



Scientific article

## DECARBONIZATION PATHWAYS OF THE REPUBLIC OF AZERBAIJAN AND THE ENVIRONMENTAL SECURITY CHALLENGES

Fuad Humbatov<sup>1, 2</sup>  PhD, Associate Professor

<sup>1</sup> National Hydrometeorological Service within the Ministry of Ecology and Natural Resources of the Republic of Azerbaijan, Baku, Azerbaijan; [fuad.humbatov@eco.gov.az](mailto:fuad.humbatov@eco.gov.az) (FH)

<sup>2</sup> State Academy of Public Administration under the President of the Republic of Azerbaijan, Baku, Azerbaijan; [fuad.humbatov@eco.gov.az](mailto:fuad.humbatov@eco.gov.az)  
Corresponding author: Fuad Humbatov, [fuad.humbatov@eco.gov.az](mailto:fuad.humbatov@eco.gov.az)

### KEY WORDS

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climate change  
renewable energy  
inventory of GHG  
mitigation policies

### ABSTRACT

The paper studies national context of climate change combat, environmental security, low greenhouse gas emission (GHG) development scenarios for the Republic of Azerbaijan in the XXI century, analyzes the optimal pathways of transition to the green economy in the country. Since the paragraph 19 of the Article 4 of the Paris Agreement defines a task for each country - Party of the Agreement, to formulate and communicate long-term low greenhouse gas emission development strategies (LT-LEDS), preparation of such strategy is of high priority for each Party of the Agreement. In this regard, the paper focusses particularly on the energy and environmental characteristics of the decarbonization scenario in Azerbaijan.

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### 1. INTRODUCTION

XXI century witnesses unprecedented global change in search of affordable and scalable solutions to reduce the dependency on fossil fuels bearing the serious consequences for the environment and climate. The World Meteorological Organization (WMO) has confirmed that 2024 is the warmest year on record [1]. Since the global average surface temperature was 1,55 °C (with a margin of uncertainty of  $\pm 0,13$  °C) above the 1850...1900 average, according to WMO's consolidated analysis of the six datasets. According to the reliable climate models, without significant climate action, the world is headed for 2,5 °C to 2,9 °C temperature rise above pre-industrial levels this century, which is well above the safety limits established by scientists [2]. In the last 50 years, the number of recorded climate disasters has increased fivefold, and economic losses have increased sevenfold. Like the availability of land, minerals, water, etc., carbon emission capacity is one of the scarcest elements of natural resources. Research evidence shows that if effective policies and actions are not taken immediately, there will be irreversible global ecological catastrophe and massive economic losses, with the total cost of inaction exceeding \$1,266 trillion from 2025 to 2100.

The urgency of implementation of the comprehensive effective climate actions is especially needed for developing countries, which have been already feeling the negative impacts of climate change due to a combination of factors, including their geographical and climatic conditions, their high dependence on natural resources, and their limited capacity to adapt to a changing climate.

Regarding the term of «environmental security, in 1987, UN sub-organization – The World Commission on Environment and Development (WCED, also known as the Brundtland Commission) published the report «Our Common Future» that launched broadly the concept of sustainable development and for the first time introduced globally the term of “environmental security» [3...4].

Nowadays, environmental security concept is a pivotal component of international environmental policy, once the most countries joined the new development pathway to comprehend and effectively implement their environmental policies including climate change resilience. A series

of dedicated conferences followed on the eve of new millennium: International Conference on Environmental Security and Sustainable Development in Moscow in 1997 and in Paris in 2002, aiming to draw attention of the international community to preserving biodiversity and providing environmental safety as key priorities of environmental policy.

Actually, the main global environmental problems are air and water pollution, water quality, biodiversity and climate change. In order to effectively respond to the various global and regional environmental security challenges, almost all countries, international organizations, leading scientific centers of the world call for concentrated global cooperation between countries, international organizations, stress out the importance of collaboration between all stakeholders in all levels, broader involvement of private sector, non-governmental organizations etc. All these activities strengthen once more the role environmental diplomacy in the modern international relations.

Among the global environmental problems, the climate change issues are going to be the most challenging phenomena and necessitate very rapid and effective global actions. The Intergovernmental Panel on Climate Change (IPCC), which has proved itself as a serious scientific platform responsible for promoting the UN science base in the relevant field, already predicted that this process would lead to a global disaster if global warming would exceed 1,5 °C compared with pre-industrial levels.

It is known that the consistent rise of average temperature is mainly due to anthropogenic factors. Thus, these factors are based on gases that create the greenhouse effect (GHG). These gases are water vapor, carbon dioxide (CO<sub>2</sub>), methane gas (CH<sub>4</sub>), nitrogen oxide (N<sub>2</sub>O), fluorinated gases (HFCs, PFCs, NF<sub>3</sub>, SF<sub>6</sub>). As a result of anthropogenic activity, the volume of carbon dioxide, methane gas, nitrogen oxide and fluorinated gases with high heat generation potential has been increasing since industrial times, and their carbon gas equivalent is used as a unit of measurement to calculate the volume of all these gases [5]. It should be noted that the mechanism of creating the thermal effect of these gases was first described in 1827 by the famous physicist-mathematician Joseph Fourier, as a result of relevant research with appropriate methods of calculations.

Observations of the recent decades have shown that as a result of global climatic changes in various regions of the globe, both the scale and intensity storms, mudflows, blizzards, floods, as well as warm winds, hurricanes, and precipitation are increasing. This is evidenced only by large-scale forest fires in 2021...2024 in EU, Turkey, Russia, USA, EU and other countries, as well as heavy rains and floods in EU, Pakistan, eastern Turkey during last years. It is no coincidence that the 6th Assessment Report (AR6) by the Intergovernmental Panel on Climate Change (IPCC) emphasized that in XXI century, the average annual temperature in the world could rise by at least 3 °C, if states do not take concerted action to reduce emissions. It's evident that this report that if the international community does not take serious and effective measures to reduce greenhouse gas emissions, humanity will move from a temperature rise of 4 °C to 5 °C, which could result in an apocalypse [6]. Here are some parts of this report, describing the Possible Climate Perspectives:

- The global surface temperature will continue to rise, at least until the middle of the century, taking into account all emission scenarios. In the absence of significant reductions in carbon dioxide (CO<sub>2</sub>) and other greenhouse gas emissions in the coming decades, global warming in the 21st century will exceed 1,5 °C and 2 °C;

- Many changes in the climate system are now intensifying in direct connection with the increase in global warming. These changes include an increase in the frequency and intensity of extremely hot days, sea heat and heavy rainfall, agricultural and environmental droughts in some areas, and an increase in strong tropical cyclones, a decrease in Arctic Sea ice, snow cover and permafrost.

- Ongoing global warming is expected to further strengthen global water circulation, including the intensity of global monsoon rains, floods and droughts.

