THE REPUBLIC OF AZERBAIJAN

THE MINISTRY OF ECOLOGY AND NATURAL RESOURCES

TECHNOLOGY NEEDS ASSESSMENT

MITIGATION

 

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ENERGY, CLIMATE AND SUSTAINABLE DEVELOPMENT

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PREFACE

Azerbaijan ratified the UNFCCC in 1995 and its Kyoto Protocol in 2000. Notwithstanding that Azerbaijan has not taken any quantitative obligations to be included in the Non-Annex I group, since the ratification of the convention a wide range of mitigation activities have been implemented in the country. These activities include the use of renewable energy sources, application of more efficient technologies in the energy sector, increase of forest areas and use of gas instead of black oil at thermal power stations.

The proposed methodology for conducting the prioritization phase of the Technology Needs Assessment has been adjusted to country-specific circumstances. This involved a preliminary overview of the technological options and resources, institutional arrangements and stakeholder engagement, as well as establishing criteria for selecting mitigation technologies, and defining and selecting the priority sectors and technologies.

National experts, working closely with local stakeholders, have provided significant assessment during the prioritization process and identified the most preferable mitigation technologies, taking into account their contribution to the country's development priorities and GHG emission reduction potential. These include environmental, social and economic development priorities, taking into account costs and benefits of proposed technologies.

By supporting and scaling up investment in the mitigation technologies prioritized in this report, it is clear that substantial reductions in CO_2 emissions could be achieved from both of the prioritized sectors in Azerbaijan. Further analysis and assessment under TNA/TAP preparation process will clarify the main market barriers to achieving a widespread application of the prioritized technologies, and, importantly, define a clear action plan to overcome these barriers, including specific policies and activities from the government, private sector and civil society[1].

[1] [1] This document is an output of the Technology Needs Assessment project, funded by the Global Environment Facility (GEF) and implemented by the United Nations Environment Programme (UNEP) and the UNEP-Risoe Centre (URC) in collaboration with the Asian Institute for Technology (AIT), for the benefit of the participating countries. The present report is the output of a fully country-led process and the views and information contained herein are a product of the National TNA team, led by the Ministry of Ecology and Natural Resources of the Republic of Azerbaijan.

ACKNOWLEDGMENTS

The TNA mitigation report was developed by the mitigation team leader, under the coordination of TNA National Coordinator. The report is the outcome of a stakeholder-driven assessment to identify and evaluate mitigation technologies that will reduce GHG emission within national development objectives.

The team of experts involved in the assessment of currently available data during the stakeholder consultation process has done a great job. Thanks and appreciation should be extended to the Ministry of Ecology and Natural Resources of Azerbaijan that supported this assessment at all stages of implementation.

Special thanks go to all ministries, governmental agencies, private sector organizations and involved NGOs that provided significant support for obtaining relevant data and expert views during report development, as well as to the UNFCCC focal point in Azerbaijan who has provided valuable advice and suggestions for improvement of the report.

ENDORESMENT

The identification and prioritization of climate change adaptation technologies, as well as assessing the barriers for technology deployment and developing measures for overcoming those barriers, are important steps for Azerbaijan in developing its climate-resilient strategy.

The global “Technology Needs Assessment” project was funded by the Global Environment Facility (GEF) and implemented by the United Nations Environment Program (UNEP) and coordinated by Ministry of Ecology and Natural Resources of Azerbaijan Republic in close collaboration with all relevant ministries, agencies, institutions, non-governmental organizations, private sector and independent experts.

The methodology proposed by the UNEP Risoe Center (Denmark) for conducting the prioritization, barriers analysis and preparation of Technological Action Plans has been adjusted to meet Azerbaijan’s county-specific circumstances. This involved a preliminary overview of the technological options and resources, institutional arrangements and stakeholder engagement, as well as establishing criteria for selecting adaptation technologies and defining and selecting the priority sectors and technologies. Furthermore, the main barriers to technology deployment were identified, followed by measures to overcome these barriers and the preparation of concrete actions and project ideas.

National experts involved to the project, working closely with local stakeholders, have provided significant assessments during the prioritization of adaptation technologies, taking into account its contribution to the country’s development priorities and GHG emission reduction potential. The selected mitigation technologies applied to two prioritized sectors: agriculture and water. Current programmes and initiatives of relevant state ministries, agencies and institutions related to prioritized technologies have been taken into account during the preparation of the technology action plan (TAP).

The Ministry of Ecology and Natural Resources strongly believes that the TNA assessments on adaptation technologies will contribute to the development of a climate-resilient strategy in the country, and that the identified actions will be followed and implemented by respective institutions.

We hope that the TNA/TAP reports on climate change developed under “The Global Technology Needs Assessment” project will serve as a roadmap for Azerbaijan in fulfilling its obligations under the UNFCCC. Further, the TNA process makes an important contribution to the implementation of the country’s sustainable development strategies and, in general, towards the development of a climate resilient, “green economy”.

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Minister of Ecology and Natural Resources

Date: 14.01.2013

LIST OF ABBREVIATIONS

AIOC	Azerbaijan International Operating Company
CDM	Clean Development Mechanism
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
EST	Environmentally Sound Technology
GEF	Global Environmental Facility
HPS	Hydro-Power Stations
MENR	Ministry of Ecology and Natural Resources
MCDA	Multi Criteria Decision Analysis
NABUCCO	new gas bridge from Asia to Europe passing Caspian Sea
NATO	North Atlantic Treaty Organization
NGO	Non-governmental Organization
OSCE	Organization of Security and Cooperation of Europe
OSC	Open Stock Company
PRECIS	Providing Regional Climates for Impact Studies
PSA	Production Sharing Agreement
PSC	Project Steering Committee
RE	Renewable Energy
TAP	Technological Action Plan
TNA	Technological Needs Assessment
UN	United Nations
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
WB	World Bank
WMO	World Meteorological Organization
WP	Work Plan
WWF	World Wildlife Fund
SCARES	State Company on Alternative and Renewable Energy Sources
SOCAR	State Oil Company Azerbaijan Republic

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EXECUTIVE SUMMARY

The Republic of Azerbaijan ratified the UNFCCC in 1995. In order to facilitate the implementation of the Convention, a State Commission on Climate Change was established in 1997 by a resolution of the President of the Azerbaijan Republic. The Commission was composed of representatives of all related institutions and ministries. In 2000, the Kyoto Protocol was ratified. Under financial support of Global Environmental Facility and UN Development Program (GEF/UNDP) the Initial and Second National Communications of the Republic of Azerbaijan to the UNFCCC have been developed.

Azerbaijan is not included in the Annex I group under the Convention and has not taken any quantitative obligations in accordance with the Kyoto protocol. Therefore, the country may only participate in the Clean Development Mechanism of the Kyoto protocol. Notwithstanding that Azerbaijan has not taken any quantitative obligations, it has implemented a wide range of activities in terms of mitigation, such as use of renewable energy sources, application of more efficient technologies in the energy sector, increase of forest areas, use of gas instead of black oil at thermal electric stations and so on.

Technology needs assessment is a first step in technology transfer framework, which also includes technological information, enabling environment, capacity building and mechanisms for technology transfer. Technology needs assessment is accomplished by applying methodology proposed by the UNFCCC and other relevant institutions, such as GEF and Climate Technology Initiative. The applied methodology has been adjusted to country-specific circumstances and Azerbaijan’s TNA exercise has been conducted through the following activities: preliminary overview of options and resources; institutional arrangements and stakeholder engagement; establishing criteria for selecting mitigation measures priorities; defining priority sectors and sub-sectors; selecting priority measures and sectors; in-depth analyses, assessment and stakeholder consultation; selection of high priority actions for further development and implementation.

The current TNA Mitigation report consists of six chapters describing the current climate change policy of the country, inventory of GHG emissions, institutional arrangements of TNA, sector prioritization process, identification of criteria and technology prioritization, as well as an overview of prioritized technologies, main conclusions and next steps. Technological fact sheets on prioritized technologies of selected sectors have been provided in Annexes.

The main sources of CO_2 emissions in Azerbaijan are the energy and industrial sectors. The principal carbon sinks are represented by the agriculture and forestry sectors, as well as land-use change. GHG emission by sectors and its share in total emission for 2005 is listed below:

GHG Source and Sink Categories	Emissions 2005 (Gg CO_2 eq.)	Emission share by sectors (%)
Energy	41003	80,98
IPPU	839	1,66
AFOLU	5186	10,24
Waste	3607	7,12
Total Emission	**50635**	100
Land-use, Land-use change and Forestry	-3769	
Net emission	**46866**	

Based on the identified economic, social and environmental development priorities, results of the inventory of GHG by sectors and calculated GHG emissions forecasted to the year 2030, and potential mitigating effect on climate change by sector, the experts involved in the TNA preparation process have scored sectors and sub-sectors using proposed evaluation scheme: 0 — no benefit, 1 — faintly desirable, 2 — fairly desirable, 3 — moderately desirable, 4 — very desirable and 5 — extremely desirable.

According to provided scores and justifications performed by national experts for all sectors and sub-sectors, in keeping with greenhouse gas (GHG) mitigation measures, the following have been selected as priority sub-sectors:

- Alternative energy sources
- Commercial and residential sector

Since 2004, numerous studies have been conducted on the potential for renewable energy (RE) in Azerbaijan. What is evident is that the potential is very considerable, especially for wind, hydro and solar, with some elements of biogas and thermal energy entering the picture as well.

Application of renewable energy sources in Azerbaijan is one of the main strategies of the government. In 2004, the government adopted the State Program on Use of Alternative Energy Sources in Azerbaijan Republic (2005-2013). The objective of the State Program is to promote power generation from renewable and environmentally sound sources and to utilize hydrocarbon energy sources more efficiently.

Substantial reductions in CO_2 emissions from energy use in the commercial and residential sector can be achieved by applying mature technologies for energy efficiency that already exist widely. In spite of the availability of these high efficiency technologies and practices, energy use in this sector continues to be much higher than necessary.

Based on proposed TNA methodology, national experts have prepared a long list of possible technologies and technological fact sheets for each listed technology. Criteria for prioritization of technologies have been clustered under costs and benefits groups. Based on current national strategy documents and expert judgments, the following criteria were selected for prioritization of mitigation technologies:

For alternative energy sources sub-sector:

Costs: capital costs, O & M costs, cost effectiveness for mitigation

Environmental development priorities: reduced air pollution, GHG emission reduction by 2030

Economic development priorities: balance of payment, increased employment opportunities

Social development priorities: sustainable energy supply, increased income due to lower cost of energy

For commercial and residential sub-sector:

Costs: capital costs, O & M costs, cost effectiveness for mitigation

Environmental development priorities: GHG emission reduction by 2030

Economic development priorities: balance of payment

Social development priorities: sustainable energy supply, improved living conditions

As a next step, based on provided TNA methodology and MCDA approach, the proposed long list of technologies has been scored by experts taking into account their relevancy to the identified criteria. Then, each criterion has been analyzed according to its qualitative and quantitative importance based on information provided in the technological fact sheets. After calculation of swing value and provided weights, weights have been normalized and appropriate values calculated. As a result, the following technologies received the highest values and were prioritized for the above-mentioned sectors:

For alternative energy sources sector:

- Grid-connected wind power;
- Passive solar energy (hot water) and solar photovoltaic (electricity);
- Small hydro-powers on mountain rivers.

For commercial and residential sector:

- High efficiency lighting systems;
- Heating pumps;
- Biogas for cooking and electricity and efficient stoves.

Next steps in the TNA process will be assessment of barriers to implementation of prioritized technologies and preparation of TAP.

Results of the technology prioritization were presented to the TNA committee by the mitigation expert. The TNA committee endorsed the prioritized sectors and their technologies during the meeting held on 25 June 2012.

Chapter 1. Introduction

1.1. About TNA project

Currently, one of the main alarming issues facing the global community is climate change, which might be a cause of adverse socio-economic and environmental effects worldwide. The continuing increase in atmospheric concentrations of greenhouse gases have had an unsettling effect on the earth's radiation balance, which has resulted in the rise of annual mean temperature around the globe.

Understanding the importance of this issue, the Republic of Azerbaijan ratified the UNFCCC in 1995 and subsequently joined the Kyoto Protocol in 2000 with a goal of supporting initiatives towards the mitigation of climate change effects.

The overall decline of economic activities and energy consumption in the period 1990-2005 had directly caused the reduction in total emissions of greenhouse gases during that period. Projections of GHG emissions show that even with the implementation of all additional measures, Azerbaijan is not able to achieve the GHG emissions stabilization of the base year level and meet the Kyoto Protocol target. Policies in particular sectors, such as economy, energy and environmental protection, have significant influence on climate change mitigation issues.

The Initial National Communication by the Republic of Azerbaijan was prepared in 1998-2000. At that time, the Republic of Azerbaijan was recovering from the economic crises and difficulties in collecting statistical data, and the cessation of operations by a number of plants, led to the rise of uncertainties in a wide range of data. This was particularly the case in the calculation of the amount of greenhouse gas emissions and evaluation of abatement measures.

The Second National Communication of the Republic of Azerbaijan has been prepared as part of commitments under the UNFCCC. The report provides information on national circumstances, the amount of greenhouse gas emissions and sources, analysis of the present and future climate, the assessment of vulnerability of the economic sectors and ecosystems to climate change effects, and adaptation measures to these effects.

The purpose of the current Technology Needs Assessment Project (TNA Report) is prioritization of sectors, in compliance with the country's development priorities, and the evaluation and selection of priority greenhouse gas mitigation measures under prioritized sectors. The Assessment takes Second National Communication of the Republic of Azerbaijan to the United Nations Framework Convention on Climate Change (UNFCCC) and major development programs of the country as the basis for analyses.

Technology needs assessment is a first step in technology transfer framework, which also includes technology information, enabling environment, capacity building and mechanisms for technology transfer. Article 4.5 of the UNFCCC states that developed country Parties and other developed Parties included in Annex II "shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention."

According to the Intergovernmental Panel on Climate Change Special Report (IPCC), the term "technology transfer" is defined as a broad set of processes covering the flows of know-how, experience and equipment for mitigating and adapting to climate change amongst different stakeholders such as government, private sector entities, financial institutions, non-governmental organizations (NGOs) and research/education institutions. It comprises the process of learning to understand, utilize and replicate the technology, including the capacity to choose it, adapt it to local conditions, and integrate it with indigenous technologies. Technology for mitigating and adapting to climate change should be environmentally sound technology (EST) and should support sustainable development.

Main criteria for selecting mitigation measures were identified by their relevance to the country's development priorities and GHG reduction potential. Relevance to development priorities defines the climate change mitigation technologies that offer the greatest value to the country in meeting its current national development priorities. GHG reduction potential defines technologies that will make the biggest contributions to the country's efforts in mitigating greenhouse gas emissions.

The TNA assessment process analyzed mitigation measures with implementation potential for 2030, based on identified measures in the Second National Communication of the Azerbaijan Republic to the UNFCCC, as well as current governmental strategy and policy related to climate change.

1.2. Existing national policies on climate change mitigation and development priorities

1.2.1. Economic policy

The territory of the Republic of Azerbaijan enjoys favorable climate conditions and rich natural resources. The economy is driven mainly by oil and gas production, chemicals and petrochemicals, metallurgy, mechanical engineering, textiles and food industry. The agricultural sector also plays an important role in the development of the economy. The most significant areas of agriculture are wheat, cotton, tobacco, tea, vegetable production, vine-growing, fruit-growing and cattle breeding. The main exports are oil and oil products, electrical energy, cotton and silk fibers, and wine. Industrial products accounted for 34.5 billion manats in 2011. GDP increased from 4718.1 million manats in 2000 to 50069 million manats in 2011 (Official website of Statistics Committee of Azerbaijan).

In recent years the economy of the Republic of Azerbaijan has been growing quickly. New clean technologies are used in the development of various sectors of economy, which prevent a rapid increase in the amount of emissions of greenhouse gases into the atmosphere. In addition, the country successfully implements various actions on the abatement of climate change effects. Therefore, energy effectiveness is increased, small projects are implemented by conducting research on the use of alternative energy sources, and forests and vegetation cover zones contributing to the removal of carbon dioxide from the atmosphere are expanded.

At present, more than half of the national revenue comes from the oil industry. The Baku-Tbilisi-Ceyhan oil pipeline to Europe plays an important role in the energy security of Europe, as it has the capacity to transport 40-50 million tons of oil annually. For natural gas, the Baku-Tbilisi-Arzurum pipeline has been laid and the NABUCCO pipeline project is under consideration.

Azerbaijan has found success in social and economic development in recent years. Ensuring sustainability in these achievements has been adopted as a top priority by the state. For the past ten years some of the main factors that ensured dynamic development of the country were the allocation of oil revenues to the non-oil sectors, infrastructure development projects and the push for balanced development of various regions. Economic development of the country, since the period of independence until now, can be divided into two main stages. The first period, covering 1991-1995, was considered to be economic chaos or regress. The second period, starting in 1996 and continuing on, is of macroeconomic stability and dynamic economic development (Administrative Department of the President of the Republic of Azerbaijan, *presidential library)*.

Despite the difficult initial conditions, within a short period after the restoration of state independence, very big achievements were made in the socio-economic development of the country and its integration to the world economic system.

In the second stage of economic development, a number of large-scale policy documents (conceptions, strategies and programs) were adopted as the legal base for the realization of the aforementioned model in Azerbaijan. These include: 'Program on State Assistance to Small and Middle Entrepreneurship in Azerbaijan (1997-2000)', 'State Program of Development of Small and Middle Entrepreneurship in Azerbaijan (2002-2005)', 'State Program of Development of Agrarian Sector in Azerbaijan (2002-2006)', 'Demographic Development Concept of Azerbaijan Republic', 'State Program on Development of Tourism in Azerbaijan Republic (2002-2005)', 'State Program on Poverty Reduction and Economic Development in Azerbaijan Republic (2003-2005)', 'State Program on Social-Economic Development of Regions of Azerbaijan Republic (2004-2008) and (2009-2013)', ‘State Program of Poverty Reduction and Sustainable Development of the Republic of the Azerbaijan (2008-2015)’, and ‘State Program of Ensuring Reliable Population in the Republic of Azerbaijan in food provision (2008-2015)’, as well as a number of other documents under preparation.

