

### **Formation of the green economy and evaluation of its development**

The relevant UN structures, based on the current approaches in this area, propose the groups of economic, social and environmental indicators as the foundation for the formation and development of the green economy. The Global Green Economy Index (GGEI) or the Green Economy Benchmark Index (GEBI) is used for the final assessment. For the calculation of GGEI, it is recommended to refer to the baseline indicators as follows: efficient energy technologies, environmental quality indicators, tourism potential, and investment allocations. [17].

The baseline indicators for the calculation of GEBI are proposed: energy efficiency, pure fuel, renewable energy sources, natural resources, water, and pollution reduction.

The National Green Economy Index (NGEI) is proposed as the aforementioned indices can not fully reflect the current situation. The main indicators for the calculation of NGEI are: environmental quality, renewable energy, soil conservation, green tourism, green GDP, environmental protection costs, greenhouse gas emissions, and innovation index. The environmental quality index, characterized by the key indicators reflecting the development of the national green economy, includes: air quality, water, soil, biodiversity, environmental protection, and environmental damage. Based on the synthesis of the proposed options, both from the national and regional aspects we propose the Regional Green Economy Index (RGEI) and sub-indexes affecting its formation [17]:

- Environmental protection level (EPL);
- Specific weight of green GDP (GGDP);

- Specific weight of renewable energy (SWRE);
- Environmental Recovery Costs (ERC);
- Application level of green technologies (ALGT);
- Industrial and household wastewater treatment level (IHWTL);
- ICT Impact Index on Greening (ICTG);
- Science-education-technology index (SETI);
- Greening index in social-cultural spheres (GSCS);
- Natural Ecological Use Index (NEUI).

Thus, it can be denoted as follows:

$$RGEI = F(EPL, GGDP, SWRE, ERC, ALGT, IHWTL, ICTG, SETI, GSCS, NEUI) \quad (1)$$

Here,  $F$  is an analytical expression of the dependence on the sub-indexes of  $RGEI$ .

It should be noted that, the quality of the environment in any particular region can be characterized by the synthesis of air, water, soil, biodiversity, pollution, noise, and other quality level. It is also important to take into account the aspects of the investments allocated to the environmental protection against environmental damage.

The analysis of the development of the national green economy in Azerbaijan shows that renewable energy sources, soil conservation, ecological quality and green tourism are relatively low. These studies can serve to improve the solution of existing problems in the green economy in the future.

The solution of modern problems related to the formation of green economy requires a multidisciplinary approach. Therefore, scientific, theoretical, ecological, economic, technological, social, legal, infrastructural, medical, chemical, biological, management and innovation problems of the green economy should be comprehensively studied separately.

### **The application of advanced information technologies in the green economy**

Observations show that the formation and development trends of the green economy can be identified based on the application of advanced information technologies. Specifically, one of the aspects of green economy is the processing of large-scale information resources, in other words, through the application of *Big Data* technologies.

The importance of activities, knowledge and skills in the green economy can be evident due to the analysis of the efficient utilization of the natural resources. The state of the economy in any country may be assessed by the cost of the products and services produced and by the amount of the energy consumed to achieve a national product. This indicator used in the international statistics and shows the efficiency of the production, basing on modern technological achievements, and the professionalism of the work force [18]. The balanced use of natural resources should, first of all, be based on the precise economic analysis and assessment. In this regard, as noted, the introduction of advanced information technologies is inevitable.

In many countries, the economic growth is mostly associated with more exploitation of the natural resources - soil, water, forest, energy sources, and various minerals. Therefore, the limited natural resources can not ensure the sustainable development of the welfare of the population of the planet by maintaining up-to-date economic trends. The UN experts point out that the economic model with the features such as environmental deficiency and social injustice is far from the green economy. The protection and promotion of natural resources, which is considered to be the economic asset and public benefit for the transition to the green economy, increasing its efficient use, supporting its functions and preserving for the future generations are of particular importance [19].

Protection of the ecosystems and their services is a priority for the green economy. In the international economy, these services are often linked to the new terms "payments for ecosystem services", "environmental donors", "compensation mechanisms", and "debt exchange for nature". A number of fundamental international studies have also been devoted to the economy of the eco-services. The developments have been realized on the inclusion of the ecosystem services into the economic

practice, including the financial sector. Such implementations, analyzes and appropriate management decisions are based on the analytics of large-scale data through up-to-date ICT techniques [20].

Currently, increasing the efficiency of energy and water consumption is a national and global priority. The implemented measures and the ongoing projects cover all the spheres of life and economic subjects of the country, and therefore, the latest ICT achievements in these processes create favorable conditions for new essential results.

Necessary measures should be taken to timely prevent the emerging threats against the green economy and to eliminate the consequences. These measures require, first of all, economic analysis, assessments, and forecasts based on the accurate information. Therefore, appropriate conditions and mechanisms should be established for the application of ICT in the indicated areas.