The mentioned report showed that the emission of greenhouse gases as a result of burning fossil fuels, deforestation and other human activities can disrupt the environmental security of our civilization. Carbon dioxide levels in the air are currently at their highest level for at least the last 2 million years.

Moreover, the report predicted the most significant drastic and irreversible changes in the Earth's system, which could have very serious consequences and are of greater concern to scientists. In terms of physical research, the report recommends reducing CO<sub>2</sub> emissions and other greenhouse gas emissions to zero in the near future as an effective way of reduction of global warming caused by anthropogenic impacts. Actually, scientists' calculations show that since 1850, as a result of anthropogenic activities, 2.400 billion tons of CO<sub>2</sub> equivalent greenhouse gases have been emitted in the world, and they have been stored in the atmosphere for hundreds of years, creating a cumulative warming effect. In such situation, scientists have calculated that if only an additional 400 billion tons of CO<sub>2</sub> equivalent greenhouse gases are released into the atmosphere, the probability of keeping the average annual temperature rise at 1,5 °C will be only 66 % [7]. If we consider that about 50 billion tons of CO<sub>2</sub> equivalent heating gases are released globally into the atmosphere every year, then it is important to find out how severe this problem is and to urgently consolidate it in order to combat global warming [7]. It should be noted that the level of annual emissions in 1990 was about 35 billion tons of CO<sub>2</sub> equivalent, but has continued to rise steadily. To keep global warming at 1,5 °C, the IPCC considers it necessary to halve global GHG emissions by 2030 and achieve net-zero emission target by 2050 [8].

In light of the global climate change efforts, UNFCCC (United Nations Framework Convention on Climate Change) [9], as an effective international mechanism, as well as other climate change related treaties - the Kyoto Protocol and Paris Agreement embedded international norms aiming to stabilize GHG concentrations in the atmosphere at a level that will prevent dangerous human interference with the climate system, in a time frame which allows ecosystems to adapt naturally and enables sustainable development. It's namely the Paris Agreement that set out a global framework to avoid dangerous climate change by limiting global warming to well below 2 °C and pursuing efforts to limit it to 1,5 °C. It also aims to strengthen countries' ability to deal with the impacts of climate change and support them in their efforts. Regarding these efforts, Nationally Determined Contribution (NDC) is the pivotal document for each country - Party of the Paris Agreement [10], where the country has to declare a target of reduction of its national emissions and adapt to the impacts of climate change. According to the Article 4, paragraph 2, each Party is required to prepare, communicate and maintain successive Nationally Determined Contributions (NDCs) documents that it intends to achieve. Parties shall pursue domestic mitigation measures, with the aim of achieving the objectives of such contributions.

Moreover, according to the paragraph 19 of the Article 4 of the Paris Agreement, Parties should strive to formulate and communicate long-term low greenhouse gas emission development strategies (LT-LEDS). Taking into consideration this norm, Parties are invited to communicate these strategies to the Secretariat of UNFCCC by 2020, according to the clause 35 of the decision 1/CP 21 of UNFCCC [10]. Actually, long-term low emissions development strategies (LT-LEDS) are a crucial policy tool that can help to place short-term actions in the context of the long-term structural changes required to transition to a low-carbon, climate change resilient economy by 2050. Besides that, they can help to explore the consequences of policy choices in terms of integrated socio-economic objectives [11]. LT-LEDS should be mainstreamed to the national policy process, and represent a useful way of structuring national policy debates in a transparent, productive and ambitious way.

Another important article of the Paris Agreement is Article 13 establishing an Enhanced Transparency Framework (ETF) designed to build trust and confidence that all countries are contributing their share to the global efforts. In fact, the Katowice Conference of Parties of UNFCCC (COP24) that was held in 2018, outlined a new framework for all countries by adopting a detailed set of modalities, procedures and guidelines (MPGs) that make it operational. Through the detailed guidance on the reporting/review/consideration processes for the information to be submitted and by making these reports publicly available, the ETF will make it possible to track the progress made by each country – Party of PA. In this way, it will be possible to compare a country's actions against its plans and ambitions as described in its NDCs. On adopting ETF format, the Parties agreed at CMA.3 (Conference of Parties during the COP26 in Glasgow) [12] to provide common reporting tables for national GHG inventories; common tabular formats (CTF) for tracking progress towards NDCs and climate finance, technology transfer and capacity building; outlines of

the Biennial Transparency Report (BTR), national inventory document and technical expert review report; and a training programme for the technical review experts.

Actually, all developed countries and not only they have been consolidated to accelerate the twin green and digital transitions and associated transformation of their economy, industry and society with a view to achieving climate neutrality by 2050. This encompasses the transition to greenhouse gas neutrality of the energy and mobility sectors by 2050 at the latest, while boosting their competitiveness, resilience, and utility for citizens and society. For example, the European Climate Law [13] requires the EU economy and society to become climate-neutral by 2050 in a socially fair and cost-efficient manner and, as an intermediate target, to reduce net greenhouse gas emissions by at least 55 % by 2030 (compared to 1990 levels). In this regard, despite the active turbulences in energy market of EU because of the sanctions against Russia waging war in Ukraine, EU countries and some other developed countries have been at the forefront of climate science and they committed to keep delivering the knowledge for enabling efficient long-term decarbonization pathways and just transitions to the climate neutrality. The right and efficient transition to the climate neutrality comprises various sectoral decarbonization pathways, including rural and particularly urban resilience scenarios etc. It's no coincidence that among COP27 Presidency (7...18 November 2022, Sharm el-Sheikh, Egypt) initiatives, one of the remarkable, in terms of GHG reduction and climate change adaptation, SDGs implementation initiatives was the Sustainable Urban Resilience for the next Generation (SURGE). Thus, contributing to building sustainable, inclusive and resilient urban systems, the work of the SURGe Initiative is guided by the following overarching ten principles:

1. Low-carbon: reducing emissions and benefiting from cost savings from decreased energy use and improved energy and resource efficiency;
2. Resilient: strengthening the capacity of city systems and their inhabitants to maintain continuity through shocks and stresses and recover faster, while positively adapting and transforming towards urban sustainability, taking into account the management of internal and international migration into cities;
3. Nature-positive: Harnessing the potential of Nature-Based Solutions (NBS) to improve cities' socio-ecological resilience and wellbeing;
4. Fair, equitable, and inclusive: needs to reach the most vulnerable communities to climate change impacts by establishing social dialogue and participatory processes for co-design and prioritized implementation;
5. Multi-level climate governance and climate planning: recognizing the importance of collaboration between local, regional, and national governments and harnessing the cross-scale and cross-discipline relationships necessary for climate action to raise the ambitions of the NDCS;
6. Integrated: Leveraging co-benefits of investment in adaptation and mitigation measures while building on existing support, initiatives, and partnerships to leverage their impact and lessons learned;
7. Locally-led and culture-positive: Customize approaches depending on local contexts of new, rapidly developing cities, while recognizing that culture and heritage represent both an asset to be protected from climate impacts and a resource to strengthen the ability of communities to pursue transformative change;
8. Circular: promoting a circular value chain in buildings and constructions, but also in supply and disposal infrastructure systems, that aims at reducing both emissions and waste drastically while promoting innovation, affordability, ensuring food security, energy efficiency, and local development;
9. Financing-enabling: centered on capacity building, technology transfer, enabling frameworks and delivering solutions to support and enhance existing and innovating finance channels and mobilizing finance at scale while accelerating access for local and regional governments;
10. Health-promoting: recognizing the importance of health and wellbeing as an input to resilience, the power of health arguments to motivate change, and the significant economic and social co-benefits available from health-aware climate action.