One of the priorities of the economic policy of Azerbaijan was preparation of an oil strategy of independent state. Implementation of this strategy started in September of 1994 by signing the 30-year contract between Azerbaijan Republic State Oil Company and 13 popular oil companies on joint exploitation of 'Azeri', 'Chirag' wells and the deep part of 'Guneshli' well in Azerbaijan sector of Caspian Sea and shared division of oil production.

Main tasks of the next stage are sustaining macroeconomic stability and economic growth. Within these goals, provision of qualifying economic growth is the main priority. Aiming to achieve these tasks, while expanding the diversification of the economy, the government wants to minimize dependence on the oil sector, transit to innovative economy, promote intensive production in agriculture, and develop the economy in clusters. Moreover, comprehensive measures should be taken in order to strength energy, food and ecological security.

1.*2.2.* Energy policy

Azerbaijan is richly endowed with oil and gas resources and has recently experienced the oil production boom. Oil production reached 23.5 million tons in 1991 and accounted for 71.4% of total oil output in the former Soviet Union. However, after the break-up of the Soviet Union, production fell significantly between 1991-1997, due to outdated technology, poor planning and lack of investment in new drilling and rehabilitation of existing wells. Since the signing of the “Contract of the Century” in 1994, 29 “Production Sharing Agreement” contracts have been signed between the Azerbaijan government and the Azerbaijan International Operating Company (AIOC). In the 14 years since the signing of the contract, Azerbaijan has received $40 billion in foreign investment in this sector. Today, the oil and gas sector share in total foreign investment accounts for 80-90%. Oil production peaked at 45.5 million tons with record capacity in Azerbaijan in 2008. The oil and gas revenues of the country are expected to be $200 billion by 2024 (Administrative Department of the President of the Republic of Azerbaijan, *presidential library)*.

In recent years, Azerbaijan has signed several very important energy contracts in accordance with Production Sharing Agreements (PSA) that helped the inflow of foreign investment into the oil sector. As an outcome of the successful energy policy, Azerbaijan is currently enjoying huge oil revenues.

In 2008, Azerbaijan had an estimated 7 billion barrels of crude oil and 1.37 trillion cubic meters of gas reserves. The main oil reserves are located offshore in the Caspian Sea, particularly the Azeri-Chirag-Guneshli (ACG) field which is estimated to have accounted for over 80% of the total oil output in Azerbaijan in 2008.

Oil demand is mainly driven by economic activity, consumer preferences and conservation factors. After the break-up of the Soviet Union, demand for oil in Azerbaijan fell from 12 MT in 1991 to 5.07 MT in 2007. This shows that significant amounts of oil were available for export. According to the Energy Information Agency, Azerbaijan exported a net of about 749,000 bbl/d of oil in 2008.

In 2008, 7.3 MT of refinery oil products were produced: 4.8 MT by Baku Oil refinery and the other 2.5 MT by the Azerineftyag refinery. This shows that the two refineries were operating well below capacity and with overall utilization rates as low as 40%.

Azerbaijan has created a new model to attract foreign investment in the oil and gas sector by providing Production Sharing Agreements (PSA). PSAs are a common type of contractual arrangements signed between SOCAR as a government agency and the foreign partner, AIOC. Its structure is to keep the PSC benefits and principles and allow investors to avoid the unfavorable taxes of a joint venture. It makes PSA more attractive to foreign investors as they enjoy form exemption from Value Added Tax, non-taxable dividends, elimination of restrictions on banking issues including no restriction on foreign bank accounts, payroll currency and dollar withdrawals, implementation of the international accounting system, elimination of various governmental audits and application of international practices on labor laws (Administrative Department of the President of the Republic of Azerbaijan, *presidential library)*.

With regard to the legislative base related to energy sector, major laws such as Law on Energy Utilization, Law on Power Engineering, Law on Energy, and Law on Electric and Thermal Power Plants have been passed.

State Programs reflecting the energy policy could be listed as follows: State Program on Poverty reduction and Economic Development, Measures on Strengthening Financial Discipline in Energy and Water Sectors, State Program on Socio-Economic Development of the Regions of Azerbaijan Republic for 2004-2008 and for 2009-2013, and State Program on Utilization of Alternative Energy Sources (2005 – 2013). The objective of the last State Program listed, is to promote power generation from renewable and environmentally sound sources and to utilize hydrocarbon energy sources more efficiently. The major tasks of State Programs include:

- Define the potential of alternative (renewable) energy sources for electric power generation *(the technical aspects of this are largely completed)*;
- Raise the efficiency of utilization of the country's energy sources by developing renewable energy sources;
- Ensure the opening of additional jobs with creation of new energy production sites;
- Given the existing total capacity of traditional energy sources in Azerbaijan, increase the energy capacities through the application of alternative energy sources and, therefore, achieve the country's energy security.

According to the program, Azerbaijan has set a target to have 20% share of renewable energy in electricity and 9.7% share of RE in total energy consumption by 2020 (Perspectives of use of alternative and renewable energy in Azerbaijan, *Ministry of Industry and Energy)*.

Azerbaijan signed a memorandum with the EU, in November of 2006, with the goals of modernization of electric grid, enhancement of security and reliability of the energy infrastructure, as well as preparation of programs and regulations for the development of renewable energy sector to achieve efficient use of energy.

On 29 December 2011, the President of Azerbaijan Republic issued an order on preparation of National Strategy on the use of alternative energy for the period of 2012-2020. The main objectives of the strategy are to identify main directions of electricity from RE sources and legal framework for usage of RE sources.

1.2.3. Environmental policy

The environmental strategy of the country is aimed at the protection of natural resources at national, regional and international levels by strengthening coordination of actions, the application of scientifically-grounded development principles, and ensuring the sustainable use of resources to meet the needs of present and future generations.

Ensuring environmental sustainability of development requires the elimination and restriction of serious problems arising from industrial activities. Given the current state of the environment and socio-economic conditions, three main directions of national policy can be identified:

1. Prioritizing the maximum reduction of environmental pollution and stringent environmental regulation;
2. Sustainable use of natural resources to meet the needs of present and future generations, including the use of renewable energy sources and more efficient consumption;
3. Assessing global environmental problems at the national level and working to ameliorate them by identifying possible solutions and broadening relations with international institutions.

The following principles should be taken as priorities to achieve objectives in environmental policy:

- Use of contemporary methods of economic and human resources management to improve the quality of the environment;
- Development and introduction of incentive-inducing economic models and technologies to meet the needs of present and future generations;
- Implementation of principles of fair distribution of resources among present and future generations;
- Protection of the ecosystems and biodiversity that support daily human activities;
- Consideration of alternatives in the effort to meet short-term and long-term economic, environmental and social objectives;
- Wider involvement of representatives of public and non-governmental organizations in decision-making processes on environmental issues;
- Prevention of any activities likely to result in irreversible damage to the environment;
- Ensuring the development of a strong, multifaceted economy that facilitates the protection of the environment;
- Broadening relations with international institutions and developed countries in the area of environment protection;
- Enhancement of education and public awareness-raising.

In 1996, the national environmental policy was presented as part of the National Report on the State of the Environment in Azerbaijan. The National Environmental Action Plan was prepared in 1998, in which priority projects on alarming environmental issues were identified.

Evidence of its successful promotion include: the development of a relevant legislative base to European standards; improved governance on environment protection; and steady implementation of priority projects in partnership with international institutions.

As socio-economic processes develop rapidly, new methodologies and principles are emerging in environmental policy. The National Programme on Environmentally Sustainable Socio-economic Development, prepared by MENR and approved by the President in 2003, has reflected an improved environmental policy and provided opportunities for its application.

In recent years, a number of laws on environmental issues adopted by the National Parliament of the Republic of Azerbaijan, including the Law on Public Environmental Education and Awareness-Raising, have made it possible to fill gaps in this area.

Particular attention is given by MENR to the development of relations with international institutions and donor countries, with the goal of resolving current problems. Notably, cooperation has now been extended with UNDP, UNEP, the EU, UN Industrial Development Organization, NATO, OSCE, the Global Environmental Facility, the Organization for Economic Development and Cooperation, the

World Bank, the Asian Development Bank, the World Wildlife Fund and other agencies. In addition, bilateral cooperation has been established with various developed countries. To date, The Republic of Azerbaijan has joined 20 international environmental conventions and signed relevant protocols (Environment in Azerbaijan, *Baku 2005-2007)*.

Chapter 2. Institutional arrangement for TNA and stakeholder involvement

The Ministry of Ecology and National Resources is the main national institution guiding environmental policy in Azerbaijan. MENR plays the role of national focal point at the UNFCCC in Azerbaijan and has a leading role in preparation of National Communication and TNA projects. The State Commission on Climate Change that has been entrusted to coordinate implementation of commitments made under the UNFCCC was established in Azerbaijan by the Presidential Decree of 30 April 1997. It is composed of representatives of 18 ministries and other governmental institutions, including Ministry of Agriculture, Ministry of Economic Development, Ministry of Industry and Energy, SOCAR, National Scientific Academy of Azerbaijan and so on.

2.1. National TNA team and stakeholder engagement

A Memorandum of Understanding was signed between the Ministry of Ecology and Natural Resources of Azerbaijan and UNEP Riso Centre in Denmark on 18 July 2011. After this, the TNA National coordinator was appointed.

In this regard, the Project Steering Committee (PSC) was established. Main responsibilities of the PSC are to monitor the project implementation, give strategic guidance to the team and make prioritization of sectors for adaptation and mitigation. The first PSC meeting was held in March 2011.

The diagram of TNA national team structure is provided in figure 1. The national team consists of two groups: Adaptation and Mitigation. The Adaptation Team Leader (TL), Mr. Rafig Verdiyev (replaced by Mr. Bariz Mehdiyev), and Mitigation TL, Mr. Gulmali Suleymanov, were appointed. Other experts under adaptation and mitigation groups were involved from January/ February 2012.

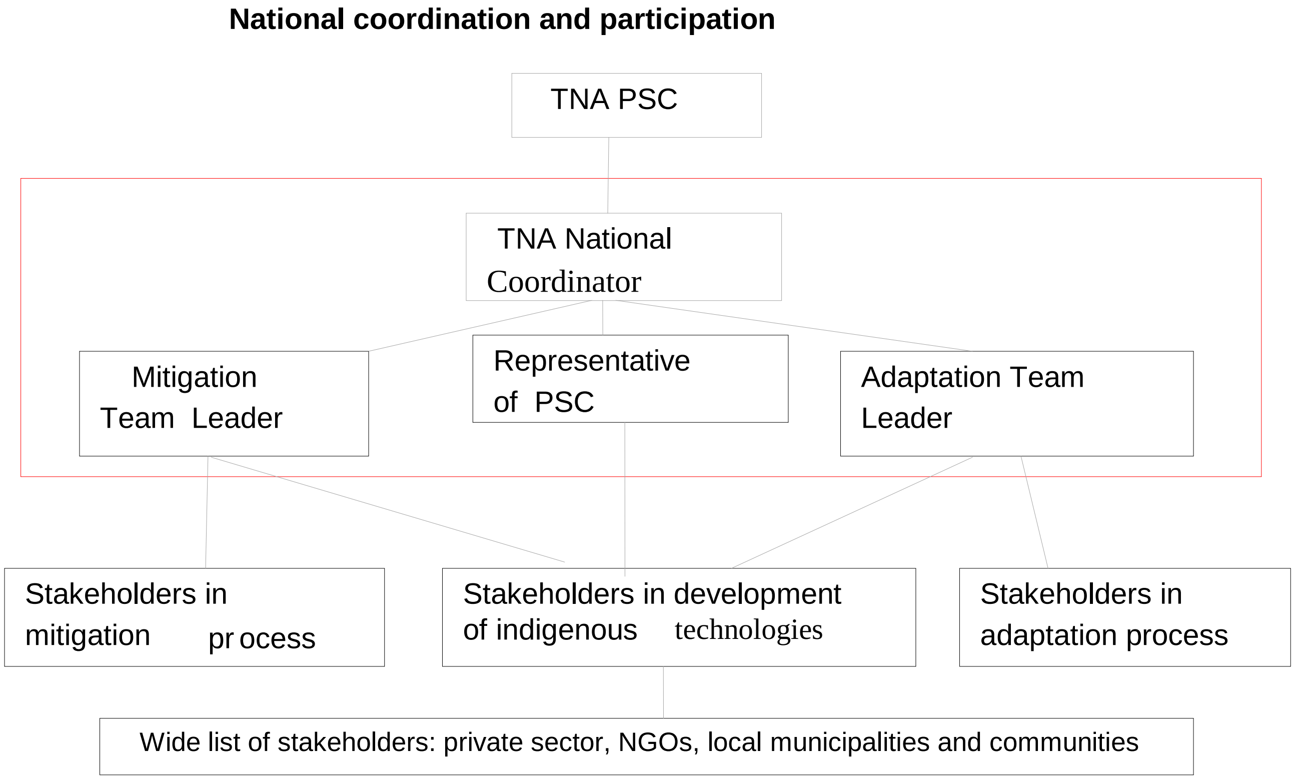

Figure 1: TNA National coordination and participation

2.2. Stakeholder Engagement Process followed in TNA – Overall assessment

The First National workshop was conducted on 27 December 2011. It was attended by 21 participants representing MENR, Ministry of Agriculture, Ministry of Economic Development, Ministry of Industry and Energy, State Agency on Alternative and Renewable Energy Sources (renamed State Company on Alternative and Renewable Energy Sources by Presidential Decree dated 01 June 2012), Ministry of Transport, Ministry of Finance, National Academy of Sciences, State Oil Company (SOCAR), State Land and Cartography Committee, Azersu Open Stock Company (OSC), Amelioration and Water Farms OSC, relevant NGOs and private sector.

Participants were informed about TNA coordination structure and TNA work plan.

Azerbaijan has already identified development priorities as part of national development strategies, poverty reduction strategies, sector policies, as well as Second National Communication to the UNFCCC. The National Team has generated a list of development priorities, based on those official publications, which they consider applicable to the country's sustainable development, with both the short-term and long-term goals, for the purpose of guiding technology needs assessment. The list of development priorities has been discussed with key stakeholders in order to identify key development priorities under main clusters: economic, social and environmental.

During the discussion of key development priorities TNA National Coordinators widely presented economic development details, including sustainable development, energy security, low-carbon development in energy sector, development of infrastructure, tourism development and use of modern agricultural technology to provide food security. Other experts presented social and environmental priorities. As a result of intensive discussions, a consensus was reached regarding the main development priorities of the country.

Chapter 2. Institutional arrangement for TNA and the stakeholders' involvement

After having a long list of sectors, experts prioritized the sectors using TNA methodology. The selected priority sectors were: alternative energy sources and commercial and residential sector.

Intensive debates were held, particularly on the selection from 2 sectors: oil and gas production and commercial and residential sector. These sectors are included to the energy category, which itself generates 90% of GHG emissions. Analyses of information from the Initial and Second Communications show that emissions from the commercial and residential sector are higher than the oil and gas production sector. Another reason for selecting the commercial and residential sector is that there is greater potential for application of mitigation technologies over 10 years, compared to the oil and gas production sector. Additionally, application of mitigation technologies in the oil and gas production sector are much easier as the sector is regulated by one major company that has already taken a strategy to reduce GHG emissions. However, in the commercial and residential sector application of mitigation technology is much more difficult as there are a variety of consumers and a need for change in behavior. Moreover, this sector is becoming increasingly important as the country's population and economy grows year-by-year. Along with this, it should be mentioned that a wide range of activities related to application of modern technologies have been provided in this sector, especially after signing the "Contract of the Century" in 1994. Presently, up-to-date technologies of worldwide oil companies such as BP and Statoil, with lower GHG emissions, are used in the oil and gas production sector. In this regard, it is easy to see that there are many uncertainties existing in the commercial and residential sector.

There were also some debates on the current status of the transport sector in regard to GHG emissions. The transport sector is also one of the major sectors with GHG emissions, however, the rapid development of the sector over the last few years in Azerbaijan forced the implementation of a wide range of activities that will lead to reduction of emissions. Examples of this are the rehabilitation of roads, construction of main roads, application of Euro-2 standards for vehicles (Euro-4 standards are to be applied in coming years), and preventing the import of vehicles with higher emission release into the country.

As a next step, possible technologies under prioritized sectors were discussed and a long list of technologies was identified.

Mitigation experts have developed technological fact sheets for each technology. The MCDA tool for prioritization of technologies was applied. The prepared technological fact sheets have also been analyzed by the stakeholder groups. Finally, possible mitigation technologies have been prioritized (detailed information is provided in the chapters 4 and chapter 5).

After submission and approval of TNA for mitigation report, the TNA mitigation team will provide barrier analyses for the application of prioritized technologies and develop TAP.

Chapter 3. Sector prioritization and overview of prioritized sectors

The main sources of CO_2 emissions in Azerbaijan are the energy and industrial sectors. The principal carbon sinks are represented by the agriculture and forestry sectors, as well as land-use change.

CO_2 emissions in the energy sector come from the burning of fuel during the production of energy, oil and gas extraction, transport, and from human settlements. CO_2 emissions from stationary sources equated to 45120 Gg in 1990, and fell to 31375 Gg by 2005. Emissions from human settlements constituted 114% of the baseline year level, while 76.4% came from energy production and 71.9% from industry.

The level of CO_2 emissions in the transport sector changed from 4341 Gg in 1990 to 3632 Gg in 2005. Aviation and vehicles contributed the highest gains in emissions; domestic aviation accounted for 302 Gg in 2005.