### From the green economy towards the green information economy

The main target of the information society building in modern times, at first glance is considered to be the comprehensive application of information technologies and the expansion of electronic services to the population. In fact, the information society building has a broader scope, covering the complex informatization of the activities of all regions of the country, production and non-production areas, local municipalities and civil society organizations. Therefore, information society building should be viewed as a process of informatization of the society on macro and micro levels. In this case, in general, many preventive measures are inevitable for "greening" process in the information society building. These measures can be grouped in several ways.

At present, the industrial economy is mostly developed on the basis of green technologies, in line with the development trends of the world. The largest green economy in the industrial economy goes through the informatization, i.e., through ICT (Figure 1).

There is enough greening potential for automated production and informatization of management processes. Therefore, the process of greening the industrial economy should first be considered in the context of the informatization of the economy. In other words, it is also necessary to achieve the application of the greening technology by innovative methods of the new economy, i.e., the information economy. This, in turn, is the formation and development of a green innovative information economy (Figure 2).

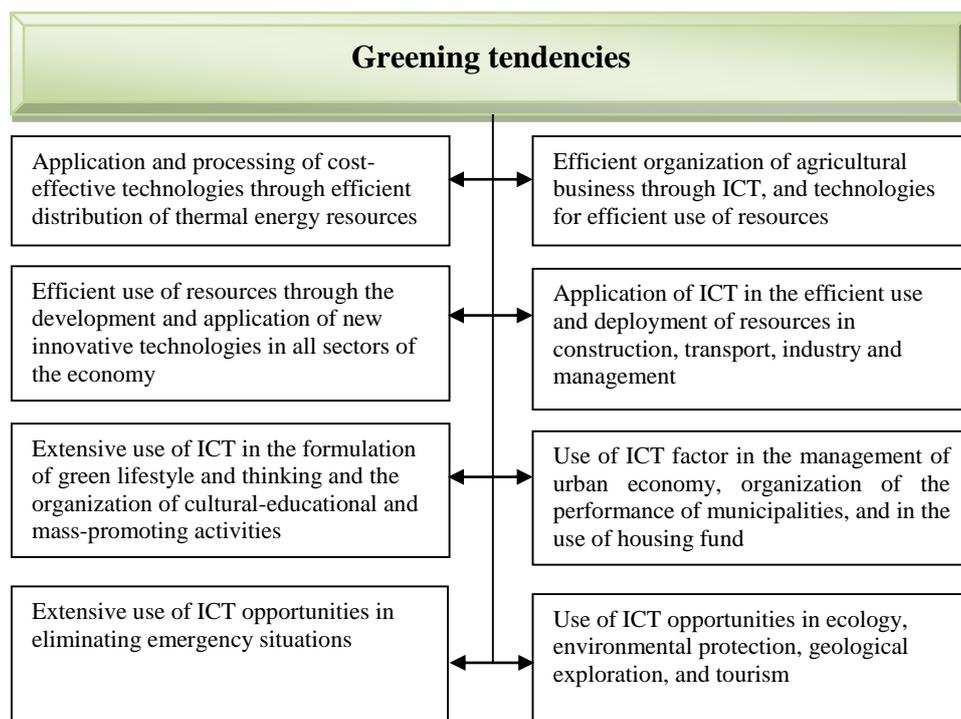


Figure 1. Some aspects of greening economy based on ICT

## ICT problems in greening the information economy

At present, the renewal and production of the ICT industry based on green technology is very significant. Relevant scientific studies are carried out in this area, projects are implemented, and green technologies are developed. Many other innovative technologies are being developed and applied in scientific and technical spheres as Green ICT, Green Computer mouse, Green Innovation in ICT, Sustainable Computers and Communications, ICT for Sustainable Development, Sustainable ICT projecting, Green Computer Networks, Smart Cities and Green ICT Systems, Green Data Centers, Green ICT Conferences, Green E-devices, Green biomedicine, Green Media, Green ICT Media Library, Green ICT in Management, Green Metrics, Healthcare and Green ICT, Global Green ICT Renewal, and Green ICT Art.

Along with this, as the innovative information economy is formed, there are many problems that can be solved through the development and application of relevant green technologies. For example, the development of anti-radioactive technologies is one of the major challenges of the modern era. Thus, the informatization of the society, mass digitization, widespread use of wireless networks, constant use of wireless equipment, and fast digitization increases the radioactivity of the environment and damages the human health. Therefore, in parallel with e-government building, the development and application of appropriate healthier anti-radioactive technologies is inevitable.