Passing to the regional context of the environmental security in terms climate change impacts, one of the most vulnerable regions in the world in this regard is the South Caucasus region, that is related to the physical and geographical position of the regions. Serious negative impacts of climatic changes in the region are increasing aridity, Caspian Sea level-fluctuations, more frequent extreme weather events (e.g., severe droughts, floods, and hailstorms), making almost all economic sectors climate-sensitive. Nowadays, most countries in the region are already experiencing rising temperature, increasing water scarcity, rising frequency of droughts and forest fires, as well as growing rates of desertification. Particularly climate-sensitive economic sector for the countries of the region is agriculture and this problem necessitates global and regional cooperation towards implementation of effective mitigation and adaptation measures, because of the regional food security and the fact that the majority of the population of the region extensively depends on agriculture sector for their livelihoods.

In this region, Azerbaijan is particularly vulnerable to climate change impacts. According to weekly drought monitoring data received from NASA from GRACE satellites, the country has been exposed to a sharp drought both in terms of underground water and terrestrial humidity. Moreover, according to the report of UNDP containing climate change impacts projection, as a result of the drought caused by the climate change for the period 2021...2050, water supply of the country will decrease by 23 % [14] In April, 2022, «Azercosmos» OJSC has prepared and submitted to the government an assessment report “Impact of global climate change on the Republic of Azerbaijan”, where it’s proved a satellite assessment of the impacts of climate change on the base of satellite technology. The report evaluates effectiveness of measures against climate change on the base monitoring of effects of mitigation, adaptation measures, using satellite images provided by the high-frequency satellite «Azersky». The main results of the satellite monitoring confirm the scale of the predicted processes associated with climate change. These results could be summarized as follows:

1. In the winter season of the years 2017...2021, up to 30 % of field reductions were recorded in snow drifts;
2. According to the results of monitoring the mirror surface of water bodies over the past 5 years, there has been a decrease by 4,3 %, and throughout the country by 2 %., but there is an increase in area by 7...10 % compared to 2021.
3. As a result of analysis of changes in the water level of the Kura River based on satellite schemes, a decrease in the area of the mirror surface of the water was observed, and over the past 2 years it was found out that the width of the river in some places decreases up to 40...60 meters. Due to the decrease in the water level in the river, it was recorded that in 2021 the inflow of sea water was mixed into Kura River up the place near the village of Arabgardashbeyli of the Salyan district, situated even in the 45 km distance from the seaside.
4. Compared to the last 20 years, dry areas have been increased, and by 2021 the territories being subjected to a very severe drought the country has grown by 15 %.
5. Based on data processing over the past 20 years, 6 % more areas with a high risk of drought have been identified in the country [14]

Actually, all these climate change impacts could seriously undermine progress that has been made in the socio-economic and environmental activities of Azerbaijan during last 30 years, if the country will not timely implement effective climate change mitigation and adaptation measures, elaborate and proceed low emission and climate resilient development pathway including transition to the green economy, as it requires contemporary global environmental security standards.

Acknowledging global climate change challenges, Azerbaijan has already outlined the clean environment and green growth development priority among five national priorities within the «Azerbaijan 2030: National Priorities for Socio-Economic Development» document approved by the relevant Order of the President of the Republic of Azerbaijan issued on February 2, 2021. This strategic document was adopted in order to meet the national commitments to the United Nations’ 2030 Agenda for Sustainable Development, as well as the Paris Climate Agreement and consists of the following priorities: (i) sustainably growing competitive economy; (ii) society based on dynamic, inclusive and social justice; (iii) competitive human capital and modern innovations space; (iv) great return to territories liberated from occupation; and (v) clean environment and «green



growth» country [15]. Realization of the last priority necessitates clear understanding and analysis of all effective strategies, policies, measures, scenarios of climate resilience, decarbonization prospective and the mentioned monograph of the author – «Low emission development outlook and its role in the environmental security system of the Republic of Azerbaijan» is an attempt towards detailed analysis of the long-term low GHG emission development scenarios, their classification in terms of GHG reduction potential and effectiveness in terms of SDG implementation, as well as their role in the environmental security of the country.

By the way, «Azerbaijan 2030: National Priorities for Socio-Economic Development» outlined new target to double Azerbaijan's GDP by 2030 under a new 10-year development plan which requires an average annual growth rate of 7 % of GDP [16].

It's remarkable that from the very beginning of the implementation of the Sustainable Development Goals they became of high importance for Azerbaijan [17]. Actually, the country is among few countries around the globe and the first in the South Caucasus region that has submitted its third Voluntary National Report (VNR) about implementation of the 2030 Agenda in the country [18]. Scoring 72,4 out of 100 points possible on the SDG achievement index, Azerbaijan ranks 55th out of 165 countries in the 2021 Sustainable Development Report with the best result in the region. These reports highlight Azerbaijan's progress in areas such as poverty reduction, healthcare, nutrition, women's labor force participation, clean water and sanitation, access to energy, internet usage, threatened species survival, as well as improving population welfare and sustainable development of cities and communities. Azerbaijan, along with crude oil and natural gas, recently became an exporter of electric energy. Today, the country exports electric energy to 4 neighboring countries. Meantime, actually domestic electricity consumption level tends to rise due to population growth and economic development.