In the industrial operations and materials use sector, the biggest sources of CO_2 emissions have been mineral materials production and metallurgy. After a period of decline in the metallurgical sector, it started to grow again after 2004. The production of lime nearly ceased altogether, but has resumed in recent years. CO_2 emissions from cement production accounted for 478 Gg in 1990 and 391 Gg in 2005.

The emissions from international aviation and shipping that are part of the International bunker were not included in the national cadastre. Emissions from these sources increased from 431 Gg and 31 Gg in 1990 to 1375 Gg and 47 Gg in 2005. The increase in emissions in aviation is caused by the broadening of international relations (Second National Communication, *2010*).

3.1. An overview of sectors, projected climate change, GHG emission status and trends of the different sectors

Following the TNA handbook, as a first step in the sector prioritization process, sectors and sub-sectors with GHG relevance have been obtained from Second National Communication and other relevant reports. Based on TNA methodology, main categories and sectors, as well as sources of GHG emissions are listed:

Table 1: Main sectors and sub-sectors with high GHG relevance

Sector	Sub-sector	Sources
1. Energy	1. Energy production	1. Energy production 2. Energy transmission and distribution 3. Energy demand
	2. Oil and gas extraction, storage, transportation and refining	1. Production, refining, storage and transportation of oil and gas 2. Flaring of gas
	3. Industry	1. Ferric and non-ferric metallurgy 2. Building materials production
	4. Transport	1. Auto-transport 2. Railways 3. Domestic aviation 4. Domestic navigation
	5. International bunker	1. Aviation 2. Navigation
	6. Commercial and residential sector	1. Usage of electrical energy and heat

2. Alternative energy sources	1. Solar 2. Wind 3. Biomass 4. Geothermal 5. Hydro-power	Zero emission
3. Agriculture and silviculture	1. Stock-raising 2. Plant-growing 3. Silviculture	1. Manure 2. Plant-growing wastes 3. Wood biomass
4. Wastes		1. Solid wastes 2. Communal sewage
5. Industry	1. Metallurgy 2. Ore-free mineral products 3. Chemical industry	1. Ferric and non-ferric metallurgy 2. Building materials production 3. Chemical industry 4. Cement production

Source: Second National Communication

As a next step, the National GHG inventory was reviewed and GHG emissions of the sectors were listed:

Table 2: GHG inventory in Azerbaijan

GHG source and sink categories (Gg per year)	CO_2 emissions	CO_2 removals	CH_4	N_20	CO_2 eq. emissions
Total (Net) National Emission	**35845**	**3769**	**687,29**	**1,15**	**46866**
1. Energy	**35007**		**283,3**	**0,15**	**41003**
Energy and transformation industries	14979		0,4	0,06	15006
Industry	6418		0,3	0,03	6434
Transport	3632		0,6	0,03	3654
Commercial/Institutional	2068				2068
Residential	6828				6828
All other sectors	1082		1,0	0,03	1112
Biomass burnt for energy					0
Oil and natural gas system			281,0		5901
Coal mining					0
2. Industrial Processes	**838**		**0,04**		**839**
3. Agriculture			**246,95**		**5186**
Enteric Fermentation			221,50		4651,5
Manure management			25,45		535,5
Rice cultivation					0
Agricultural crop residue					0
Emissions from soils					0
4. Land-use, Land-use change and Forestry		**3769**			**-3769**
Changes in forest and other woody biomass stock		2947			-2947
Forest and grassland conversion					0
Trace gases from biomass burning					0
Uptake from abandonment of managed lands		822			-822
Emissions and removals from soils					0
5. Other appropriate sources					0
5a. Waste			**157**	**1**	**3607**
Municipal solid waste disposal			72	1	1822
Domestic wastewater					0
Industrial wastewater			85		1785
Human sewage					0
5b. Emissions from Bunker fuels	**1422**				**0**
Aviation	1375				0

Navigation	47				0

Different indices are widely used in scientific researches on the analysis of sustainable development of countries in recent years. It is more relevant to take the main macroeconomic factors such as population growth, Gross Domestic Product (GDP), total energy and fuel energy used in the country, which characterize the development of the country.

The amount of the country's carbon dioxide emission into the atmosphere is mostly related to the changes in these factors. These changes are given in the following figure:

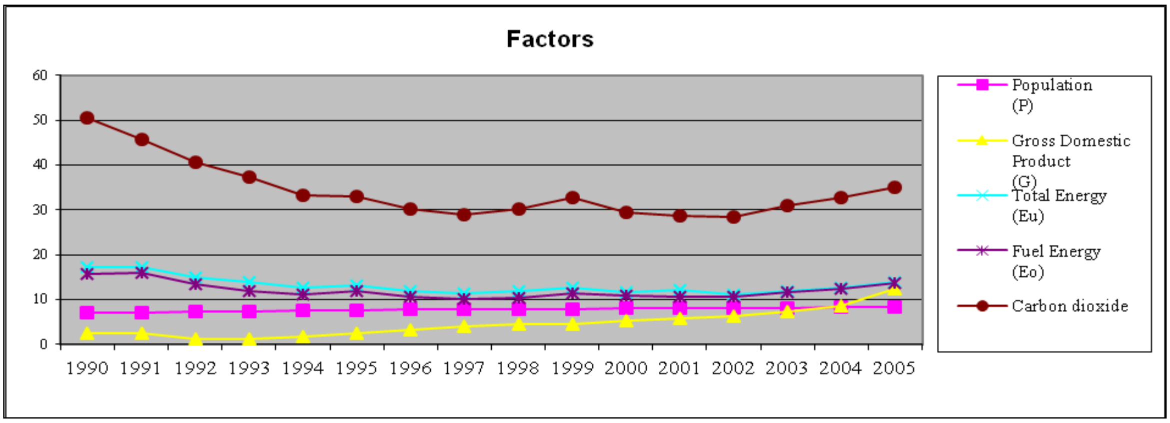

Figure 2: Factors development in Azerbaijan

Source: Mitigation Report to SCN, 2009

As it can be seen from the diagram, the population and GDP increase almost every year, while the total energy, fuel energy use and carbon dioxide emissions increase intensively from 2002, onward.

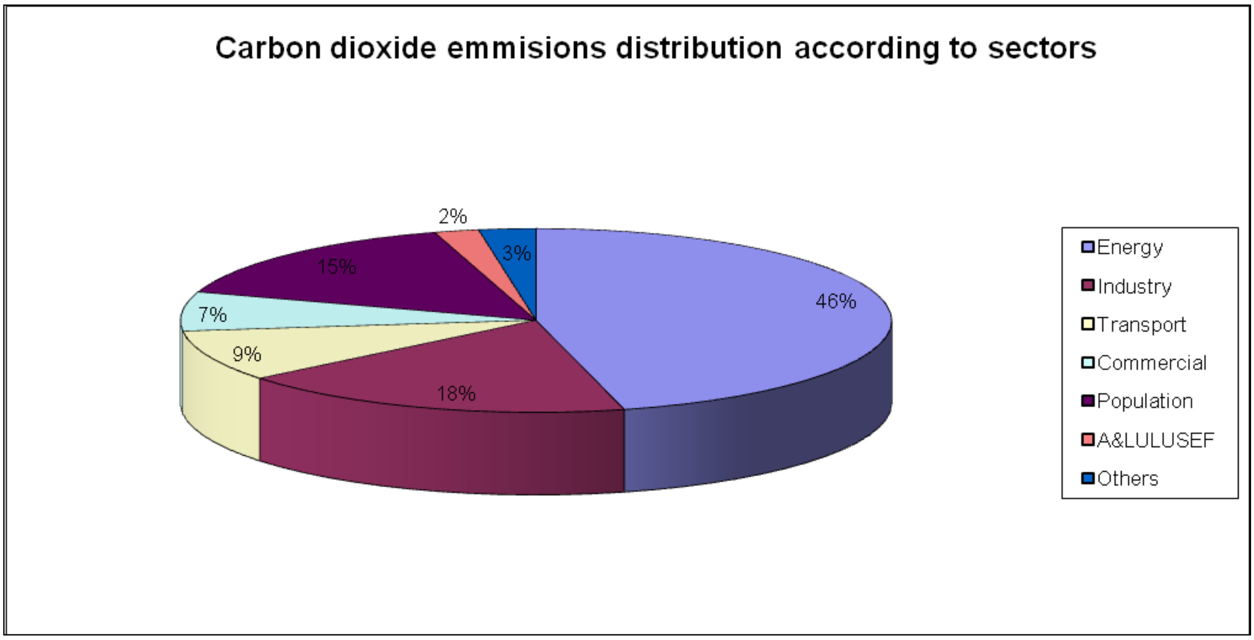

Figure 3: Carbon dioxide emissions distribution according to sectors

Source: Mitigation Report to SCN, 2009

Calculated values of the distribution of emissions by sector are shown in figure 4.

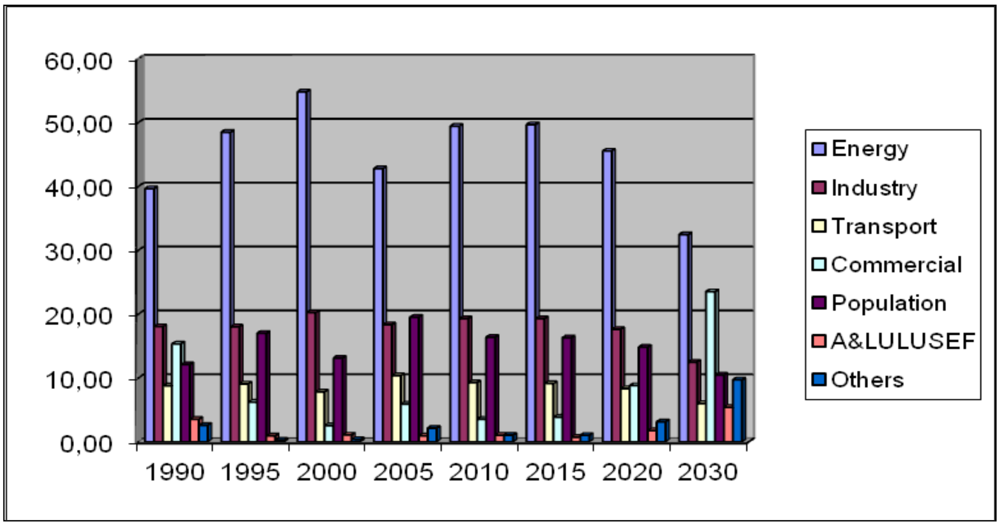

Figure 4: Distribution of emissions of carbon dioxide in % from 1990-2030

Source: Mitigation Report to SCN, 2009

Forecasted values of emissions of carbon dioxide for 2030 is provided in figure 5:

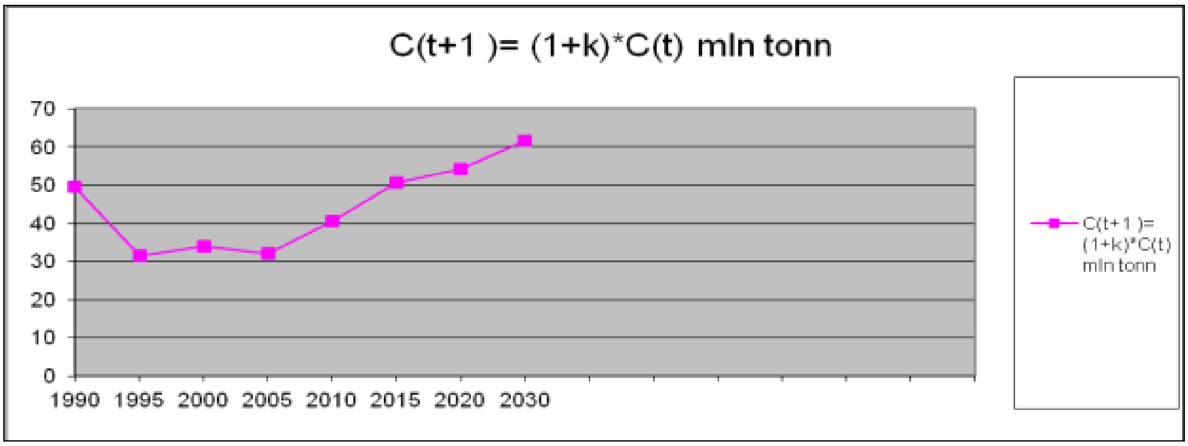

Figure 5: Forecasting the emission of carbon dioxide

Source: Mitigation Report to SCN, 2009

3.1.1. Fuel and Energy Complex

Oil and gas extraction, refining and electric power are included in the fuel and energy complex of Azerbaijan. At present, more than half of the national income of Azerbaijan's economy falls under oil industry share.

The Baku-Tbilisi-Ceyhan oil pipeline, which is constructed for the purpose of transporting oil produced in Azerbaijan to Europe, plays an important role in the development of the country's economy. Annually, 40-50 million tons of oil is transported through this pipeline. The official opening of the pipeline took place on 13 July 2006, in Ceyhan, Turkey (Annual Report, *SOCAR)*.

The positive changes currently taking place in the oil and gas industry create conditions for the future establishment of a very complex offshore oil industry in the Azerbaijan sector of the Caspian Sea.

3.1.1.1. Oil and gas

At present, approximately 2.4 billion m^3 of associated gas is released annually from the offshore and onshore deposits during oil and gas production. Approximately 195 thousand m^3 of gas is burnt due to the lack of necessary technologies. Associated gas collection and processing gives the opportunity to use the by-products (electricity, thermal energy, etc.) for domestic needs.

This can bring about 17.6 thousand m^3 of gas economy for 25 years, which is equal to 19.3 million tons of conventional fuel. As a result, 1.4 million tons of carbon dioxide emissions can be reduced (Mitigation report for SNC, *2009)*.

3.1.1.2. Oil refinery

Oil refinery is the most intensive industrial sector from an energy point of view. There are two oil refineries in Azerbaijan with the total capacity of 20.5 million tons. Oil heating installations are the main sources of GHG pollutants.

Technological developments increase the efficiency of the oil-refining sector. The supply of equipment with these technologies can save 55 million tons of conventional fuel for 20 years and can provide 100 million tons of reduction in carbon dioxide emissions in the future (Mitigation report for SNC, *2009)*.

3.1.1.3. Natural gas processing, transportation and distribution

The estimations carried out according to the methodology of the Intergovernmental Panel on Climate Change indicate that approximately 443 thousand tons of methane is released into the atmosphere during oil and gas production. This is equal to the volume of 632.85 million m^3 of natural gas. The planned construction of the 2000 km long main transit gas pipeline is of great importance, as this gas pipeline will enable Turkmen and Kazakh natural gas to be taken to the European market from the Caspian Sea.

The application of new technologies will result in 44.4 million tons of conditional fuel savings in the gas sector in the next 25 years and a decrease of 590 million tons of CO_2 equivalent.

3.1.1.4. Transport

As a result of analysis carried out on railway transport, these potential areas were identified for application of new technologies leading to decrease of GHG emissions:

1. Complete electrification of railway may reduce the amount of used fuel up to 3.2 times. This will result in 60.5 thousand tons of conventional fuel economy and a reduction of 139 thousand tons of carbon dioxide emissions annually.
2. At present the railway is towed with the help of a steady flow, while alternating current is used in European countries and Russia. The transition of the railway to alternating current will result in 141 thousand tons of conventional fuel economy and 256 thousand tons of reduction in carbon dioxide emissions annually.
3. Implementation of energy economy measures will result in 10% electric power, which means 39 thousand tons per year in fuel economy. The reduction of carbon dioxide emissions will consist of 71 thousand tons.
4. Starting in the year 2000, domestic aviation began to develop in the country leading to the subsequent increase of GHG emissions. Presently, inventory of GHG in this sector is not

provided, which creates an indefinite problem. It is assumed that this information will be identified during the development of the Third National Communication.

3.1.1.5. Commercial and residential sector

The commercial and residential sector is the largest sector with energy consumers. It is also one of the most important “Energy” category sectors in terms of energy efficiency and fuel economy.

Increase in the volume of energy consumed comes from inefficient heating systems and lack of natural gas supplied to some rural areas. In most rural areas, people still use electrical devices with low efficiency, as well as kerosene and wood, to heat their houses and for cooking purposes. Active heating systems in some parts of the cities work inefficiently and require periodic maintenance.

CO_2 emissions from the commercial and residential sector contain all the emissions from fuel combustion in households. Data on GHG emissions from the residential and commercial sector (for 2005) was provided in the Second National Communication and was noted as being 8 888 Gg. The value for CO_2 emissions from this sector in Azerbaijan was 6.46 million metric tons as of 2008. Over the past 18 years this indicator reached a maximum value in 2008 and a minimum value of 2.39 million metric tons in 1993. This data is from the International Energy Agency; inventory of GHG in the residential and commercial sector is to be provided under the Third National Communication.

3.1.1.6. Electric power

The electric power system of the Republic of Azerbaijan combines 10 thermal power stations (TPS) and 6 hydro-power stations (HPS). Currently available installed capacity of these power stations is 4000 MW. Approximately 450 MW of this power falls to modular type TPS share, built recently. The breakdown of produced energy is such that 90% is obtained from TPS and 10% from HPS.

The amount of fuel for energy consumption of 1 kW-hour has decreased 14.5% with conditional fuel unit from 2001 until the end of 2007.

More than 50% of energy produced falls to the state district power station of Azerbaijan (AzDRES) and 20% of it to Shirvan TPS. As a result of the reconstruction of AzDRES, its productive capacity will be increased to 600 MW. A 70% power increase is expected as a result of the complete modernization of the existing TPS.

3.1.2. Wastes

At present, there are more than 200 landfills and dumps with the total area of 900 ha in the country. Their condition is unsatisfactory, and this causes the increase in environmental pollution, anti-sanitary conditions and methane gas emissions.

The total volume of solid waste reaches 6.0-6.5 million m^3. It is expected that the volume of solid waste will be 12.9 million m^3 in 2025, which is more than 2.2 times the level of 1990. The collection of methane gas for 25 years will reach 1976 tons or 41.469 million tons of carbon dioxide equivalent.