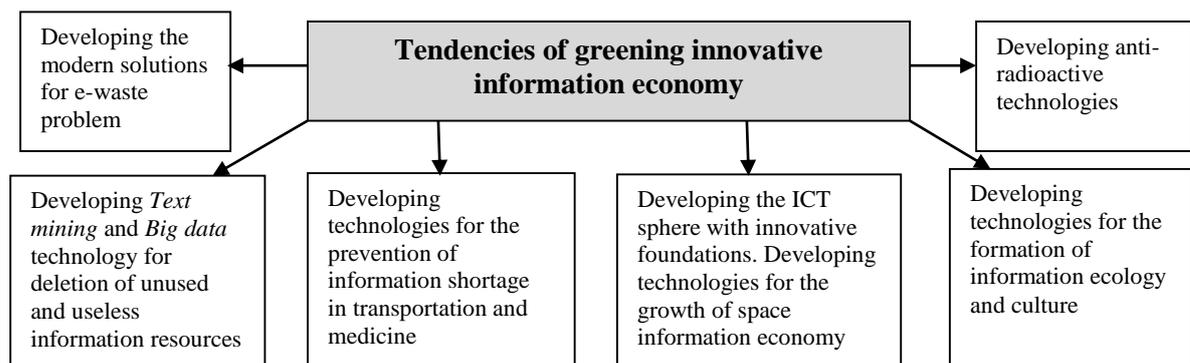


Figure 2. Tendencies of greening innovative information economy

Additionally, new requirements are submitted to the Big Data technologies in terms of current information abundance. Thus, the gradual increase in the use of different computers and information networks leads to the growing amount of information. As a result, the volume of information resources is extremely growing, and extracting the necessary information from the unnecessary information becomes difficult. This leads to extra time and financial expenditures. The abundance of information creates information "dump" in a certain period of time. Their non-cancellation causes serious problems. Storage, systematization, processing, protection and transfer of any electronic information belonging to any person or organization are required to be handled in terms of greening. Information culture, information use, and information retrieval methods should be re-developed on the basis of these requirements. Certain technologies should be developed for effective and efficient use of large volumes of data. Despite all this, along with the information abundance there is a problem of information shortage in society. Untimely access to the most important information in appropriate fields as transport, agriculture, trade, and medicine, creates information wastes of the industrial economy and causes more time and financial expenditures. Therefore, rapid and powerful growth of the informatization process is advantageous and is a driving force for the development of the society. At the same time, the informatization process is one of the greening technologies realized in various fields of the industrial economy.

One of the main undesirable problems of information society building is the electronic waste, which is the logical consequence of mass informatization, and their timely utilization. Though there are many progressive methods and experiences in the world practice in this field, many important problems still remain unsolved. The timely solution of these problems directly contributes to the physical greening of the innovative information economy.

### **Developing some models for the transition to the informatization of the green economy**

International statistical information on the environmental protection proves the need to transmit to the green economy. Organization for Economic Cooperation and Development (OECD) forecasts that 61-72% of the world's flora and fauna can be destroyed, and the natural territory of up to 7.5 million km<sup>2</sup> (approximately as much as Australian) may be spoiled by 2050. According to the estimates of the International Energy Agency, the oil fields six times more than of Saudi Arabia must be found, taking into consideration the expected increase in consumption in 2030. Another fact is that the reserves of 800 mines, which constitute 75% of the world's oil reserves, have been already exhausted, and the level of production of many mines has overlapped and diminished.

South Korea, China and France have been investing in green growth most after the economic crisis in the years 2008-2009 [22].

In these countries, 80.5%, 37.8% and 21.2% of the stimulating financial measures are in line with the environmental criteria. Russia announces 2017 as the year of ecology. Kazakhstan adopted the Concept of Transitioning to Green Economy in 2013. According to many surveys and calculations, oil and gas will be ranked second main energy source by the 2030s. All of this proves once again that relevant mechanisms and models should be developed for the transition from the current economy to the green economy. The models and mechanisms for green economic development can cover several independent processes, such as:

- Reducing the anthropogenic impact of the economy on the environment;
- Increasing the efficient use of natural resources;
- Achieving energy efficiency of the economy;
- Improve the legal regulations for reduction of the environmental risks in infrastructural projects and production processes;
- Evaluating the green economic outcomes.

In such circumstances, the development of the general model for green economy is of particular importance.

*The development of a macroeconomic model for the relative depletion of resources and the transition to a new economy* is a very important issue. Some authors have shown the mathematical model of the relative depletion of resources depending on the extracted resources using the Verhulst curve [23].

Researchers from the Lunda University of Switzerland have worked on a new model of reducing major resources of the world. This model predicts that the first production peak of iron will be in 2030 and the second one will be in 2060. In the following years, iron is expected to be a deficit resource. Although the production of gold has already experienced its peak period, its deficit can be observed in 2070. The peak for platinum is expected to be in 2020. The relevant years for lead, silver, and zinc is 2030, while for copper, chromium, nickel and molybdenum this peak is expected to be in 2040-2050 [23]. These facts also indicate the necessity of the gradual depletion of resources and the development of a macroeconomic model for the transition to a new economy.