Let's recall in chronical order the main steps of the country the field of climate change cooperation. After joining the United Nations Framework Convention on Climate Change (UNFCCC) in 1995, in 1997 the late president Heydar Aliyev, taking into account the urgency of the problem related to climate change, issued Decree No. 560 dated April 30, 1997 «On measures to ensure the implementation of the commitments made by the Republic of Azerbaijan in accordance with the United Nations Framework Convention on Climate Change, approved by the Republic of Azerbaijan on January 10, 1995» establishing the State Commission on Climate Change in the country. On 11.03.2020, with the Decree [19] of the President of the Republic of Azerbaijan Ilham Aliyev, a new composition of the State Commission was determined. The establishment of this State Commission under the chairmanship of the Deputy Prime Minister of the Republic of Azerbaijan led to the strengthening of consistent institutional and legislative activities in the field of combating climate change in Azerbaijan. Thus, a special Working Group consisting of specialists and experts of state bodies was formed to organize the facilitate the work of the commission. Thus, along with the Ministry of Environment and Natural Resources, relevant specialists from the Ministry of Economy, the Ministry of Energy, the Ministry of Agriculture, the State Statistics Committee of the Republic of Azerbaijan and other state bodies were involved to the Working Group. On July 23, 2020, the first meeting of the State Commission was held, during which a number of important decisions were made, the Ministry of Ecology and Natural Resources (MENR) of the Republic of Azerbaijan was assigned as a responsible and coordinating body for regularly informing the Commission on the relevant activities implemented in this direction. Over the past period, the Republic of Azerbaijan has prepared and submitted its First National Communication (NC) (2000), Second National Communication (2010) and Third National Communication (2015), as well as its First Biennial Updated Report (BUR) (2014), Second Biennial Updated Report (2018) to the Convention Secretariat. The last, the Fourth National Communication was officially submitted to the secretariat on 23.06.21 [20]. The country submitted its INDC (Intended Nationally Determined Contributions) document on 19.01.2017, where it officially declared a target of 35 % reduction of its GHG emissions by 2030 compared with the base year (1990) level, taking into account national circumstances, national priorities of development, national interests of the country. The NDC2 Azerbaijan's revised commits to a 40 % reduction in emissions by 2050, compared to 1990 levels, conditional on international support [21]. The sectors identified for mitigation measures include

energy, industrial processes and product use, agriculture, land use, land use change and forestry, and waste.

## 2. MATERIALS AND METHODS

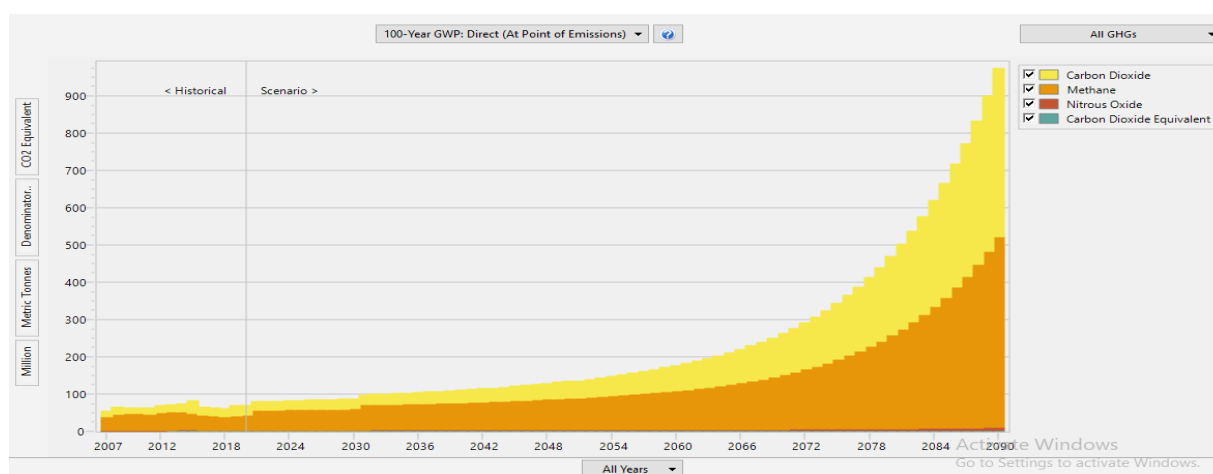
As it mentioned above, the actual paper contains some results of the monograph «Low emission development outlook and its role in the environmental security system of the Republic of Azerbaijan» studying the greenhouse gas (GHG) emission development pathways, i.e. scenarios (projections) in Azerbaijan for the next decades, taking into account the current NDC goals, on the base qualitative analyses, using of the special LEAP (Low Emissions Analysis Platform) modelling technique [22] for evaluation of the emission reduction effects of the relevant mitigation policies and measures. Each scenario is based on corresponding to mitigation policies, measures, as well as assumptions in the relevant sectors (corresponding to the 2006 IPCC Guidelines [23], AR4 emission factors) of reaching net-zero emission target. Moreover, there will be analyzed the mentioned scenarios in terms of their role in the environmental security of the country.

In order to conduct comparative analysis of all these GHG emissions development options there will be presented three GHG emission development scenarios, namely - Business as Usual (BAU) Scenario, Realistic Low Emission Development Scenario (RLEDS) and Best Low Emission Development Scenario (BLEDS). Let's bring some definitions of these development scenarios:

Business as Usual (BAU) Scenario is a projection of the level of GHG emissions that would result if future development trends follow those of the past and no change in climate change mitigation policies and measures take place. The scenario assumes that there are no climate change strategies, policies and measures being or to be implemented since 2021 [24], no relevant green transition changes in technology, economics etc. Business as Usual (BAU) Scenario is used later on as benchmark for other scenarios here below and separate mitigation policies and measures for qualitative assessment of their GHG reduction potential and effects. Here below in the paper, in order to evaluate the GHG emissions reduction of mitigation actions or their overall total effects within the Realistic Low Emission Development Scenario (RLEDS) or within the Best Low Emission Development Scenario (RLEDS) we'll provide a comparative analysis of each mitigation action vis-à-vis the BAU Scenario on the base of LEAP calculations. Hence the BAU Scenario plays a benchmark in our modelling analysis and it's elaborated on the base of the official statistical and other available data for the past years till the first scenario year - 2021. That's why for the years following the first scenario years, BAU Scenario corresponds to the development under the existing conditions, but without implementing any mitigation policies and measures.

## 3. RESULTS AND DISCUSSION

Figure 1 shows the LEAP projection of the BAU Scenario, taking into account long-term assumptions on the national economy development.