The sewage system in 78 central districts and 35 of the urban-type settlements of Azerbaijan have been poorly developed: 304 km of main collectors and 660.7 km of district and street collectors. The collection capacity of methane gas in the next 25 years is expected to be 500 thousand tons or 10.5 million tons of carbon dioxide equivalent.

3.1.3. The possibilities of use of renewable and alternative energy sources in the Republic of Azerbaijan

Energy security, environmental pollution and global climate change are among the main issues that concern all of humanity. Different ideas for potential solutions to these problems are being advanced by scientists and specialists, of which currently the most important is the use of renewable and alternative energy sources. This is particularly important for Azerbaijan Republic, as it is one of the countries with favorable opportunities for the use of alternative energy sources due to its geographical location and climate.

Table 3: Fuel and energy potential of Azerbaijan Republic

№	Fuel and energy resources	Fuel and energy resources potential	Fuel and energy resources potential in oil equivalent	Rational fuel-energy balance of the country, mln.t.o.e.	Disposition of the fuel-energy resources
1	Oil	1 bln.ton	1000 mln.ton	7	Caspian Sea and (onshore) land
2	Natural Gas	1 trillion m^3	870 mln.ton	12	Caspian Sea and (onshore) land
3	Brown coal	25 mln.ton	8 mln.ton	-	Alazan-Airichai lowland
4	Oil-shales	35 mln.ton	7 mln.ton	-	Guba and Ismailly regions
	Total traditional energy resources	**-**	**1885 mln.ton**	**19**	-
5	Large HPPs	5 bln. kWh per year in average	1,2 mln.ton per year	0,6	Big rivers in the country
6	Small HPPs	3,2 bln. kWh per year in average	0,8 mln.ton per year	0,4	Water channels and mountain rivers in the country
7	Wind Power Units	4 bln. kWh per year in average	1 mln.ton per year	0,25	Major part of the country
8	Solar heaters	100 thous.per year in average	0,066 mln.ton per year	0,06	Major part of the country
9	Thermal waters	10 thous.t.s.f. per year in average	0,066 mln.ton per year	0,006	Northern, North-Western, Southern and Western areas of the country
10	Biomass (wood)	10 thous.t.s.f. per year in average	0,066 mln.ton per year	0,006	Major part of the country
	Total renewable energy resources	**-**	**3,138 mln.ton per year**	**1,31**	-
	Total energy resources	**-**	**1888,138**	**20,31**	-

Source: Annual report, *SOCAR*

Use of alternative energy sources is a priority issue for the country. “The State Program on the Use of Alternative and Renewable Energy Sources" was approved in 2004 aiming to promote use and application of renewable energy sources. In December 2011, a new Presidential Order was issued on the preparation of National Strategy on the use of Alternative and RES for 2012-2020, in order to create a truly sustainable energy system for the country.

Hydro-power resources are both economically favorable and have important energy potential for Azerbaijan. During recent years, new facilities have been constructed on the Nakhchivan and Kura rivers.

The potential of small hydro-power technology in Azerbaijan is high as well. According to current estimates the technical potential of this sector is 4.9 billion kWh and the economic productive potential is 1.7 billion kWh.

The Development Program of small hydro-power technology in Azerbaijan considers the modernization and restoration of the existing small HPSs as well as the construction of new stations on Mountain Rivers and irrigation canals. The increase of hydro-electric power production will cause fuel economy and decrease carbon dioxide emissions.

3.2. Process, criteria and results of sector selection

Based on methodology provided in the TNA Handbook, according to the results of provided analysis of relevant national documents, the country's development priorities have been clustered under economic, social and environmental priorities.

Table 4: Clustered development priorities and defined criteria under each priority

Environmental Development Priorities
Conservation and rational use of natural resources
Reduction of natural disasters
Water pollution prevention
Biodiversity conservation
Atmosphere air protection
Prevention of soil degradation, including cleaning of soils polluted by oil and other products
Improvement of solid industrial and household wastes
Protection of forests
Combating desertification
Climate change
Social Development Priorities
Poverty reduction
Improvement of water and sanitation system in regions of country
Reduction of unemployment
Public participation and awareness-raising
Reduction of child mortality and infectious diseases
Food security
Economic Development Priorities
Sustainable development
Energy security
Low-carbon development in energy sector
Development of infrastructure
Tourism development
Use of modern agricultural technology to provide food security

After the consideration and identification of the development priorities, the identified sectors from the GHG inventory were listed according to their emission share.

Table 5: Summarized GHG inventory in Azerbaijan

GHG Source and Sink Categories	Emissions 2005 (Gg CO_2 eq.)
Energy	41003
IPPU	839
AFOLU	5186
Waste	3607
Total	**50635**
CO_2 removal	**3500**
Net emission	**47135**

Source: Second National Communication, *2010*

* AFOLU - Agriculture, Forestry and Other Land-use

* IPPU - Industrial processes and product use

Table 6: List of sectors by their GHG emission

GHG Source and Sink Categories	Emissions 2005 (Gg CO_2 eq.)	Emission share by sectors (%)
Energy	41003	80,98
IPPU	839	1,66
AFOLU	5186	10,24
Waste	3607	7,12
Total	**50635**	100

Source: Second National Communication, *2010*

Based on the identified economic, social and environmental development priorities, results of the inventory of GHG by sectors and calculated GHG emissions forecasted to the year 2030, and potential mitigating effect on climate change by sector, the experts have evaluated the sectors using the following evaluation scheme:

0 — no benefit
1 — faintly desirable
2 — fairly desirable
3 — moderately desirable
4 — very desirable
5 — extremely desirable

As a result, the national team and stakeholders have identified the performance matrix below for prioritizing using MCA method and based on economic, social and environmental priorities and potential in GHG reduction.

Table 7: Scoring the sub-sectors within energy supply, industry, agriculture, forest, land-use and waste

		Economic Priorities	Social priorities	Environmental priorities	GHG reduction potential	Total benefit
Energy supply	Energy production	5	5	4	4	18
	Oil and gas production	5	5	4	4	18
	Transport	3	4	4	4	15
	Commercial and residential sector	4	5	5	5	19
	Alternative energy sources	4	5	5	5	19
Industry	Metallurgy	4	4	4	4	16
	Ore-free mineral products	4	4	4	4	16
	Chemical industry	4	4	4	4	16
Agriculture, forest, land-use	Agriculture	4	4	3	3	14
	Silviculture	3	3	5	4	15
Waste	Wastes	3	4	3	3	13

Based on the given scores, this criteria contribution graph has been prepared by experts:

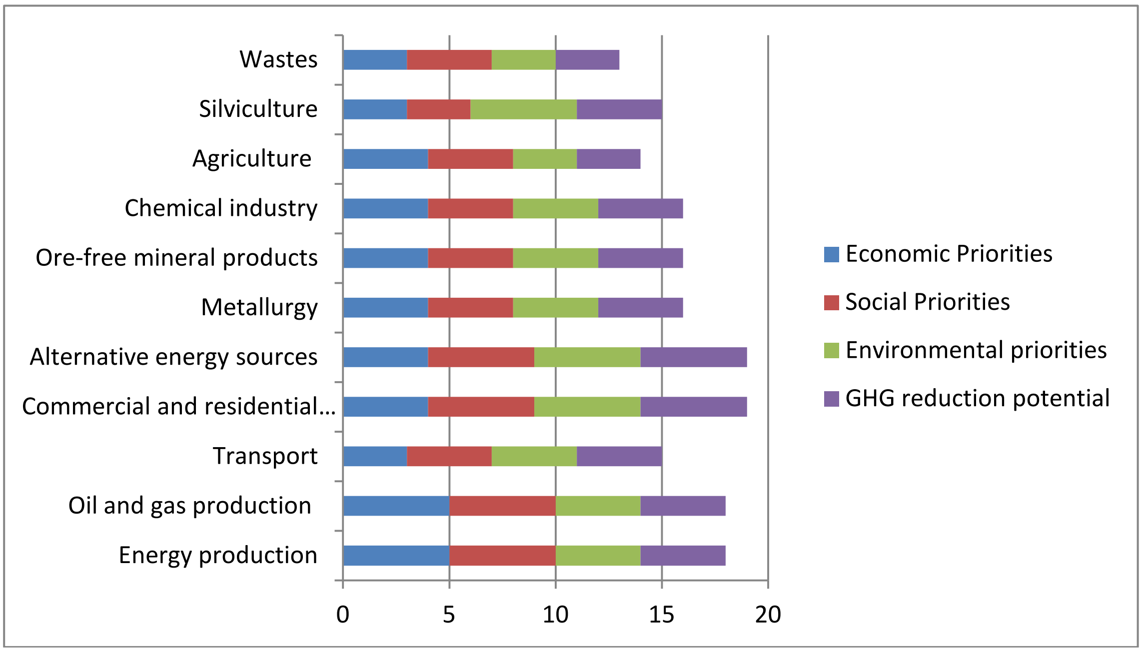

Figure 6: Criteria contribution graph

The criteria contribution graph is prepared taking the scoring for the sectors under different criteria to give an overview of the contribution of each sector on the criteria. On the basis of the criteria contribution graph, sectors have been judged on whether they are desirable for intervention. The sector having strong contribution to both GHG emission reduction and meeting development priorities has been considered as the priority sector – in this case, the Energy sector.

Table 8 gives the cumulative score of development priorities and GHG reduction potential for the Energy sector. Based on this, the sub-sectors under the Energy sector have been classified accordingly, in table 9.

Table 8: Cumulative score clustered under development priorities and GHG reduction potential

Energy Sub-sector	Development priorities	GHG reduction potential
Energy production	14	4
Oil and gas production	14	4
Transport	11	4
Commercial and residential sector	14	5
Alternative energy sources	14	5

Table 9: Desirability of interventions in energy sector

Energy	Development priorities	GHG emission reduction
Energy production	**Extremely desirable**	Faintly desirable
Oil and gas production	**Extremely desirable**	Faintly desirable
Transport	Faintly desirable	Faintly desirable
Commercial and residential sector	**Extremely desirable**	**Extremely desirable**
Alternative energy sources	**Extremely desirable**	**Extremely desirable**

As it can be seen from the above tables, alternative energy sources and commercial and residential sectors falling under the Energy category have higher scores for prioritization. Intensive debates were held on selection from two sectors: oil and gas production and commercial and residential sector. These sectors are included in the energy category, which itself generates 90% of GHG emissions. Analyses of information from the Initial and Second Communications show that emissions from the commercial and residential sector are higher than the oil and gas production sector. Moreover, the commercial and residential sector is becoming increasingly important as the country's population and economy grows year-by-year. Therefore, after a number of discussions, and according to the provided evaluation, the following have been identified as priority sectors for mitigation:

- Alternative energy sources
- Commercial and residential sector

The experts provided assessments for justification of the scores given for potential improvements and contribution to development priorities in each sub-sector.

For the commercial and residential sector, **Economic development priorities**: this sub-sector is in-line with the country's economic development priorities, as the construction sector is rapidly developing in the country with the involvement of private sector. As well, population of the country, mainly urban population, increases year-by-year.

Social development priorities: improves living conditions of population.

Environmental development priorities: according to the most recent data from the Second National Communication, rapid increase in GHG emissions from this sector is expected for 2030. Application of new environmentally sound technologies, such as energy efficiency bulbs, heating technologies, building management structures and so on, may lead to high reduction in GHG emissions.

For alternative energy sources sub-sector, **Economic development priorities**: currently, 10% of energy production is provided by alternative energy sources, such as hydro-power and wind energy. It is well suited to the country's economic development priorities and energy policy.

Social development priorities: use of alternative energy sources provides sustainable and qualitative energy supply for both commercial sector and population. It also improves energy supply in remote areas.

Environmental development priorities: this sub-sector does not contribute GHG emissions. Its negligible negative impacts, such as noise and danger to biodiversity (e.g. wind power stations negatively affect bird migration), may be prevented by the application of proper technology and selection of location areas.

In the energy production sub-sector, almost 90% of electricity production is based on use of organic fuel. Therefore, the following justification has been provided for the given scores under this sub-sector:

Economic development priorities: this sub-sector is in-line with the country's economic development priorities, but it creates serious environmental problems such as GHG emissions and harmful substances.

Social development priorities: this sub-sector is in-line with the country's social development priorities, as it improves employment level and living conditions, but it creates serious environmental problems such as GHG emissions and harmful substances resulting in threats to human health.

Environmental development priorities: despite the fact that new technologies are applied in this sub-sector, it still remains less suitable for the country's environmental development priorities.

For oil and gas production **Economic development priorities**: this sub-sector is in-line with the country's economic development priorities, as it is the biggest economic sector of the country.

Social development priorities: incomes from this sub-sector are used for social development of the country, as well as for implementation of a number of social development programs, such as poverty reduction.

Environmental development priorities: this sub-sector is the main source of methane emissions, which contribute to global warming.

For the transport sub-sector, **Economic development priorities**: this sub-sector is in-line with the country's economic development priorities, as most parts of national investments are provided to transport infrastructure development.

Social development priorities: development of the transport sector decreases the number of injuries and accidents, as well as prevents heavy traffic.

Environmental development priorities: according to the latest statistics, emissions from the transport sector have an increasing tendency and will last in future years.

Chapter 4. Technology prioritization for alternative energy sources sector

4.1. GHG emissions and existing technologies for alternative energy sources sector

Azerbaijan has a cheap and easy-to-use oil and gas reserve, so a rapid transition to renewable energy sources is an optimistic goal. Over the past four years, 10 new power plants were built in Azerbaijan. There are a total of 19 stations in the country, 10 of which are the plants built during the last four years. The future energy potential of the 10 newly built stations will equal to the MW and the total energy potential of Azerbaijan - 6400 MW, of which only 800 megawatts of hydroelectric power are accounted for. In 2015, the government of Azerbaijan intends to substantially increase the energy potential of the country from the current 6500 MW to 9000 MW. This is planned along with the construction of gas turbine stations in Tovuz, Shyhli, and Poylu, which will have a total capacity of approximately 550 MW.

Specialists and experts from Azerbaijan estimate that 20% of the electricity in the country may be from alternative sources of energy. The Ministry of Industry and Energy has placed modest goals on the development of alternative energy in the country. According to the Ministry, in the future, alternative and renewable sources could account for up to 5-7% of electricity production and 10% of thermal energy. Establishment of the Coordinating Council for realization of the State Program of Renewable Energy Sources will help develop this direction. The Presidential Order on 6 July 2009 established the State Agency for Alternative and Renewable Energy under the Ministry of Industry and Energy. The agency began work on the design and construction of mini hydro-power plants. Currently, work continues on the construction of stations such as "Goychay-1" (3 MW) and "Balakian-1" (1.5 MW). The State Program plans to continue creating a number of large and small hydro-power plants in the country through to 2015, which will save more than 2 MTs of fuel and reduce about 10 MTs of carbon dioxide emissions (A roadmap in renewable energy in Azerbaijan, *2009*).

An analysis of government programs and ongoing projects in the energy sector shows that Azerbaijan has achieved sustained production of electricity and fully meets both industry and social needs, in becoming the exporter of electricity. However, virtually all of the old power plants and energy infrastructure require a major upgrade and the introduction of new processes and technologies, meeting international standards. The development of alternative energy sources and energy system integration into international networks will not only require a high level of safety and reliability of the technology, but also the continued harmonization of the country's legislation and legal framework in the field of energy.

4.2. An overview of possible mitigation technology options in alternative energy sources sector and their mitigation benefits

The second report of the Working Group on Climate Change of Azerbaijan presented several forecast scenarios for climate change and their impact on the economy. Reducing greenhouse gas emissions, primarily CO_2, is a necessary condition to mitigating the negative impacts of climate change in all scenarios. Using alternative energy sources promotes the reduction of carbon monoxide emissions.

It should be noted that despite the huge potential in the field of alternative energy sources, the State Program and the Agency for Alternative Energy are planning the short term development of three main areas: small hydro, wind power, especially on the Absheron Peninsula and the coastal zone of the Caspian Sea, and solar energy–using solar panels to generate electricity and solar collectors for thermal energy. Biological energy sources, such as biogas plants, biodiesel fuel, etc., will also be used to a lesser extent. However, there is virtually no long-term plan to use other sources, which have great potential and are widely used in international practice - hot springs, the use of natural biomass and its processing to produce ethanol and other fossil fuels.

Application of renewable energy sources in Azerbaijan is one of the main strategies of the government. In 2004, the government adopted the State Program on Use of Alternative Energy

Sources in Azerbaijan Republic (2005-2013). The objective of the State Program is to promote power generation from renewable and environmentally sound sources and utilize hydrocarbon energy sources more efficiently.

The major tasks of the State Program include:

- Define the potential of alternative (renewable) energy sources for electric power generation;

- Raise the efficiency of the country's utilization of energy sources by developing renewable energy sources;

- Ensure the opening of additional jobs with creation of new energy production sites;

- Given the existing total capacity of traditional energy sources in Azerbaijan, increase the energy capacities of alternative energy sources and, therefore, achieve the country's energy security.

Under this program, by 2009 Presidential Decree, the State Agency for Alternative and Renewable Energy Sources under the Ministry of Industry and Energy of the Republic of Azerbaijan was established.

The Agency has the mandate of the principal regulatory institution in the field of renewable energy and is tasked with assessment of sustainable energy potential, shaping relevant policies, including tariff policy, and elaboration and enforcement of relevant procedures such as issuing special permissions to the public and private entities to construct power generation facilities. Other tasks include:

- Participation in the development and preparation of public policies for creating the infrastructure of renewable energy, and ensuring the accomplishment of this policy;
- Participation in the preparation and creation of the normative documents regulating the Renewable Energy sector;
- Putting forth suggestions on the use of renewable energy sources, designing, building, operation of facilities and mechanisms of regulating the activity related to the production of necessary equipment for the purposes listed;
- Preparation of proposals for measures to encourage the activity (design, construction, maintenance and production) and to meet demand for Renewable Energy;
- Monitoring activities in the Renewable Energy sector;
- Other activities specified by law.