*When developing the models for transition to green economy, the development criteria should be taken into account.* The methodological recommendations, approaches, and methods for the economic assessment of the previous contamination (damage) accumulated as a result of economic activity have not been fully developed yet.

The major international organizations have worked out a system of indicators for sustainable development. Prof. K. Goffman proposed the indicator "Debt to Nature". The State Administration for Environmental Protection of the People's Republic of China (SAEP PRC) has developed a green GDP indicator [23].

The UN Statistics Division has included the Environmental Adaptive Cleaner Domestic Product (EACDP) criteria. This criteria is calculated as follows:

$$EACDP = (CDP - NRD) - VED \quad (2)$$

Here, CDP - cleaner domestic product, NRD - value expression of natural resources depletion, VED - value expression of ecological damage.

The World Bank has developed a more interesting indicator. This indicator is called the "Net Saving" (NS). This indicator is calculated as follows:

$$NS = (GDS - VIA) + EC - NRD - EDP \quad (3)$$

Here, GDS – general domestic savings; VIA - value of the impaired produced assets, EC - education costs, NRD – value of natural resources depletion, EDP - value of the damage from the environmental pollution.

The criterion NS can also be regarded as a global benchmark for the transition to a green economy:  $NS \rightarrow \max$ . If we point out this indicator in terms of economic and environmental components, we can obtain two equal criteria. They can be expressed as vector-criterion:

$$\begin{aligned} F_1 &= GDS - VIA + EC \rightarrow \max \\ F_2 &= NRD + EDP \rightarrow \min \end{aligned} \quad (4)$$

By finding a Pareto-solution compromise through this vector-criterion, a balanced transition to the green economy can be achieved.

In addition to the above mentioned circumstances, it is also necessary to consider the geophysical and economic factors affecting the previous damages as a result of anthropogenic impacts during the modeling the processes of the green economy formation. Geophysical factor or absorption (assimilation potential) indicates the ability of nature to protect itself. It separates the natural and anthropogenic effects and eliminates their harmful effects. At the same time, as a result of economic factors, the opposite process also happens. Thus, in the economic assessment, the current price of the damage increases due to inflation processes. Hence, as a result of two different processes, the environmental damage both increases and decreases. During the modeling process, certain calculations can be made by the absorption coefficient and the discounting coefficient. The total damage can be calculated by summing up the damages over the years. This methodology was introduced as a pilot project in 1996 and 2013 in some areas of Russia. Since this methodology does not fully address the factors of damage collection, there is a need to improve the methodology and to develop models that meet the new economic and environmental conditions.

In general, replacement of resources in production leads to the change of economic, environmental and social factors. The costs and prices change. The amount of damage related to the pollution increases. The resource replacement is not welcomed. Although the image of the manufacturer is damaged, price reduction is of great importance for the consumer. These factors necessitate the development of a model for the economic evaluation of the resource replacement in production. Cost, increase in the processing and production costs, demand-supply inconsistency and other factors have a direct impact on the natural resource replacement. At the same time, assessment of the possibility of technological realization of the resource replacement is a question. Therefore, a model of this process and the optimal replacement of the natural resource should also be developed.

In addition to the foregoing, there is a need for the development of the general evaluation models of environmental pollution damages [24, 25]. The following are suggested in this field:

- economic and social evaluation model of damages (current and past) due to the

- environmental pollution;
- evaluation of hazardous waste emissions into the atmosphere;
- evaluation model of waste waters and wastes (current and past) released into water basins;
- evaluation model of environmental damage in separate regions and production areas;
- developing the conceptual model of transition to the green economy and working out the development criteria;
- econometric models of factors of the green economy formation;
- macro-economic model of transition to knowledge and ICT-based green economy.

The abovementioned models enable the most important assessment, analysis and planning issues for the transition to the green economy. At the same time, the solution of complex issues related to the strategic development of the transition to the green economy at the national and regional level is of great importance. Moreover, the development of the models that predict socio-economic and environmental outcomes based on the principles of the green economy can enable to achieve the growth in the preferred new economic conditions. The creation of an intellectual information system for the transition to the green economy may lead to the improvement of the welfare of the society.

### Conclusion

There are many challenges facing the information society and ICT in the provision of the long-term economic development and ecological balance. One of the key issues is the development and application of the green economy technologies. Therefore, the economy and society of Azerbaijan should, first of all, use the greening technology of the post-industrial economy in the most effective way. At the same time, the growth of the non-oil sector should be achieved through the diversification of the economy. In addition, the information economy itself must be greened through the use of high technologies. In the new economic conditions, the advantages of the green economy are higher than its disadvantages. Therefore, the green economy should be viewed as way to a sustainable development as a new stage in the information economy.

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