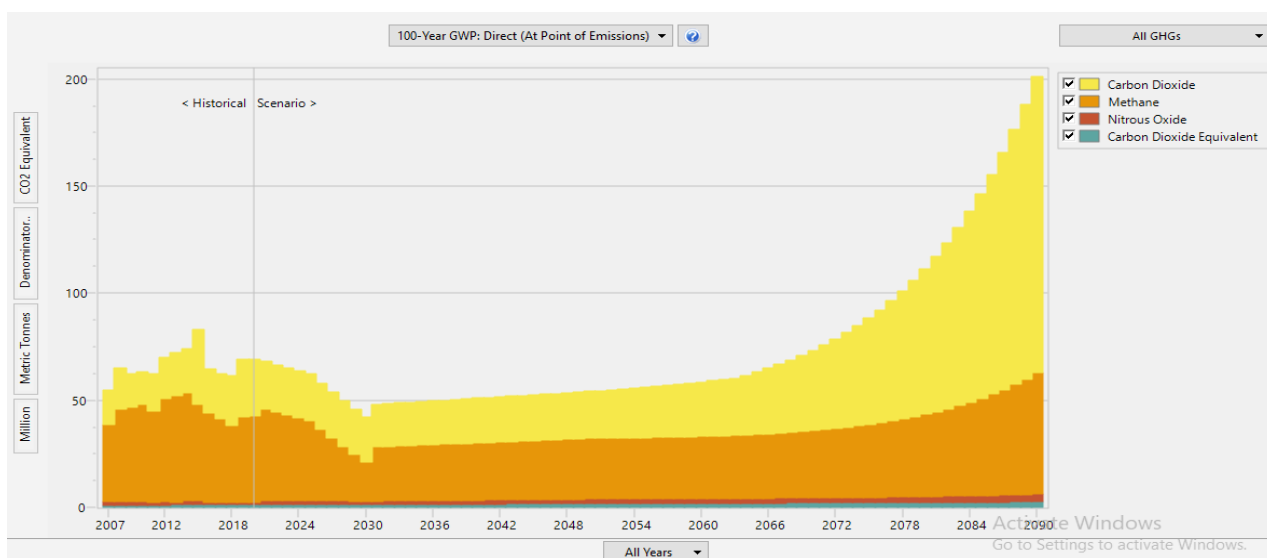


**Figure 1.** GHG emissions projection in the BAU Scenario, LEAP

As it can be seen from Figure 1, within the BAU scenario the volumes of GHG emissions will reach 87,9, 134,9 and 974,1 million tons of CO<sub>2</sub> equivalent (including removals), respectively by the years: 2030, 2050, 2095. The scenario assumes that there are neither any abatement policies, nor major changes in technology, green transition of economics, climate change policies, so that normal circumstances can be expected to continue unchanged.

**Realistic Low Emission Development Scenario (RLEDS)** is a projection of the level of GHG emissions in some separate sector or totally for all sectors (depending on assumptions in place), taking into account all mitigation policies and measures (sectoral or total) that have been formally (i.e. legally) adopted (with finance allocation) and still having mitigation effect or being implemented (it's WM scenario in terms of definitions given in many sources related to the 2006 IPCC Guidelines [25]) by 2021 (as a first scenario year), as well as those which have not yet been formally adopted (without finance allocation) but have been agreed to be implemented in order to comply with the country reduction commitments (it's WAM scenario in terms of definitions given in many sources related to the 2006 IPCC Guidelines). As it's seen from the definition, RLEDS in some sectors or in all sectors comprises both «with measures» (WM) and «with additional measure» (WAM) scenarios corresponding the relevant policies and measures. Here's the LEAP projection of this scenario taking into account national circumstances and implemented mitigation actions which are described in detail in the above-mentioned monograph [24].

According to the Figure 2, describing the RLED Scenario, the volumes of GHG emissions reach 42, 54,2 and 201,2 million tons of CO<sub>2</sub> equivalent (including removals) by 2030, 2050, 2090 respectively, which are much less than the relevant indicators of the BAU Scenario in the mentioned years.



**Figure 2.** GHG coverage projection within the BAU Scenario (LEAP model)

**Best Low Emission Development Scenario (RLEDS)** is a projection of the level of GHG emissions in some separate sector or totally in all sectors that takes into consideration all mitigation policies and measures of the RLEDS by 2021 (as a first scenario year), that is added with additional assumptions in order to reach net-zero emission level by some year in the future. In fact, the scenario is based on the necessary conditions and assumptions of reaching net-zero emission level in the future. This scenario in some sectors or totally for all sectors (depending on assumptions in place) should be considered the most needed and important pathway for each country in light of the Paris Agreement and above-mentioned Conference of Parties decisions.

By the way, the term «low-emission development» and abbreviation «LEDS» (i.e. low-emission development strategy) were first appeared in some documents of the United Nations Framework Convention on Climate Change (UNFCCC) in 2008 [26]. Despite the fact, the term «low-emission development» has no still agreed formal definition, actually it's broadly used by the specialists, describing forward-looking national economic development plans or strategies that



encompass low-emission and/or climate-resilient economic growth. Such strategies can provide value-added to existing climate change and development related roadmaps, strategic documents etc.

Here below, in order to be laconic and able to focus more on the scenario of decarbonization of the country, i.e. BLED Scenario, we'll provide more detailed description of the LEAP calculations only for the Best Low Emission Development (BLED) Scenario.

#### *Best Low Emission Development (BLED) Scenario*

In this section, for the purpose of brevity we'll consider only mitigation strategies, policies, actions related mainly to the Energy sector, all other mitigation actions are given in the above-mentioned monograph [24].

Best Low Emission Development (BLED) Scenario includes all the mitigation policies and measures of the Realistic Low Emissions Development Scenario (RLEDS), in the Energy sector they are following:

- 1) Reduction of Associated Petroleum Gas (APG) emissions in the oil production (mitigation action, being implemented by SOCAR);
- 2) Reduction of leakage in gas distribution system via modernization of whole system (mitigation action, being implemented by «Azerigas» Production Association of SOCAR)
- 3) Oil and natural gas production;
- 4) Flaring gas volume reduction within Azeri-Chirag-Guneshli (ACG) project (mitigation action, being implemented by - BP (Azerbaijan));
- 5) BP 10-year sustainable emissions reduction Plan;
- 6) BP South Caucasus Pipeline expansion (SCPX) offset project;
- 7) Oil and natural gas production;
- 8) Drilling process - Application of new technologies (Implemented by – SOCAR);
- 9) Oil refining production process optimization action at Heydar Aliyev Oil Refinery (Implemented by – Heydar Aliyev Oil Refinery (SOCAR));
- 10) Electric power industry.

Mitigation measure to improve energy efficiency in electricity generation (being implemented by Azenerji LLC). All actual mitigation measures in this field of electric power industry period could be grouped as follows:

- 1) Rehabilitation of obsolete power plants;
- 2) Construction of new stations with high energy efficiency;
- 3) Reconstruction of transmission and distribution networks;
- 4) Improve energy efficiency in the demand sector;
- 5) Construction of power plants based on renewable energy sources;
- 6) Improve tariff policy.