Main identified targets of the country for the period of 2020 is indicated below.

- 20% share of renewable energy in electricity (10% in 2011: 9.8% hydro-power, 0.2% other renewable energy);
- 9.7% share of renewable energy in all energy consumption (2.3% in 2011).

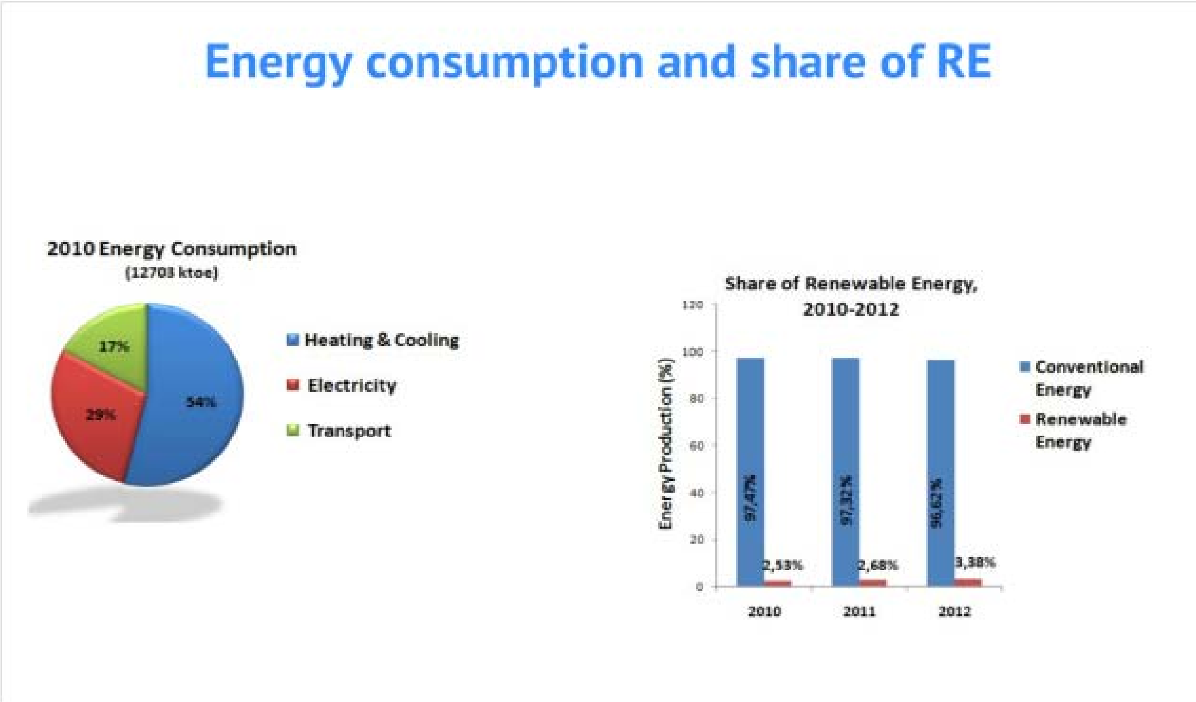

Figure 7: Energy consumption and share of RE

Source: Perspectives of use of alternative and renewable energy in Azerbaijan, presentation

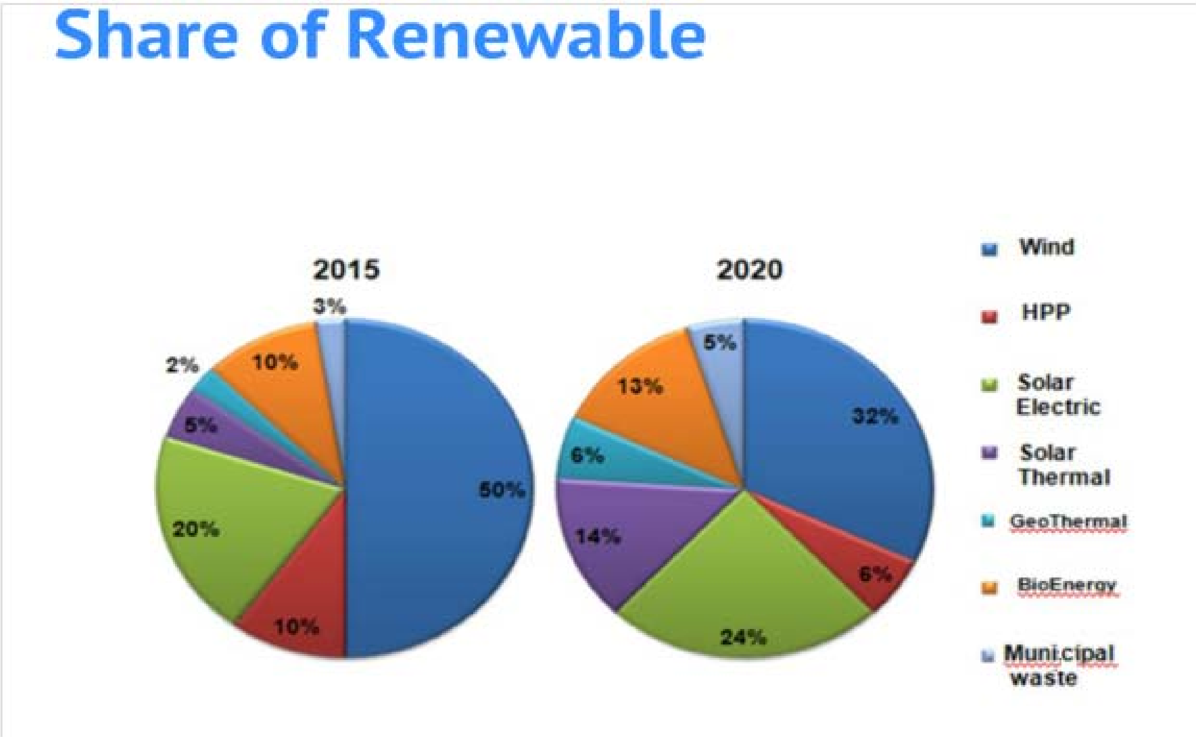

Figure 8: Share of renewable energy

Source: Perspectives of use of alternative and renewable energy in Azerbaijan, presentation

4.2.1. Alternative (renewable) energy potential of Azerbaijan

Wind power

Wind power is a more preferable energy source than solar, hydro, geothermal and biomass due to its cost, environmental soundness and unlimited availability.

Practice shows that many of the regions in Azerbaijan have great potential for application of wind power facilities. Calculations suggest that Azerbaijan has about 800 MW of annual wind power capacities due to its geographical location, nature and economic infrastructure. This reserve means 2.4 billion kWh of electricity, according to rough calculations. This would imply the possibility of saving up to 1 MT of conditional fuel and, more importantly, the prevention of emitting large quantities of wastes including ozone-cracking carbon dioxide.

Long-term surveys have determined that convenient windy conditions are prevalent in the Absheron Peninsula, Caspian seashore and islands in the northwest of the Caspian basin. It is feasible to use medium-capacity wind power facilities in Ganja-Dahskesen zone and Sharur-Julfa area of Nakhchivan Autonomous Republic, as the annual average speed of wind in those regions is 3-5 m/sec.

In Azerbaijan there are favorable climatic conditions for the development of wind energy production. Wind speeds of 3-5 m/sec are prevalent in the foothills and lowlands of the country. Wind speeds in coastal regions vary between 6 and 8-20 m/sec. In the Absheron Peninsula – aside from the predominant north wind – northwest and south winds are observed. The probability of wind speed gradient between 9 and 20 m/sec is 30%.

Perspective areas in terms of wind energy production are the Apsheron Peninsula, coastal area and islands. The viability of these areas is predetermined by the average annual wind speed, which is 5.5-8.0 m/sec in the identified regions. Moreover, the fact that winds are blowing 250 days a year in Azerbaijan makes it unreasonable to ignore the wind energy production potential.

The Japanese company Tomen, together with the Azerbaijan Scientific-Research Energy and Power Design Institute, has installed two wind towers of 30 m and 40 m heights and determined that the annual average wind speed in Absheron is 7.9-8.1 m/sec. The company had also prepared a Feasibility Study for the installment of a 30 MW wind power plant in the Gobustan region.

Below, data from the application of wind energy is provided.

- The technical potential for energy production – 4.0 billion kW-hours;
- The amount of fuel economy for 20 years – 2.4 million tons of conditional fuel;
- The reduction in carbon dioxide emissions in 20 years – 4.4 million tons.

Solar power

The climate condition of Azerbaijan creates great opportunities for production of electric and heat energy using solar power. The number of annual sunshine hours in Azerbaijan is 2400-3200 hours.

Development of solar power can partially solve energy problems in many regions of the country. Several developed countries have recently started to widely apply Photovoltaic Programs (PVP). Azerbaijan’s involvement in this program can play an important role in the application of such types of energy systems.

The use of solar energy is considered logical in the regions with entering solar radiation of over 120 kW-hour/m^3 per year. In many regions of Azerbaijan the volume of entering solar radiation makes up 1600-1800 kW-hour/m^3, while the average annual duration of solar radiance is 2200-2600 hours with a radiation level of 3-6 kW/m^3. These figures show that the practical use of solar energy is economically justified for the country, as the location and proximity of solar stations to the “energy source” make it more efficient and economically viable.

Use of solar energy in Azerbaijan is preferable in sectors such as heating and hot water supply, air conditioning, industry, communications and transport. Relative simplicity of the usage of solar energy enables mass construction of standard small power plants with capacity of 50 to 3000 kW.

Implementation of a project practicing the usage of solar energy would allow savings of 0.13 million of CFT of fuel and the reduction of CO_2 emissions by 232,000 tons after 10 years.

Small hydro-power plants

The generation capacity of hydro-power plants within Azerbaijan's overall power system is presently 17.8%. Approximately 2.4 billion kWh of total electricity generated in 2003 was produced by hydro-power plants, which constituted 11.4% of overall electricity generation.

Currently, there are some hydro-power potentials in the country that are still undeveloped. Research related to this area showed that the overall hydro-power potential of rivers in Azerbaijan Republic equals 40 billion kWh. The technically feasible potential totals 16 billion kWh, 5 billion kWh of which is related to small hydro-power plants.

Estimated technical capacity of the sector equals 4.9 billions of kW-hour, while economically efficient capacity totals 1.7 billions of kW-hour. However, the role of smaller hydro-energy production facilities is low and they work only at 2% of a fixed capacity.

Construction of hydro-power plants has an important role in resolution of country-level issues such as regulation of floodwaters, environmentally sound electricity generation and creation of new irrigation systems. It is possible to locate dozens of small hydro-power plants on rivers and water facilities, and these plants can generate up to 3.2 billion kWh annually.

Smaller Hydro-energy Production Development Program of Azerbaijan provides for technological modernization and reconstruction of existing smaller HPPs as well as the construction of new stations on mountain rivers and irrigation canals.

From a near-term perspective, it would be expedient to install 64 small HPPs. These HPPs can be located on irrigation canals, rives with unregulated flow, and water reservoirs that are under-construction. Use of micro HPPs in the electricity supply of objects and settlements that are remote from transmission lines and substations of countrywide grid system can resolve electricity problems, as well as social problems.

Currently, many regions of Azerbaijan suffer from the shortage of electricity. Smaller HPPs might help resolve this problem. Some of the many advantages of smaller HPPs are:

- They may be located close to energy consumers;
- Losses occurring during the energy's long distance transportation are low;
- Smaller HPPs conserve the natural landscape;
- Smaller HPPs eliminate the possibility of GHG emissions.

For smaller HPPs located on the irrigation canals it is recommended to use water releasing constructions, which have permanent drain with considerable head of water. Economic advantage of smaller HPPs is evident. Improvement of existing, and construction of new, HPPs would allow a 28.2% increase of the share of energy produced by the HPPs. In other words, a two-fold increase as compared to the baseline year might be achieved as a result.

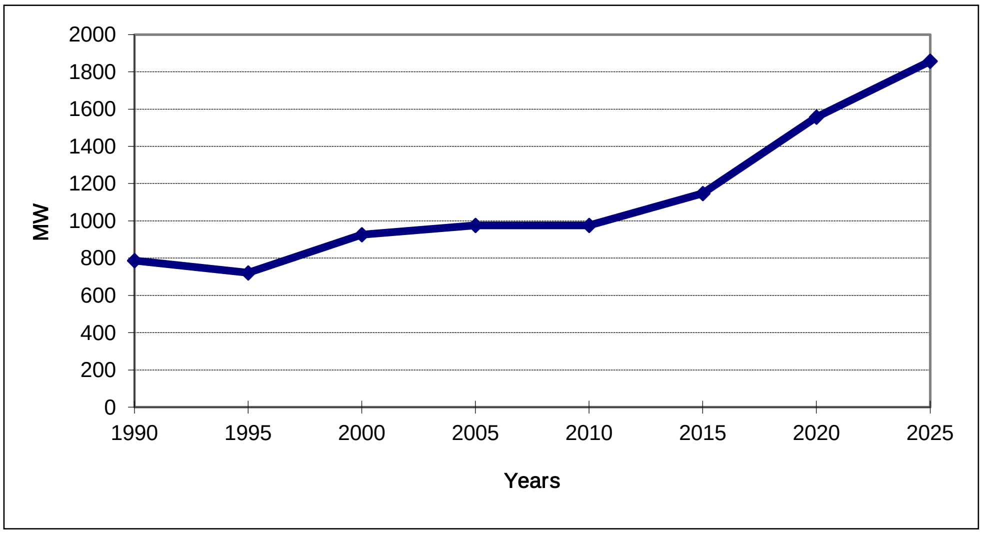

Figure 9: HPP development forecast in Azerbaijan

Source: A roadmap in renewable energy in Azerbaijan, 2009

Increase of electrical energy production on HPPs would enable savings of oil fuel and reduction of CO_2 emissions.

Table 10: CO_2 emission due to application of hydro-power

Indicators	**Years**					
	2000	**2005**	**2010**	**2015**	**2020**	**2025**
Electrical power production Billions of kW-hour	1.9	2.0	2.0	2.4	3.3	3.9
Fuel oil saved (thousands of tons)	570	600	600	720	990	1170
Volume of CO_2 emissions reduced (thousands of tons)	1755	1847	1847	2216	3047	3602

Source: A roadmap in renewable energy in Azerbaijan, 2009

Biomass power

Rapid development of industry, agriculture and social service in Azerbaijan Republic creates new opportunities for electricity generation from biomass. The sources of bio-substances in the country include the following:

- Combustive industrial wastes;
- Wastes from forestry and wood-working;
- Agricultural and organic wastes;
- Domestic and communal wastes;
- Wastes processed from areas polluted with oil and petroleum products.

Studies suggest that much of the composition of production wastes in all industrial sites is biomass substances. It is feasible to produce biogas, bio-liquid and solid bio-substance that can be used for electricity generation. More than 2.0 million tons of solid domestic and production wastes are annually thrown into waste treatment sites in Azerbaijan Republic. Utilization (processing) of solid domestic and production wastes would partially resolve the problems in heating public buildings in Baku and other large industrial cities.

Geothermal power

The heat from the earth's depth is widely used in industry, agriculture, domestic, communal and health sectors of many countries. The advantage of using geothermal power in energy production and consumption is that its application does not require large amounts of funding.

Azerbaijan Republic is rich in thermal waters, usually found in the Great and Small Caucasus, Absheron Peninsula, Talish mountain-row zone, Kura lowland and Caspian-Guba area. Exploitation of thermal waters in noted areas would partially cover domestic and other heat energy needs.

Attracting private investments in connection with implementation of actions envisaged under the State Program and maximum use of alternative (renewable) energy sources can be conducive to connecting additional capacities to the power system.

4.2.2. Renewable energy initiatives in Azerbaijan

In recent years various projects related to the application of renewable energy have been implemented in Azerbaijan. Below, information is provided on several projects implemented in the country, in collaboration with the government of Azerbaijan (SCARES), Caspian Technology Company, ALTEN GROUP (a private company), international organizations such as KfW and UNDP, and the Norwegian government.

- **Caspian Technology Company**

The Pilot Project consists of two V52 wind turbines manufactured by Vestas Deutschland GmbH. The project site is located in the 55th km of Baku-Guba highway.

Due to correct site selection, the project was completed in only 8 months. The Pilot Project has 35 kV grid connection, which provides transfer of green energy.

The project is able to produce 6.5 MW. energy per year and, therefore, save 2 mln m^3 of gas.

- **SCARES Experimental Polygon and Training Center in Gobustan**

The training center was established by ABEMDA under State Program on Development of Alternative Energy Sources. The Experimental Polygon and Training Center is located in Gobustan and occupies a total area of 38 ha. Below, some information is provided on the applied technology at the center.

- Installed wind turbines: 3 X 0.9 megawatt = 2.7 megawatt;
- Solar panels park: 1.8 megawatt;
- Biomass equipment: 1 megawatt;
- Other equipment: Regulatory equipment, water reservoir, test area, workshop;
- Freeze camera - Capacity: 330 cubic meter, +5 / - 5.

- **ALTEN GROUP**

ALTEN GROUP is one of Azerbaijan's largest alternative energy service providers, with service divisions operational throughout the country. It manages alternative energy projects in Azerbaijan and around the world. Additionally, the company operates from a purpose-built production facility, which focuses on the design and manufacture of small biogas and greenhouse systems, solar streetlights and garden lamps.

- **KfW renewable energy projects**

KfW renewable energy projects are to lend support to the Azerbaijan Energy Sector. The loan amount is 61 million Euros. There are plans to implement further projects in the amount of 130 million Euros in the future, with cooperation from SAARE. Additionally, preparation to develop the Wind Energy Atlas of Azerbaijan began in 2012.

- **Increasing of RE potential for CDM mechanism in Azerbaijan**

The total budget of the project implemented during 2006-2010, funded by the Norwegian government, was $300,000. The main purposes of the project were support for establishment of RE structures, strengthening of potential policy for the Ministry of Ecology and National Resources, developing legal framework for the CDM, establishment of CDM strategy for Azerbaijan and preparation of list of potential CDM Projects.

- **Technical assistance for support of development of Small Hydro-Power Stations**

The total budget of the project implemented during 2007-2010, funded by the Norwegian government, was $1.5 million. The main activities under the project were analysis of the legal environment and changes, analysis of the potential of Small Hydro-Power Stations, analysis of the investment environment and establishment of Small Hydro-Power Stations in Azerbaijan.

- **Promoting Development of Sustainable Energy in Azerbaijan**

The total budget of the project, financed by the EU and the Norwegian government, is $1.440 million. The project covers the period of January 2011 – June 2013. Main project activities are:

- Establishment of Small Hydro-Power Stations;
- Awareness of sustainable energy, PR works;
- Evaluation of RE potential and economic efficiency;
- Preparation of pilot projects on wind.

2012-2013 RE Projects in Azerbaijan

Project Name and Location	Size (MW)	Budget	Potential investors
Pirakushkul Wind Park	110	€165 mln	Government of Azerbaijan (10-25%)+ KfW
Hovsan Sewage-Gas Station	50	€75 mln	Government of Azerbaijan (10-25%)+POSCO
ABSHERON PV Solar Park	25	€ 87.5 mln	Government of Azerbaijan (10-25%)+JICA
Offshore Wind Park	100	€ 250 mln	Government of Azerbaijan (10-25%)+Private Investor
1000 House / 1000 Power Stations	50	€ 80 mln	Government of Azerbaijan + Private Investor

Figure 10: Projects related to renewable energy in Azerbaijan planned for 2012-2013

Source: Perspectives of use of alternative and renewable energy in Azerbaijan, presentation

After analysis and stakeholder consultations, the possible mitigation technologies for alternative energy sources have been summarized in table 11.

Table 11: List of possible technologies for alternative energy sources

Sector	Sub-sector	Technology	Scale of application	Medium/ long term availability
Alternative energy sources	Solar energy	Passive solar energy (hot water) and solar photovoltaic (electricity)	Small-scale	Long-term
	Wind energy	Grid-connected wind power	Large-scale	Long-term
	Small hydro-power	**a)** HPPs located on the irrigation canals **b)** HPPs located on mountain rivers	Small-scale	Medium-term
	Bioenergy	**a)** The biomass use in thermal energy production **b)** The use of the organic residues in the obtaining of biogas by anaerobic fermenting	Small-scale	Long-term
	Thermal energy	Using the geothermal energy of national hot spring water	Small-scale	Long-term

Regarding the reduction of CO_2 emissions due to application of the above-mentioned technologies, it should be mentioned that by applying solar energy for heating, use of fuel energy could be saved. The estimates show that during the use of solar energy for heating, energy savings for one family is 9400 kVt electric energy (May-September months – 2500 kVt, October-April months – 6900 kVt). This leads to the reduction of 6 tons of CO_2 emissions. This is calculated for one family and may be applied to a number of families in order to increase the overall reduction of CO_2 emissions.

Using solar energy as electric energy, total savings in electric energy for one family will be 3000 kVt. Multiplying 3000 to 0.64 kg/kVt results in 1.9 tons of reduction in CO_2 emissions per year. This is calculated for one family and may be applied to a number of families in order to increase the overall reduction of CO_2 emissions.

The same type of calculation may be applied to mechanical wind conservation. For one family the reduction in CO_2 emissions will be 1.9 tons per year. For air generating technology, if it is used both for heating and energy purposes, the reduction in CO_2 emissions for one family will be 7.9 tons per year.

Similiar calculations may be used to estimate the reduction in CO_2 emissions for the application of small hydro-power plants.

When applying biomass for electricity in rural areas, atmospheric emissions affecting climate change are calculating at “zero” level. In spite of the fact that during the burning of biomass there is CO_2 emission into the atmosphere, it is considered a renewable energy as biomass is generated due to absorbation of that gas. When using biomass for electricity generation, the calculation is as follows:

As it is seasonal, autumn and spring seasons are considered during calculations. Therefore, when generating electricity during 6 months, 1500 kVt hours of energy per year is generated (250 kVt-hours/month * 6 months). This means an emission reduction of 0.96 tons/year (1500 kVt/hours * 0.64 kg/kVt-hours).

The use of biogas is fairly low in rural areas of Azerbaijan and it is mainly used for cooking and heating purposes. Biogas devices may be constructed for the use of individual households. The calculation of CO_2 emissions per household (considering that one household on average has 2 dairy cows, 1 cow and 10 sheep) are as follows:

(2 * 0.02) + (1 * 0.01) + (10 * 0.0001) = 0.051 tons methane/year. This amount of methane is equivalent to 1.07 tons of CO_2.

Geothermal energy sources are mainly used for generating hot water or heating purposes. When calculating the reduction of CO_2 emissions, the same method as the above applications will be used. Based on calculations, 9400 kVt of electricity is saved and the reduction in CO_2 emissions will be approximatly 6.0 tons.

4.3. Criteria and process of technology prioritization

As mentioned in previous chapters, the MCDA approach was applied during prioritizing of the possible mitigation technologies for selected sectors. MCDA uses criteria, scores and weightings, which are necessarily subjective concepts, requiring human judgment for their determination. It, therefore, acknowledges the fact that there is no such thing as an objective decision and subjective judgments are explicitly elicited, encoded and tested for coherence against uncertainties.

The mitigation expert has provided assessment of current national priorities identified in national strategic programs, sector policies, action plans and other documents, including the Second National Communication. As a result of intensive discussions with the stakeholders group, the following sets of criteria were defined to prioritize technologies for alternative energy sources sector under costs and benefits:

Table 12: Criteria for alternative energy sources sector under cost and benefits

Criteria	Definition
Cost	
Capital Costs (Infrastructure, etc.)	It includes number of technology units established and its costs based on required energy or heat production volume. Generally, for alternative energy sources, infrastructures are built by government or private sector.
O & M Costs	These include costs incurred from maintaining infrastructures.
Cost effectiveness for mitigation	Cost effectiveness for mitigation is calculated on the basis of grid emission factor (that was equal to 0.620 $kgCO_2/kWh$ in 2006) and price of produced energy (USD per kWh).
Environmental Development Priorities	
Reduced air pollution	Improving air quality by reducing air pollutants such as SOx, NOx, suspended particulate matter, non-methane volatile organic compounds, dust, fly ash and odor.
GHG emission reduction by 2030	Reduction in GHG emissions by 2030 through promotion of clean energy and efficient technologies in energy production.
Social Development Priorities	
Sustainable energy supply	Application of alternative energy sources will lead to sustainable energy supply.
Increased income due to lower energy costs	Application of alternative energy sources will decrease energy costs leading to increase of income of both commercial sector and population.
Economic Development Priorities	
Balance of Payment (BoP)	Reduction in the use of organic fuel, with the possibility of using the saved fuel for organic chemical industry and other sectors of national economy.
New employment opportunities	Development of alternative energy sector will lead to the emerging of new employment opportunities.

Relevance to development priorities defines climate change mitigation technologies that offer the greatest value to the country in meeting its current national development priorities. Implementation potential defines scale of implementation and diffusion of the technology, which can be realistically achieved if key barriers are overcome. GHG reduction potential defines technologies that will make the biggest contributions to the country's efforts for mitigating greenhouse gas emissions.

The performance of the technology, or measure on the criteria, was assessed considering the information already collated in the technological fact sheets, option page, available country knowledge and relevant experts input. The mitigation expert has prepared technological fact sheets for all listed technologies using available sources of information, including ClimateTechWiki. All stakeholders involved in the process were familiarized with the prepared technological fact sheets.

Next, the technologies were scored on a scale of 0-100 by the stakeholder group, which consisted of 11 experts. Each expert scored the listed technologies against identified criteria, giving a score of 0 to the lowest priority technology, a score of 100 to the highest priority technology, and appropriate scores to all others. For instance, if hydro-power stations at mountain rivers is the least preferred technology within the contribution to the country's development priorities criteria, the experts have given a 0 score to that technology. Conversely, if mechanical wind energy conservation technology is the most preferred technology within another criteria, the experts have given a 100 score to that technology. Then, the average score given to a particular technology within one criterion is calculated. The same process is followed for scores given to all technologies.

The results of scoring for each technology within each criterion under selected sectors are provided in table 13.

Table 13: Scoring technologies against criteria for alternative energy sources sector

Technologies	**Costs**			**Environmental development priorities**		**Social development priorities**		**Economic development priorities**	
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**
Passive solar energy (hot water) and solar photovoltaic (electricity)	100	100	80	100	80	100	100	90	90
Grid-connected wind power	80	90	100	90	100	90	90	100	100
HPPs located on the irrigation canals	90	90	90	30	40	30	40	30	40
HPPs located on mountain rivers	90	90	90	80	90	80	80	80	70
The biomass use in thermal energy production	50	60	70	10	30	50	50	40	40
The use of organic residues in the obtaining of biogas by anaerobic fermenting	40	0	50	20	20	20	20	0	20
Using the geothermal energy of national hot spring water	0	50	0	0	0	0	0	20	0

C1 – criteria of Capital Costs

C2 – criteria of O & M Costs

C3 – criteria of Cost effectiveness for mitigation

C4 – criteria of Reduced air pollution under environmental development priorities

C5 – criteria of GHG emission reduction by 2030 under environmental development priorities

C6 – criteria of Sustainable energy supply under social development priorities

C7 – criteria of Increased income due to lower energy costs under social development priorities

C8 – criteria of Balance of Payment (BoP) under economic development priorities

C9 - criteria of New employment opportunities under economic development priorities

Table 14: Most preferred and least preferred technologies for alternative energy sources sector

Technologies	Costs			Environmental development priorities		Social development priorities		Economic development priorities	
	C1	C2	C3	C4	C5	C6	C7	C8	C9
Most preferred	Passive solar energy (hot water) and solar photovoltaic (electricity)	Passive solar energy and solar photovoltaic	Grid-connected wind power	Passive solar energy and solar photovoltaic	Grid-connected wind power	Passive solar energy and solar photovoltaic	Passive solar energy and solar photovoltaic	Grid-connected wind power	Grid-connected wind power
Least preferred	Using the geothermal energy of national hot spring water	The use of organic residues in the obtaining of biogas by anaerobic fermenting	Using the geothermal energy of national hot spring water	Using the geothermal energy of national hot spring water	Using the geothermal energy of national hot spring water	Using the geothermal energy of national hot spring water	Using the geothermal energy of national hot spring water	The use of organic residues in the obtaining of biogas by anaerobic fermenting	Using the geothermal energy of national hot spring water

4.4. Results of technology prioritization

After scoring each technology within the identified criteria and determining the most and least preferred technologies within each criterion, the next step was calculating swing weight. The following formula was applied for calculation of the swing weights:

Swing weight = {(Most preferable) - (least preferable)}/ Most preferable

The results of the calculations are provided in the table below.

Table 15: Performance matrix for alternative energy sources technologies

Technologies	Costs			Environmental development priorities		Social development priorities		Economic development priorities	
	C1	C2	C3	C4	C5	C6	C7	C8	C9
Passive solar energy (hot water) and solar photovoltaic (electricity)	1.097.000.000	109.700.000	0.105	High		High	High	18.000.000	High
Grid-connected wind power					3.96 MT				
Using the geothermal energy of national hot spring water	2.500.000		0.161	Low	0.005 MT	Low	Low		Middle
The use of organic residues		410.000						12.000	
Swing value	0.9970	0.9960	-0.0005		0.9998			0.9993	

After calculating the swing weight, **weights of each criterion were determined**. This was started by giving 100 to the criteria which have shown the greatest swing in value. Since GHG emission reduction by 2030 criterion has shown the greatest swing, it was given a weight of 100 and the other criteria were weighted relative to this.

After the weights are assigned to the criteria, this weight is normalized. By using these weights, correct final relative values of these alternatives are obtained. Normalization indicated relative importance. Relative value requires that criteria be examined as to their relative importance with respect to each other. The normalization was done using the following formula:

Normalized weight = weight of criteria/total weight

Results of normalization of weights are provided in the table below.

Table 16: Normalized weights for alternative energy sources sector technologies

Technologies	Costs			Environmental development priorities		Social development priorities		Economic development priorities		Total
	C1	C2	C3	C4	C5	C6	C7	C8	C9	
Normalized weights	0.192	0.171	0.021	0.085	0.213	0.107	0.042	0.148	0.021	**1**
Weights	90	80	10	40	100	50	20	70	10	**470**

The overall weighted score was then calculated by combining the weights and scores of the most preferred technologies. Letting the preference score for option *i* on criterion *j* be represented by ***sij*** and the weight for each criterion by ***wj***, then for *n* criteria the overall score for each option, S*i*, is given by:

$$S_i = w_1 s_{i1} + w_2 s_{i2} + \ldots + w_n s_{in} = \sum_{j=1}^{n} w_j s_{ij}$$

The overall results of calculations are provided in the table below.

Table 17: Overall weighted scores for technologies under alternative energy sources sector

Technologies	Costs			Environmental development priorities		Social development priorities		Economic development priorities		Overall weighted score
	C1	C2	C3	C4	C5	C6	C7	C8	C9	
Normalized weights	0.192	0.171	0.021	0.085	0.213	0.107	0.042	0.148	0.021	**1**
Passive solar energy (hot water) and solar photovoltaic (electricity)	100	100	80	100	80	100	100	90	90	**94**
Grid-connected wind power	80	90	100	90	100	90	90	100	100	**92**
HPPs located on the irrigation canals	90	90	90	30	40	30	40	30	40	**56**
HPPs located on mountain rivers	90	90	90	80	90	80	80	80	70	**86**
The biomass use in thermal energy production	50	60	70	10	30	50	50	40	40	**43**
The use of organic residues in the obtaining of biogas by anaerobic fermenting	40	0	50	20	20	20	20	0	20	**18**
Using the geothermal energy of national hot	0	50	0	0	0	0	0	20	0	**12**

spring water										

As a result, the following technologies have received the highest overall weighted scores:

1) Passive solar energy (hot water) and solar photovoltaic (electricity) – 94

2) Grid-connected wind power – 92

3) HPPs located on mountain rivers - 86

The results of the technology prioritization process have been presented at the TNA Committee meeting for further review, discussions and endorsement. Sensitivity analysis was conducted on assessment results to evaluate the robustness of the results relative to the weights and scores applied and other uncertainties. During this exercise, the effect of uncertainties on inputs was analyzed and balance in achieving key objectives was explored. Individual technologies were compared against each other within the same categories.

At the final stage, the cost information of prioritized technologies was combined with benefit assessments for cost-benefit ratios.

The overall results of calculations are provided in the table below.

Table 18: Cost-benefit analysis for prioritized technologies under alternative energy sources sector

No.	Technology Option	Costs (USD) USD/kWh	Development benefits
1	Passive solar energy (hot water) and solar photovoltaic (electricity)	0.102-0.4	56
2	Grid-connected wind power	0.065	59
3	HPPs located on mountain rivers	0.015-0.057	51

Costs and benefits of prioritized technologies have been compared. Benefits of prioritized technologies do not vary greatly, but cost of grid-connected wind power technology is lower. Taking into account that the benefit from grid-connected wind power is relatively higher, it has been selected as a top technology.

To sum up, after conducting prioritization of technologies process using MCDA tool, for the alternative energy sector the following technologies have been prioritized:

- Grid-connected wind power;
- Passive solar energy (hot water) and solar photovoltaic (electricity);
- Small hydro-powers on mountain rivers.

All prioritized technologies are important for the country and almost all of them are reflected in the national strategy on renewable energy document that covers the period of 2012 to 2020. The government firmly intends to develop this sector and with this aim established the State Company on Alternative Energy Sources, in order to further develop and implement the policy on application of renewable energy sources.

Detailed information on prioritized technologies under the alternative energy sub-sector is given in technological fact sheets provided in Annexes.

Chapter 5. Technology prioritization for commercial and residential sector

5.1. GHG emissions and existing technologies for commercial and residential sector

The commercial and residential sector is the largest sector with energy consumers. It is also one of the most important “Energy” category sectors in terms of energy efficiency and fuel economy.

Population growth in Azerbaijan was around 1% from 1995-2010 and increased 1.3% in 2011, bringing the total population of the country to 9,111,000. Approximately 53% of the total population lived in urban areas. Increase of population and economic development leads to rise in use of energy, both in commercial and residential sectors. Increase in the volume of energy consumed comes from inefficient heating systems and lack of natural gas supplied to some rural areas. In most rural areas, people still use electrical devices with low efficiency, as well as kerosene and wood, to heat their houses and for cooking purposes. Active heating systems in some parts of the cities work inefficiently and require periodic maintenance.

CO_2 emissions from the commercial and residential sector contain all the emissions from fuel combustion in households. Data on GHG emissions from the residential and commercial sector (for 2005) was provided in the Second National Communication and was noted as being 8 888 Gg. The value for CO_2 emissions from this sector in Azerbaijan was 6.46 million metric tons as of 2008. Over the past 18 years this indicator reached a maximum value in 2008 and a minimum value of 2.39 million metric tons in 1993. This data is from the International Energy Agency; inventory of GHG in the residential and commercial sector is to be provided under the Third National Communication.