Besides the mentioned mitigation measures, let's additionally propose the following GHG reduction assumptions in the Energy sector within the Best Low Emission Development (BLED) Scenario:

- 1) Annual oil production reduction by 1 % beginning from 2021 within the global trend on reduction of oil production;
- 2) Annual wood consumptions decrease by 3 % in the Commercial and Public sectors of the country beginning from 2021;
- 3) Natural gas production reduction by 1 % beginning from 2021
- 4) Natural gas leakages reduction up to 1 % by 2050;
- 5) Annual gas consumption decreases by 1 % in the Household since 2021;
- 6) Annual decrease of motor gasoline consumption by 1% in the Household, Agriculture (forestry, fishing) since 2021;
- 7) Annual decrease by 5 % of the thermal energy production and its gradually substitution by renewable energy production according to the relevant state programs;

As well as the following assumptions in the Transport sector:

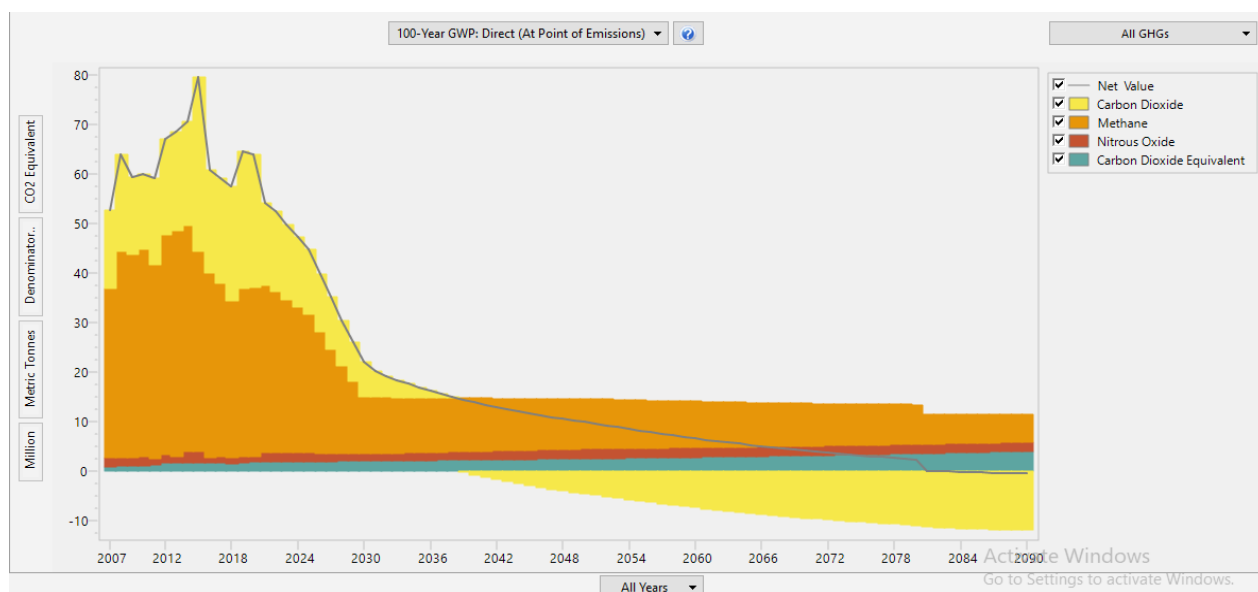
- 1) Annual decrease by 5 % of the diesel consumption in transport sector since 2021;
- 2) Annual decrease by 2 % of motor gasoline consumption in transport sector since 2021;
- 3) Annual decrease by 1 % of the LPG consumption in transport sector since 2021;
- 4) Annual decrease by 2 % of the CNG consumption in transport sector since 2030;

### 5) Completion of the electrification of the National Railroad System by 2030.

All these assumptions are quite feasible due to the overarching policies and measures of greening of economy (expanding use of renewable energy sources, green hydrogen production, energy effectiveness measures, climate smart technologies etc) incorporated to the mentioned five national priorities of the «Azerbaijan 2030: National Priorities for Socio-Economic Development» document approved by the relevant Order of the President of the Republic of Azerbaijan issued on February 2, 2021.

In order to measure the overall total effect of mitigation policies and measures within **Best Low Emission Development Scenario (RLEDS)** in the Energy sector we'll provide comparative analysis of the GHG emissions reduction generated during **the BLEDS** and **the BAU Scenario** via LEAP modelling. For this purpose, all the above-mentioned assumptions and measures have been analyzed and modelled in LEAP and included to BLEDS Scenario.

Upon modeling all the mitigation measures and assumptions in all sectors we'll get the following graph 3 and table 1 reflecting GHG-coverage of the GHG emissions within the BLEDS Scenario.



**Figure 3** GHG coverage projection within the BLEDS Scenario (LEAP model)

As it's seen from the last table corresponding to the Figure 3, i.e. the projection of the BLEDS, within this scenario GHG emissions reaches net zero emission level in 2081, i.e. all emissions by sources and removals by sinks become equal.

## 4. CONCLUSION

For each country it's extremely important to have a GHG pathway bringing the country to the carbon neutrality. By the way, according to the relevant methodology of calculation of total effects of above-mentioned mitigation policies, measures, as well as assumptions within this pathway, the year of net zero emissions could be earlier or later than 2081, depending on the relevant assumptions that could be strengthened or weakened dictated by the national circumstances of the socio-economic development.

Moreover, within the BLEDS pathway Azerbaijan could successfully reduce its emissions even up to 86 % level by 2050 compared to the 1990 emissions, that is much more under the 2050s goal of 40 % reduction of emissions. «40 % reduction» target by 2050 has been included to the NDC2 of the country and a new updated version of NDC document is going to be officially submitted to the Secretariat of UNFCCC before COP30 in Belem (Brazil) on November, 10...21, 2025. As it was in the RLEDS, within the BLEDS we could notice that an essential part of mitigation potential relates namely to the mitigation policies, actions and assumptions in the Energy sector.

**Table 1***GHG-coverage of the GHG emissions within the BLED Scenario, million tons of CO<sub>2</sub> equivalent*

<b>GHG</b>	<b>CO<sub>2</sub></b>	<b>CH<sub>4</sub></b>	<b>N<sub>2</sub>O</b>	<b>CO<sub>2</sub> eq</b>	<b>TOTAL</b>
2021	16,7	33,8	2,0	1,8	54,3
2022	16,3	32,5	2,0	1,8	52,5
2023	15,2	31,0	1,9	1,8	49,9
2024	14,1	29,5	1,8	1,8	47,3
2025	13,1	28,1	1,8	1,9	44,7
2026	11,8	24,5	1,7	1,9	39,8
2027	10,5	21,0	1,6	1,9	35,1
2028	9,3	17,7	1,6	1,9	30,5
2029	8,1	14,6	1,5	2,0	26,1
2030	7,0	11,7	1,4	2,0	22,0
2031	5,2	11,5	1,4	2,0	20,1
2032	4,3	11,4	1,5	2,0	19,2
2033	3,5	11,3	1,5	2,0	18,3
2034	2,8	11,2	1,5	2,1	17,6
2035	2,1	11,1	1,6	2,1	16,9
2036	1,5	11,1	1,6	2,1	16,2
2037	0,9	11,0	1,6	2,1	15,6
2038	0,3	10,9	1,6	2,2	15,0
2039	-0,3	10,8	1,7	2,2	14,4
2040	-0,8	10,8	1,7	2,2	13,9
2041	-1,3	10,7	1,7	2,2	13,3
2042	-1,8	10,6	1,8	2,2	12,8
2043	-2,2	10,6	1,8	2,3	12,4
2044	-2,6	10,5	1,8	2,3	12,0
2045	-3,0	10,4	1,9	2,3	11,6
2046	-3,4	10,4	1,9	2,3	11,2
2047	-3,8	10,3	1,9	2,4	10,8
2048	-4,1	10,2	1,9	2,4	10,5
2049	-4,4	10,2	2,0	2,4	10,2
2050	-4,6	10,1	2,0	2,4	9,9
2051	-5,0	10,0	2,0	2,5	9,6
2052	-5,3	10,0	2,0	2,5	9,2
2053	-5,6	9,9	2,0	2,5	8,8
2054	-5,9	9,8	2,0	2,6	8,5
2055	-6,1	9,7	2,0	2,6	8,1
2056	-6,1	9,6	2,0	2,6	7,8
2057	-6,7	9,6	2,0	2,6	7,5
2058	-7,0	9,5	2,0	2,7	7,2
2059	-7,2	9,4	2,0	2,7	6,9
2060	-7,5	9,3	2,0	2,7	6,6
2061	-7,7	9,3	1,9	2,8	6,3
2062	-7,9	9,2	1,9	2,8	6,0
2063	-8,2	9,1	1,9	2,8	5,7
2064	-8,4	9,0	1,9	2,9	5,5
2065	-8,6	9,0	1,9	2,9	5,2
2066	-8,8	8,9	1,9	2,9	5,0
2067	-9,0	8,8	1,9	3,0	4,7
2068	-9,2	8,8	1,9	3,0	4,5
2069	-9,4	8,7	1,9	3,0	4,3
2070	-9,6	8,6	1,9	3,1	4,1
2071	-9,8	8,6	1,9	3,1	3,8
2072	-9,9	8,5	1,9	3,2	3,6
2073	-10,1	8,4	1,9	3,2	3,5
2074	-10,2	8,4	1,9	3,2	3,3
2075	-10,4	8,3	1,9	3,3	3,1
2076	-10,5	8,3	1,9	3,3	2,9
2077	-10,7	8,2	1,9	3,4	2,8
2078	-10,8	8,1	1,9	3,4	2,6
2079	-10,9	8,1	1,9	3,4	2,5
2080	-11,1	8,0	1,9	3,5	2,3
2081	-11,4	6,0	1,9	3,5	0,0

In order to strengthen legal and institutional framework for decarbonization and climate resilience, first of all it's necessary to establish MRV (Measurement, Reporting, Verification) system related in the previous paragraphs, as well as establish ETF (Enhanced Transparency Framework) for effective implementation of goals of NDC documents and enlarge participation of

the country in the global climate change efforts. For this purpose, actually the government of the Republic of Azerbaijan undertakes necessary measures on the base of best international experiences.

## REFERENCES

1. WMO confirms 2024 as warmest year on record at about 1.55°C above pre-industrial level [Electronic resource] URL: <https://wmo.int/media/news/wmo-confirms-2024-warmest-year-record-about-155degc-above-pre-industrial-level>, date of access: 15.02.2025
2. United Nations Environment Programme (2023). Emissions Gap Report 2023: Broken Record – Temperatures hit new highs, yet world fails to cut emissions (again). Nairobi, 2023, 100 p. DOI: <https://doi.org/10.59117/20.500.11822/4392>
3. Dell'Anna F. (2021). Green jobs and energy efficiency as strategies for economic growth and the reduction of environmental impacts. *Energy Policy*, Vol. 149, pp. 112031
4. Kumar R. (2020). The United Nations and global environmental governance. *Strategic Analysis*, Vol. 44(5), pp. 479-489.
5. IPCC Updates Methodology for Greenhouse Gas Inventories [Electronic resource] URL: <https://www.ipcc.ch/2019/05/13/ipcc-2019-refinement>, date of access: 15.02.2025
6. Climate Change 2021: The Physical Science Basis [Electronic resource] URL: <https://www.ipcc.ch/report/ar6/wg1>, date of access: 15.02.2025
7. Hannah Ritchie, Pablo Rosado, and Max Roser (2020) Greenhouse gas emissions (scientific article, IPCC) [Electronic resource] URL: <https://www.ipcc.ch/sr15/chapter/spm>, date of access: 15.01.2025
8. Special Report: Global Warming of 1.5 °C. Summary for Policymakers. [Electronic resource] URL: <https://www.ipcc.ch/sr15/chapter/spm/>, date of access: 15.01.2025
9. What is the United Nations Framework Convention on Climate Change? [Electronic resource] URL: <https://unfccc.int/process-and-meetings/what-is-the-united-nations-framework-convention-on-climate-change>, date of access: 15.01.2025
10. Paris Agreement (2015). FCCC/CP/2015/10/Add.1 [Electronic resource] URL: [https://unfccc.int/files/meetings/paris\\_nov\\_2015/application/pdf/paris\\_agreement\\_english.pdf](https://unfccc.int/files/meetings/paris_nov_2015/application/pdf/paris_agreement_english.pdf), date of access: 10.12.2025
11. Colombier M., Spencer T., Waisman H. (2016) Long-term low emissions development strategies and the Paris Agreement – Why, what and how?. *IDDR*, 4 p. [Electronic resource] URL: [https://www.iddri.org/sites/default/files/import/publications/pb0616\\_ts-et-al\\_it-leds.pdf](https://www.iddri.org/sites/default/files/import/publications/pb0616_ts-et-al_it-leds.pdf), date of access: 10.12.2025
12. Overview of the enhanced transparency framework under the Paris Agreement. UNFCCC. [Electronic resource] URL: [https://transparency-partnership.net/system/files/document/20190424\\_Intro%20to%20MRV\\_Jigme.pdf](https://transparency-partnership.net/system/files/document/20190424_Intro%20to%20MRV_Jigme.pdf), date of access: 10.12.2025
13. Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) [Electronic resource] URL: <https://eur-lex.europa.eu/eli/reg/2021/1119/oj/eng>, date of access: 10.12.2025
14. Assessment report on «Impact of global climate change on the Republic of Azerbaijan» by the «Azercosmos» OJSC, April 2022.
15. Vision 2030: National priorities for robust socio-economic development in Azerbaijan [Electronic resource] URL: [https://azertag.az/en/xeber/Vision\\_2030\\_National\\_priorities\\_for\\_robust\\_socio\\_economic\\_development\\_in\\_Azerbaijan-1846113](https://azertag.az/en/xeber/Vision_2030_National_priorities_for_robust_socio_economic_development_in_Azerbaijan-1846113), date of access: 10.01.2025
16. Mikayil Jabbarov: «Target to double Azerbaijan's GDP by 2030 will be challenging» [Electronic resource] URL: <https://apa.az/en/xeber/finance-news/Mikayil-Jabbarov-Target-to-double-Azerbaijans-GDP-by-2030-will-be-challenging-3407236>, date of access: 10.01.2025
17. MAIN MESSAGES FOR THE 3rd VNR OF AZERBAIJAN [Electronic resource] URL: <https://sustainabledevelopment.un.org/memberstates/azerbaijan>, date of access: 10.01.2025
18. Speech of President of Azerbaijan Ilham Aliyev in video format was presented at the annual General Debate of the 76th session of the UN General Assembly [Electronic resource] URL: <https://president.az/en/articles/view/53197>, date of access: 10.01.2025
19. Decree of the President of the Republic of Azerbaijan on amending Decree No. 560 of the President of the Republic of Azerbaijan dated April 30, 1997 «On measures to ensure the implementation of the commitments accepted by the Republic of Azerbaijan in accordance with the United Nations Framework Convention on Climate Change, ratified by the Republic of Azerbaijan on January 10, 1995» [Electronic resource] URL: <https://president.az/az/articles/view/36144>, date of access: 10.01.2025
20. Fourth national communication to the united nations framework convention on climate change (2021). Ministry of Ecology and Natural Resources Republic of Azerbaijan, Baku, 328 p.
21. «The Republic of Azerbaijan. Updated document on Nationally Determined Contributions (NDC)» [Electronic resource] URL: [https://unfccc.int/sites/default/files/NDC/2023-10/Second%20NDC\\_Azerbaijan\\_ENG\\_Final%20%281%29.pdf](https://unfccc.int/sites/default/files/NDC/2023-10/Second%20NDC_Azerbaijan_ENG_Final%20%281%29.pdf), date of access: 10.01.2025
22. LEAP-GPT: A new AI assistant for LEAP [Electronic resource] URL: <https://leap.sei.org/>, date of access: 10.01.2025
23. IPCC 2006 (2006). IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T., and Tanabe K. (eds). Published: IGES, Japan.
24. Humbatov F. Low emission development outlook and its role in the environmental security system of the Republic of Azerbaijan, monograph, Baku, 2021, 256 p.
25. Anderl M., Gössl M., Haider S., Heinfellner H., Krutzler T., Lampert C., Pazdernik K., Purzner M., Poupa S., Perl D., Schieder W., Schmid C., Stranner G., Schodl B., Storch A., Wiesenberger H., Weiss P., Zechmeister A. (2021) GHG PROJECTIONS AND ASSESSMENT OF POLICIES AND MEASURES IN AUSTRIA. *Umweltbundesamt GmbH, Vienna*, p. 184.
26. Environment. [Electronic resource] URL: <https://www.oecd-ilibrary.org/environment/low-emission-development-strategies-leds-5k451mzrnt37-en>, date of access: 10.01.2025