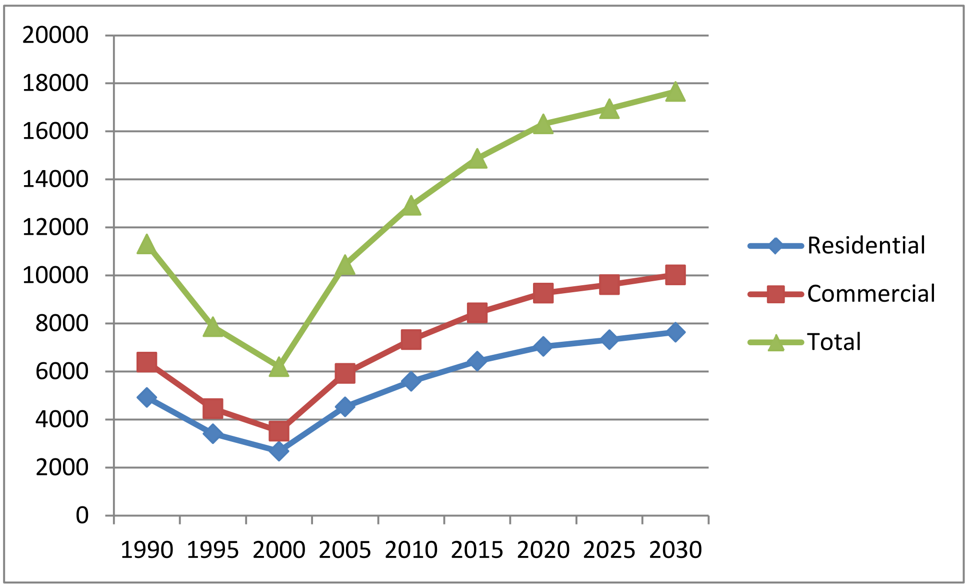

Figure 11: Forecasted GHG emission in commercial and residential sector

As it can be seen from figure 11, a sharp increase in GHG emissions is forecasted for the commercial and residential sector. In 2030, it is forecasted that the total GHG emissions from this sector will be around 17664 Gg.

In general there are many problems facing the commercial and residential sector of Azerbaijan, which require a complex solution of organizational, regulative and technological components. Installation of control and measuring equipment while the energy and natural gas are distributed, use of high efficiency lighting systems, combined heating systems in houses and buildings, heating systems using solar energy, efficient ventilation and air conditioning systems and building energy management structures are possible mitigation measures for this sector. These measures are mainly suitable to apply in urban areas. It is clear that one of the important issues in capacity building for consumers in the commercial and residential sector is change in behavior. Consumers should understand that by using less energy they not only lower their expenses, but also contribute to creating a better environment. The statistical numbers of 2010 show that total consumption of electric energy was 5.775 million kWt/hours in the residential sector and 3.478 million kWt/hours in the commercial sector. The replacement of existing light bulbs with 20 W compact fluorescent ones will result in 7.8 million kW-hours or 73% of electric power economy.

5.2. An overview of possible mitigation technology options for commercial and residential sub-sector and their mitigation benefits

In the year 1990, 21,399 Gcal of thermal energy was produced in Azerbaijan. Statistical data shows that by 1998 this volume decreased by 68%, 12% of which was due to the housing sector (Second National Communication, 2010).

During the economic transition period (1995-2005) most heating systems were completely destroyed or not operating properly. There have been developments in this sector in recent years and most of the newly constructed buildings are equipped with modern heating systems. However, additional assessments are required in order to estimate current level of application of the system (Initial National Communication).

According to IEA Heat Pump Centre, in February 2006, a 30% market penetration of heat pumps into existing heating markets would reduce global CO_2 emissions by 6%. This is equivalent to 1,500 Mt of CO_2 per annum (IEA Heat Pump Centre, 1997 and 2006).

Heat pumps can improve security of energy supply by reducing energy demand, and the small amount of electricity used can also be supplied by renewable energy generation. There are large savings in operating costs compared to conventional heating or cooling systems, although the upfront capital costs are higher.

Rough estimates provided for the capital city of Baku show that rehabilitation of heating and hot water supply systems would provide the annual saving of 383 thousand CFT of fuel and the reduction of 600 thousand tons of CO_2 emissions, on average.

Biogas technology helps improve the livelihoods of poor rural people and contributes to the reduction of greenhouse gas emissions. The use of biogas helps minimize carbon emissions caused by burning fuel wood and by the natural decomposition of organic waste. This alternative form of energy also reduces the use of fossil energy. It helps improve sanitation conditions as cattle dung is no longer burned to generate power but is channeled into biogas digesters. Biogas plants also produce organic waste that is dried and used as fertilizer.

Biogas for cooking, electricity and use of efficient stoves is mainly suitable for application in rural areas--mostly remote areas with no gas supply, dependant on wood resources. It will lead to less harm to forest resources and reduce subsequent GHG emissions.

In Azerbaijan, there is a huge potential for application of biogas in rural areas, particularly in remote communities still not supplied with gas. Along with social benefits, application of biogas reduces the amount of GHG emission. Unfortunately, the precise calculation of GHG emission reduction by application of biogas technology has not yet been provided in the country. Such estimations are expected to be made during the development of the Third National Communication.

There are a number of initiatives under different projects for the application of biogas in rural areas of the country. ALTEN GROUP is pioneering biogas plant production in Azerbaijan. In 2009, in collaboration with German and Ukrainian biogas engineers, ALTEN GROUP's pilot biogas plant was successfully constructed and installed. Subsequently, as a result of the positive response of local farmers, the company implemented biogas reactors capable of mass production at different capacities: 5, 10, 15 and 20 cubic meters. ALTEN GROUP is also designing and building a large-scale biogas plant of 250-kilowatts near Azerbaijan's capital, Baku (approximately 8 km from the city), which is to be part of a planned combined electric powerhouse consisting of a wind power farm and a solar panel plant.

The application of a modern universal system of supervision and accounting allows the establishment of a system of control and accounting of electric power, in which the loss of energy consumption is excluded.

According to estimations of local experts, annual energy consumption will decrease by 30%. The total potential of fuel economy will be 2.1 million tons of conventional fuel over 20 years and carbon dioxide emissions reduction will be 4 million tons.

The carried out calculations show that the restoration of the heating and hot water supply system will result in 383 thousand tons of conventional fuel economy and 600 thousand tons of reduction in carbon dioxide emissions in Baku.

Total potential of fuel economy is expected to be 7.7 million tons of conditional fuel within 20 years, and approximately 12 million tons of carbon dioxide emissions reduction.

Installation of control-measuring devices in flat-communal and housing sector will result in 63.2 million tons of natural gas economy and the reduction of 102.4 billion tons of CO_2 emissions within 20 years.

5.3. Criteria and process of technology prioritization

As mentioned in pervious chapters, the MCDA approach was applied during prioritizing of the possible mitigation technologies for selected sectors. MCDA uses criteria, scores and weightings, which are necessarily subjective concepts, requiring human judgment for their determination. It, therefore, acknowledges the fact that there is no such thing as an objective decision and subjective judgments are explicitly elicited, encoded and tested for coherence against uncertainties.

The mitigation experts have provided an assessment of possible technologies for mitigation in the commercial and residential sector that are most suitable for application in the country at the present time. The prepared long list of technologies has been discussed with relevant stakeholders group and the final list of possible technologies was developed (table 19).

Table 19: List of possible technologies for commercial and residential sector

Sector	Technology	Scale of application	Short, medium/long term availability
Commercial and residential sector	Installation of control and measuring equipment while the energy and natural gas are distributed	Small-scale	Medium-term
	High efficiency lighting systems	Medium-scale	Long-term
	Heating pumps	Small-scale	Medium-term
	Heating systems using solar energy	Small-scale	Long-term
	Efficient ventilation and air conditioning systems	Small-scale	Long-term
	Building energy management structures	Large-scale	Long-term
	Biogas for cooking and electricity and efficient stoves	Small-scale	Long-term

Regarding the reduction of CO_2 emissions due to application of the listed technologies, it could be mentioned that, according to statistical data of 2008 and 2009, positive results have taken place from the installation of control and measuring equipment while the energy and natural gas are distributed.

Consequently, installation of measuring equipment has resulted in the saving of 2773.5 million kVt-hours of energy and the reduction of approximately 1.78 MT of CO_2 emissions.

Regarding the high efficiency lighting systems, one family consisting of 4 persons on average light at least 15 light bulbs for 2 hours. This will amount to 1095 kVt of used electricity for one year. By using energy saving light bulbs that are 5 times more efficient than the traditionally used ones, total used electricty for one year will be 216 kVt. Therefore, 879 kVt less energy will be used, which will lead to a reduction of 0.56 tons of CO_2 emission.

During the stakeholder-driven assessment process of possible technologies, experts have decided to combine biogas for cooking and electricity and efficient stoves together, as they have some similarities and doing so would not minimize their effects on GHG emissions.

The mitigation expert has provided assessment of current national priorities identified in national strategic programs, sector policies, action plans and other documents, including the Second National Communication. As a result of intensive discussions with the stakeholders group, the following sets of criteria were defined to prioritize technologies for commercial and residential sub-sector under costs and benefits:

Table 20: Criteria for commercial and residential sub-sector under cost and benefits

Criteria	Definition
Cost	
Capital Costs (Infrastructure, etc.)	It includes number of technology units established and its costs. Generally, for commercial and residential sub-sector, infrastructures and equipment are built by government or private sector.
O & M Costs	These include costs incurred from maintaining infrastructures.
Cost effectiveness for mitigation	Cost effectiveness for mitigation is calculated on the basis of grid emission factor (that was equal to 0.620 $kgCO_2/kWh$ in 2006) and price of produced energy (USD per kWh). For the heat energy saving technologies, cost effectiveness for mitigation is calculated on the basis of the specific conception.
Environmental Development Priorities	
Reduced air pollution	Improving air quality by reducing air pollutants such as SOx, NOx, suspended particulate matter, non-methane volatile organic compounds, dust, fly ash and odor.
GHG emission reduction by 2030	Reduction in GHG emissions by 2030 through promotion of clean energy and efficient technologies in energy production.
Social Development Priorities	
Sustainable energy supply	Application of new technologies will lead to sustainable energy supply.
Improved living conditions	Application of new technologies will lead to improved living conditions of population (e.g. stable energy and heat supply).
Economic Development Priorities	
Balance of Payment (BoP)	Reduction in the use of organic fuel, with the possibility of using the saved fuel for organic chemical industry and other sectors of national economy. Application of measuring technologies will lead to decrease of energy and heat losses, leading to economic benefits.

Relevance to development priorities defines climate change mitigation technologies that offer the greatest value to the country in meeting its current national development priorities. Implementation potential defines scale of implementation and diffusion of the technology, which can be realistically achieved if key barriers are overcome. GHG reduction potential defines technologies that will make the biggest contributions to the country's efforts for mitigating greenhouse gas emissions.

The performance of the technology, or measure on the criteria, was assessed considering the information already collated in the technological fact sheets, option page, available country knowledge and relevant experts input. The mitigation expert has prepared technological fact sheets for all listed technologies using available sources of information, including ClimateTechWiki. All stakeholders involved in the process were familiarized with the prepared technological fact sheets.

Next, the technologies were scored on a scale of 0-100 by the stakeholder group, which consisted of 11 experts. Each expert scored the listed technologies against identified criteria, giving a score of 0 to the lowest priority technology, a score of 100 to the highest priority technology, and appropriate scores to all others. For instance, if hydro-power stations at mountain rivers is the least preferred technology within the contribution to the country's development priorities criteria, the experts have given a 0 score to that technology. Conversely, if mechanical wind energy conservation technology is the most preferred technology within another criteria, the experts have given a 100 score to that technology. Then, the average score given to a particular technology within one criterion is calculated. The same process is followed for scores given to all technologies.

The results of scoring for each technology within each criterion under selected sectors are provided in table 21.

Table 21: Scoring technologies against criteria for commercial and residential sector

Technologies	**Costs**			**Environmental development priorities**		**Social development priorities**		**Economic development priorities**
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
Installation of control and measuring equipment while the energy and natural gas are distributed	0	0	60	70	60	0	60	80
High efficiency lighting systems	100	20	100	100	100	30	80	100
Heating pumps	90	100	90	80	90	100	100	90
Heating systems using solar energy	60	60	50	60	60	10	30	30
Efficient ventilation and air conditioning systems	40	70	30	40	0	20	0	0
Building energy management structures	90	30	0	0	40	40	10	40
Biogas for cooking and electricity and efficient stoves	70	50	20	30	50	60	70	50

C1 – criteria of Capital Costs

C2 – criteria of O & M Costs

C3 – criteria of Cost effectiveness for mitigation

C4 – criteria of Reduced air pollution under environmental development priorities

C5 – criteria of GHG emission reduction by 2030 under environmental development priorities

C6 – criteria of Sustainable energy supply under social development priorities

C7 – criteria of Improved living conditions under social development priorities

C8 – criteria of Balance of Payment (BoP) under economic development priorities

Table 22: Most preferred and least preferred technologies for commercial and residential sector

Technologies	Costs			Environmental development priorities		Social development priorities		Economic development priorities
	C1	C2	C3	C4	C5	C6	C7	C8
Most preferred	High efficiency lighting systems	Heating pumps	High efficiency lighting systems	High efficiency lighting systems	High efficiency lighting systems	Heating pumps	Heating pumps	High efficiency lighting systems
Least preferred	Installation of control and measuring equipment while the energy and natural gas are distributed	Installation of control and measuring equipment while the energy and natural gas are distributed	Building energy management structures	Building energy management structures	Efficient ventilation and air conditioning systems	Building energy management structures	Efficient ventilation and air conditioning systems	Efficient ventilation and air conditioning systems

5.4. Results of technology prioritization

After scoring each technology within the identified criteria and determining the most and least preferred technologies within each criterion, the next step was calculating swing weight. The following formula was applied for calculation of the swing weights:

Swing weight = {(Most preferable) - (least preferable)}/ Most preferable

The results of the calculations are provided in the table below.

Table 23: Performance matrix for technologies under commercial and residential sector

Technologies	Costs			Environmental development priorities		Social development priorities		Economic development priorities
	C1	C2	C3	C4	C5	C6	C7	C8
High efficiency lighting systems	936.000.000		0.054	High	90 MT			2.418 MT of conditional fuel
Heating pumps		100.000.000				High	High	
Installation of control and measuring equipment while the energy and natural gas are distributed	25.000.000	2.500.000						

Building energy management structures			0.081	Medium		Medium	Low	
Efficient ventilation and air conditioning systems					7.2 MT			125 MT
Swing value	0.973	0.975	-0.05		0.920			0.948

After calculating the swing weight, **weights of each criterion were determined**. This was started by giving 100 to the criteria which have shown the greatest swing in value. Since the criterion of O & M costs has shown the greatest swing, it was given a weight of 100 and the other criteria were weighted relative to this.

After the weights are assigned to the criteria, this weight is normalized. By using these weights, correct final relative values of these alternatives are obtained. Normalization indicated relative importance. Relative value requires that criteria be examined as to their relative importance with respect to each other.

The normalization was done using the following formula:

Normalized weight = weight of criteria/total weight

Results of normalization of weights are provided in the table below.

Table 24: Normalized weights for technologies under commercial and residential sector

Technologies	Costs			Environmental development priorities		Social development priorities		Economic development priorities	Total
	C1	C2	C3	C4	C5	C6	C7	C8	
Normalized weights	0.18	0.2	0.02	0.12	0.14	0.1	0.08	0.16	**1**
Weights	90	100	10	60	70	50	40	80	**500**

The overall weighted score was then calculated by combining the weights and scores of the most preferred technologies. Letting the preference score for option *i* on criterion *j* be represented by ***sij*** and the weight for each criterion by ***wj***, then for *n* criteria the overall score for each option, S*i*, is given by:

$$S_i = w_1 s_{i1} + w_2 s_{i2} + \ldots + w_n s_{in} = \sum_{j=1}^{n} w_j s_{ij}$$

The overall results of calculations are provided in the table below.

Table 25: Overall weighted scores for technologies under commercial and residential sector

Technologies	Costs			Environmental development priorities		Social development priorities		Economic development priorities	Overall weighted score
	C1	C2	C3	C4	C5	C6	C7	C8	
Normalized weights	0.18	0.2	0.02	0.12	0.14	0.1	0.08	0.16	**1**
Installation of control and measuring equipment while the energy and natural gas are distributed	0	0	60	70	60	0	60	80	**36**
High efficiency lighting systems	100	20	100	100	100	30	80	100	**75**
Heating pumps	90	100	90	80	90	100	100	90	**93**
Heating systems using solar energy	60	60	50	60	60	10	30	30	**48**
Efficient ventilation and air conditioning systems	40	70	30	40	0	20	0	0	**29**
Building energy management structures	90	30	0	0	40	40	10	40	**39**
Biogas for cooking and electricity and efficient stoves	70	50	20	30	50	60	70	50	**53**

As a result, the following technologies have received the highest overall weighted scores:

1) Heating pumps – 93

2) High efficiency lighting systems – 75

3) Biogas for cooking and electricity and efficient stoves - 53

The results of the technology prioritization process have been presented at the TNA Committee meeting for further review, discussions and endorsement. Sensitivity analysis was conducted on assessment results to evaluate the robustness of the results relative to the weights and scores applied and other uncertainties. During this exercise, the effect of uncertainties on inputs was analyzed and balance in achieving key objectives was explored. Individual technologies were compared against each other within the same categories.

At the final stage, the cost information of prioritized technologies was combined with benefit assessments for cost-benefit ratios.

The overall results of calculations are provided in the table below.

Table 26: Cost-benefit analysis for prioritized technologies under commercial and residential sector

No.	Technology Option	Costs (USD) USD/kWh	Development benefits
1	Heating pumps	1.53	55
2	High efficiency lighting systems	0.13	51
3	Biogas for cooking and electricity and efficient stoves	0.66	30

Costs and benefits of prioritized technologies have been compared. Benefits of heating pumps and high efficiency lighting systems do not vary greatly, but cost of heating pumps is higher than the other two technologies. Biogas for cooking and electricity and efficient stoves has lower benefits. Taking into account the results of the cost-benefit analysis, high efficiency lighting systems and heating pumps have been selected as top technologies.

To sum up, after conducting prioritization of technologies process using MCDA tool, for the alternative energy sector the following technologies have been prioritized:

- High efficiency lighting systems;
- Heating pumps;
- Biogas for cooking and electricity and efficient stoves.

All prioritized technologies are important for the country and almost all of them are reflected in the national programs of the country.