# ӘЗІРБАЙЖАН РЕСПУБЛИКАСЫН ДЕКАРБОНИЗАЦИЯЛАУ ЖОЛДАРЫ ЖӘНЕ ЭКОЛОГИЯЛЫҚ ҚАУІПСІЗДІК МӘСЕЛЕЛЕРІ

Фуад Гумбатов<sup>1,2</sup> PhD, қауымдастырылған профессор

<sup>1</sup> Әзірбайжан Республикасының Экология және табиғи ресурстар Министрлігі жанындағы Ұлттық гидрометеорологиялық қызмет, Баку, Әзірбайжан; fuad.humbatov@eco.gov.az

<sup>2</sup> Әзірбайжан Республикасы Президентінің жанындағы Мемлекеттік басқару Мемлекеттік Академиясы, Баку, Әзірбайжан; fuad.humbatov@eco.gov.az

Автор корреспонденіт: Фуад Гумбатов, fuad.humbatov@eco.gov.az

## ТҮЙІН СӨЗДЕР

салдарды азайту шаралары  
парниктік газдар (ПГ)  
экологиялық қауіпсіздік  
климаттың өзгеруінің тұрақты  
даму  
жаңартылатын энергия көздері  
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## АБСТРАКТ

Мақалада ХХІ ғасырдағы Әзірбайжан Республикасы үшін климаттың өзгеруіне қарсы күрестің ұлттық контексті, экологиялық қауіпсіздік, парниктік газдар шығарындыларының (ПГ) төмен даму сценарийлері зерттеледі, елдегі жасыл экономикаға көшудің оңтайлы жолдары талданады. Париж келісімінің 4 - бабының 19-тармағында Келісімге қатысушы әрбір елдің парниктік газдар шығарындылары төмен ұзақ мерзімді даму стратегияларын (LT-LEDS) тұжырымдау және жұртшылықтың назарына жеткізу міндеті айқындалғандықтан, мұндай стратегияны дайындау Келісімнің әрбір қатысушысы үшін басым болып табылады. Осыған байланысты мақалада Әзірбайжандағы декарбонизация сценарийінің энергетикалық және экологиялық сипаттамаларына ерекше назар аударылады.

# ПУТИ ДЕКАРБОНИЗАЦИИ РЕСПУБЛИКИ АЗЕРБАЙДЖАН И ВЫЗОВЫ ЭКОЛОГИЧЕСКОЙ БЕЗОПАСНОСТИ

Фуад Гумбатов<sup>1,2</sup> PhD, ассоциированный профессор

<sup>1</sup> Национальная гидрометеорологическая служба при Министерстве экологии и природных ресурсов Азербайджанской Республики, Баку, Азербайджан; fuad.humbatov@eco.gov.az

<sup>2</sup> Государственная академия государственного управления при Президенте Азербайджанской Республики. Баку, Азербайджан; fuad.humbatov@eco.gov.az

Автор корреспонденіт: Фуад Гумбатов, fuad.humbatov@eco.gov.az

## КЛЮЧЕВЫЕ СЛОВА

меры по смягчению последствий  
парниковые газы (ПГ)  
экологическая безопасность  
устойчивое развитие изменение  
климата  
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энергии  
инвентаризация ПГ  
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## АБСТРАКТ

В статье исследуется национальный контекст борьбы с изменением климата, экологическая безопасность, сценарии развития с низким уровнем выбросов парниковых газов (ПГ) для Азербайджанской Республики в ХХІ веке, анализируются оптимальные пути перехода к зеленой экономике в стране. Поскольку в пункте 19 статьи 4 Парижского соглашения определена задача каждой страны - участницы Соглашения сформулировать и довести до сведения общественности долгосрочные стратегии развития с низким уровнем выбросов парниковых газов (LT-LEDS), подготовка такой стратегии является приоритетной для каждой участницы Соглашения. В связи с этим в статье особое внимание уделяется энергетическим и экологическим характеристикам сценария декарбонизации в Азербайджане.

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