Detailed information on prioritized technologies under the alternative energy sub-sector is given in technological fact sheets provided in Annexes.

Lastly, sensitivity analysis was conducted on assessment results to evaluate the robustness of the results relative to the weights and scores applied and other uncertainties. Analysis provided by experts proved that the top three prioritized technology measures for the commercial and residential sector are priority mitigation technologies according to all the experts. Analysis showed that, for most technologies, expert judgments did not vary significantly.

Chapter 6. Summary / Conclusions

The TNA preparation process was conducted by applying methodology adjusted to country-specific circumstances of Azerbaijan. The TNA exercise has been conducted through the preliminary overview of options and resources, institutional arrangements and stakeholder engagement, establishing criteria for selecting mitigation measures priorities, defining priority sectors and sub-sectors, in-depth analyses, assessment and stakeholder consultation, and finally selection of priority measures using MCDA approach.

According to technology needs assessment process, which was performed by national experts, the following sectors have been selected as priorities:

- Alternative energy sources sub-sector
- Commercial and residential sub-sector

It should be mentioned that intensive debates were held, particularly on the selection from 2 sectors: oil and gas production and commercial and residential sector. These sectors are included to the energy category, which itself generates 90% of GHG emissions. Analyses of information from the Initial and Second Communications show that emissions from the commercial and residential sector are higher than oil and gas production sector. Moreover, the commercial and residential sector is becoming increasingly important as the country's population and economy grows year-by-year. Therefore, after a number of serious discussions, in keeping with the provided evaluation, the commercial and residential sector was identified as a higher priority than the oil and gas production sector.

Following the TNA methodology, national experts have prepared a long list of possible technologies for both sectors and technological fact sheets for each listed technology. Based on current national strategy documents and expert judgments, the following criteria were selected for prioritization of mitigation technologies under cost and benefit clusters:

Costs:

- Capital costs, O & M costs and cost effectiveness for mitigation

Benefits:

- Reduced air pollution under environmental development priorities;
- GHG emission reduction by 2030 under environmental development priorities;
- Sustainable energy supply under social development priorities;
- Improved living conditions under social development priorities;
- Balance of Payment (BoP) under economic development priorities.

Based on the provided materials and the application of TNA methodology and MCDA approach, the following technologies have been prioritized for the above-mentioned sectors:

For alternative energy sources sector:

- Grid-connected wind power;
- Passive solar energy (hot water) and solar photovoltaic (electricity);
- Small hydro-powers on mountain rivers.

For commercial and residential sector:

- High efficiency lighting systems;
- Heating pumps;
- Biogas for cooking and electricity and efficient stoves.

The next activities under TNA/TAP process are assessment of barriers in the application and implementation of prioritized technologies and preparation of TAP.

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Annex I. Technological Fact Sheets

Alternative energy sources technological fact sheets

Technological fact sheet (1)

Sector	Alternative energy sources
Sub-sector	Wind power plants
Technology name	Grid-connected wind power
Option name	
Scale	Large-scale
Availability	Available

Background/notes

Wind energy has great resource potential in most of the territories of Azerbaijan. The average annual wind speed of Absheron Peninsula, which is considered the windiest area, ranges from 5.8–8.0 m/s. The number of windy days in this area is between 245-280 days. The average annual wind speed of Nakhchivan Autonomous Republic is 1.9-2.7 m/s. The increase in the annual course of wind regime is recorded in the summer. The wind speed reaches 3.4-5.5 m/s from June to September. The average annual wind speed in the western regions of the Greater Caucasus is 0.8-2.3 m/s, while in the eastern regions it is 1.9-3.2 m/s. Annual increase in wind speed is recognized in the western regions from December to April, and from November to March in the eastern regions. The average annual wind speed is 1.8-2.4 m/s in the Lesser Caucasus. A slight increase in annual wind speed is observed at 2.8-3.2 m/s from April to December. The average annual wind speed is 1.8-2.4 m/s in the Central and lowland areas.

There are relevant governmental programs for the development of wind energy in the country. Azerbaijan has adopted State Program on utilization of alternative energy, including the wind energy sources (2005 – 2013). The objective of this State Program is to promote power generation from renewable and environmentally sound sources and to more efficiently utilize hydrocarbon energy sources. According to the program, Azerbaijan has set a target to have 20% share of renewable energy in electricity and 9.7% share of RE in total energy consumption by 2020. On 29 December 2011, the President of Azerbaijan Republic issued an order on preparation of National Strategy on the use of alternative energy for the period of 2012-2020. The main objectives of the strategy are to identify main directions of electricity from wind energy sources and legal framework for usage of wind energy sources.

- The State Company on alternative energy was recently established by Presidential Decree;
- There is cooperation with international companies on the production of wind techniques;
- The technology of wind turbines was implemented, as 2 MW turbines were constructed recently by SOCAR and private companies;
- There is experience on preparation of national technical specialists.

Advantages of the technology:

- The technology can be used in regions located far from the industrial centers;
- The technology can be used to supply electricity to individual households or used with combined regime with electricity grid;
- The technology can reduce grid electricity consumption and decrease use of organic fuels, thereby minimizing environmental effects due to emission reductions to soil, water and atmosphere air (CO_2, SO_2, NO_x etc.);
- The technology is ready for industrial application;
- Modern wind turbines have a low speed (20-40 rotations per minute) and their air-dynamics is very rigorously projected, following the goal of reducing the noise level to a minimum.

Disadvantages of the technology:

- Relatively high cost of equipment;
- There is need for financial support;
- Weak development of the national industry for production of wind techniques;
- Weak public awareness on wind energy advantages;
- As there are some negative effects related to electromagnetic and phonic pollution, there may be disruption to planted lands and landscape change;
- Requires environmentally sound location.

Implementation assumptions

According to evaluation conducted by various experts, Azerbaijan has 800-1500 MW annual wind energy resources. This reserve means 2.4 billion kW/h of electric power, which in turn can result in up to 1 million tons of conditional fuel economy annually. As a result of investigations carried out, based on long-term observations, it was determined that the most favorable wind conditions of Azerbaijan are in Absheron Peninsula, Caspian Sea coastal zone and in its islands.

- Installed capacity of the WPP with 3 MWt;
- Air generator (AG) type deWind D6;

- Yearly energy volume produced by the power station -- 11,037 kWh/year; - Actualized energy volume W_a produced during the entire period of the power stations life – 83,947 kWh; - Investment in the WPP -- 4,117 Euro; - Specific investment in the WPP – 1.37 Euro/ kW; - Price of the produced energy – 0.052 Euro/ kWh.	
Impact statements **(How the options impact countries development priorities)**	
Countries social development priorities	• Creates employment opportunities. Typically a capacity of 1 kW of wind energy creates work for 15-19 persons. • The growth of wind energy could contribute considerably to state energy security consolidation. • The implementation of wind energy sources would have a positive influence on public opinion, which would realize the necessity to protect the environment and reduce consumption of energy resources.
Countries economic development priorities	• External costs of electricity generated by wind energy were about 0.05-0.2 Euro/kWh. The production cost of grid electricity in Azerbaijan is 0.04 AZN/kWh. • Development of the national wind energy industry will decrease the initial capital investment.
Countries environmental development priorities	• Decreases SO_2 and NO_x emissions, which have a negative impact on woods, crops, generally on vegetation and particularly on the endangered species, by replacing grid electricity conception. • Technology is zero emission. • Technology is environmentally sound.
Reduction in GHG emissions over 30 years	Total GHG emission reduction for the year 2030 will be 3.96 mln ton CO_2.
Costs	
Capital costs	Based on rough calculations, there is a potential for producing 800 MW of wind energy in Azerbaijan. Taking into account that the production of 3 MW of energy requires a 4,117,000 Euro investment, total capital costs will be around 1,097,000,000 Euro.
Operational & maintenance costs	Amortization costs of the equipment may be considered as 10% of total cost per year.
Cost of GHG reduction	- Emission factor of the grid is 0.62 kg CO_2 /kWh (in 2006) - Price of the produced energy is 0.052 Euro/kWh Therefore, cost effectiveness for mitigation is 0.052/0.62 Euro per kg (CO_2) = 0.084 Euro per kg (CO_2) or 1.25 x 0.084 USD per kg (CO_2) = 0.105 USD per kg (CO_2)
Other costs	Additional costs may be needed to provide awareness-raising activities among local population and commercial sector in order to promote application of wind energy.

Technological fact sheet (2)

Sector	Alternative energy sources
Sub-sector	Solar energy
Technology name	Passive solar energy (hot water) and solar photovoltaic (electricity)
Option name	
Scale	Small-scale
Availability	Available

Background/notes

Solar energy has great resource potential in most of the territories of Azerbaijan. The number of annual sunshine hours in Azerbaijan is 2400-3200 hours. The quantity of solar energy received by each square meter of the earth's surface during a year is 1500-2000 kWh/m^2. Annual electric energy production of photovoltaic unit is 246 kWh/m^2 in the Nakhchivan AR area and 230 kWh/m^2 in the Kur-Absheron area, while the number of annual sunshine hours in Nakhchivan AR is 3200 and 2500 in the Kur-Absheron area. The quantity of annual solar energy per square meter is 2200-2600 kWh in Nakhchivan AR and 1900-2200 kWh in the Kur-Absheron area. There are relevant governmental programs for the development of solar energy in the country. Azerbaijan has adopted State Program on utilization of alternative energy, including the solar energy sources (2005 – 2013). The objective of this State Program is to promote power generation from renewable and environmentally sound sources and to more efficiently utilize hydrocarbon energy sources. According to the program, Azerbaijan has set a target to have 20% share of renewable energy in electricity and 9.7% share of RE in total energy consumption by 2020. On 29 December 2011, the President of Azerbaijan Republic issued an order on preparation of National Strategy on the use of alternative energy for the period of 2012-2020. The main objectives of the strategy are to identify main directions of electricity from solar energy sources and legal framework for usage of solar energy sources.

- The State Company on alternative energy was recently established by Presidential Decree;
- Technical capacity for solar energy is developed. The establishment of the new company Sumgait Technology Park, produced the solar collectors for production of hot water;
- There is cooperation with international companies on the production of solar energy techniques;
- The technology of solar collectors and panels was implemented, as solar collectors used by SOCAR are widely used by the population for private purposes;
- There is experience on preparation of national technical specialists.

Advantages of the technology:

- The technology can be used in regions located far from the industrial centers;
- The technology can be used to supply electricity and heat to individual households or used with combined regime with electricity grid;
- The technology can reduce grid electricity consumption and decrease use of organic fuels, thereby minimizing environmental effects, due to emission reductions to soil, water and atmosphere air (CO_2, SO_2, NO_x etc.);
- The technology is ready for industrial application.

Disadvantages of the technology:

- Relatively high cost of equipment;
- There is need for financial support;
- Weak development of the national industry for production of solar techniques;
- Weak public awareness on solar energy advantages;
- Dependant on weather conditions;
- Does not work during night period;
- Requires combined regime of operating.

Implementation assumptions (How the technology will be implemented and diffused across the sub-sector)	a) Solar installations for hot water production - area of the collector – 219 m^2 - volume of the reservoir – 5 m^3 - specific price – 637 USD/m^2 - volume of the produced energy – 2.25 MWh/year - price of thermal energy – 0.102 USD/kWh By 2030, for the use of collectors with the area of 10,000 m^2, there will be a need for 637 USD/m^2 x 10,000 m^2 = 6,370,000 USD b) photoelectric system - Investment - 3700 – 6800 USD kW - price of produced energy – 0.12 – 0.53 USD kWh at 3% By 2030, investment for construction of 3000 kWh average 5,000 USD = 15,000,000 USD

Impact statements (How the options impact countries development priorities)	
Countries social development priorities	• Creates new employment opportunities. • The implementation of solar energy sources would have a positive influence on public opinion, which would realize the necessity to protect the environment and reduce consumption of energy resources.
Countries economic development priorities	• The economic effects depend on technological application (solar stations for water heating, installations for drying fruits and vegetables, photovoltaic electricity).
Countries environmental development priorities	• Technology is zero emission. • Technology is environmentally sound. • Produced thermal or electricity substitutes for the organic fuel using in grids.
Reduction in GHG emission over 30 years	417 thousand ton CO_2.
Costs	
Capital costs	21,370,000 USD
Operational & maintenance costs	Amortization costs of the solar equipment may be considered as 10% of total cost per year.
Cost of GHG reduction	- Emission factor of the grid is 0.62 kg CO_2 /kWh (in 2006) - Price of the produced energy: a) Solar installations for hot water production are 0.102 USD/kWh - Cost effectiveness for mitigation is 0.102/0.62 = 0.16 USD per kg (CO_2) b) photoelectric system Cost effectiveness for mitigation is (0.12÷0.53)/0.62 = 0.19÷0.85 USD per kg (CO_2)
Other costs	Additional costs may be needed to provide awareness-raising activities among local population and commercial sector in order to promote application of solar energy.

Technological fact sheet (3)

Sector	Alternative energy sources
Sub-sector	Small hydro-power plants
Technology name	Small hydro-power plants at mountain rivers
Option name	
Scale	Medium-scale
Availability	Available
Technology to be included in prioritization?	Yes

Background/notes

Small hydro-power potential in Azerbaijan is about 5 bln kWh. Economically efficient resources are about 1.7 bln kWh. Currently, small HPPs are partially running in different regions of the country, such as the 1.6 MW Sheki HPP, 1.2 MW Gusar HPP, 3.0 MW Chichekli HPP, 0.8 MW Chinarly HPP, 8.8 MW Zeykhur HPP, 0.8 MW Nyugedi HPP and 3.8 MW Mugan HPP. These small HPPs have been provided for privatization in 2001 by AR Presidential Decree; three small HPPs are already privatized. In general, the operating life of these small HPPs is over as they had been erected between 1950-1960 and they are currently over 70-80% deteriorated. Some of them are fully dismantled. Future construction of 173 small HPPs with an annual output of 3.2 bln kWh of electric energy is in the works. More reasonable is the construction of 61 small HPPs, which are efficient and economical in the short- term perspective. These HPPs may be erected on irrigation canals, trained (control-flow) rivers, or near the water-storage reservoirs.

There are relevant governmental programs for the development of small hydro-power energy in the country. Azerbaijan has adopted State Program on utilization of alternative energy, including the small hydro-power energy sources (2005 – 2013). The objective of this State Program is to promote power generation from renewable and environmentally sound sources and to more efficiently utilize hydrocarbon energy sources. According to the program, Azerbaijan has set a target to have 20% share of renewable energy in electricity and 9.7% share of RE in total energy consumption by 2020. On 29 December 2011, the President of Azerbaijan Republic issued an order on preparation of National Strategy on the use of alternative energy for the period of 2012-2020. The main objectives of the strategy are to identify main directions of electricity from small hydro-power energy sources and legal framework for usage of small hydro-power energy sources.

- There is cooperation with international companies on the production of small hydro-power plants;
- The practices of small hydro plants were gained;
- There is experience on preparation of national technical specialists.

Advantages of the technology:

- They may be located close to energy consumers;
- Losses occurring during the long distance transportation of the energy are low;
- Smaller HPPs conserve the natural landscape;
- Smaller HPPs eliminate the possibility of GHG emissions.

Disadvantages of the technology:

- The technology depends on the geographical climate and relief conditions.

Implementation assumptions (How the technology will be implemented and diffused across the sub-sector)	Construction of hydro-power plants has an important role in resolution of country-level issues such as regulation of floodwaters, environmentally sound electricity generation and creation of new irrigation systems. It is possible to locate dozens of small hydro-power plants on rivers and water facilities, and these plants can generate up to 3.2 billion kWh annually. The technical potential for energy production is 4.9 billion kW-hours and economic cost-effective potential is 1.7 billion kW-hours. The amount of fuel economy is 0.57 million tons. There are sample opportunities to use small HPPs to supply power to establishments that are lacking permanent electric energy as well as those located far from the State energy system.
Impact statements (How the options impact countries development priorities)	
Countries social development priorities	• Creates employment opportunities. • The implementation of small hydro-power energy sources would have a positive influence on public opinion, which would realize the necessity to protect the environment and reduce consumption of energy resources.
Countries economic development priorities	• There is investment opportunity for 8-10% of bank interest annually. • The price of 1 kWh energy ranges from 1.5-5.7 USD.
Countries environmental development priorities	• Technology is zero emission and environmentally sound.
Reduction in GHG emission by 2030	• Reduction of carbon dioxide emissions by 2030 is 3.24 mln ton CO_2.
Costs	
Capital costs	By 2030, 164 small HPPs with an average power of 2 MW are planned on being established. Taking into account that the investment cost for production of 1 kW of electricity is around 2000 USD, total capital costs will be around 656,000,000 USD.
Operational & maintenance costs	There will be a need for operation and maintenance costs to establish small hydro-power stations, such as salary for staff, repair and protection, etc.
Cost of GHG reduction	- Emission factor of the grid is 0.62 kg CO_2 /kWh (in 2006) - Price of the produced energy power is 25 – 75 USD/kW - Price of the produced energy (0.011÷0.078) USD/kWh Therefore, cost effectiveness for mitigation is (0.011÷0.078)/0.62 = (0.018÷0.126) USD per kg (CO_2)
Other costs	***

Commercial and residential sector technological fact sheets

Technological fact sheet (4)

Sector	Commercial and residential sector
Sub-sector	
Technology name	High efficiency lighting systems
Option name	
Scale	Small-scale
Availability	Available
Technology to be included in prioritization?	Yes

Background/notes

Lighting generates greenhouse gas emissions of 1,900 Mt of CO_2 per year, which is the equivalent of 70% of the emissions from the world's light passenger vehicles. According to the IEA, lighting ranks among the major end-uses in global power demand. Lighting represented 650 mtoe of primary energy consumption and 2550 TWh of electricity consumption in 2005. Therefore, grid-based electric lighting is equivalent to 19% of total global electricity production. Statistics supplied by the IEA report (2006) show that lighting requires as much electricity as is produced by all gas-fired generation or 1265 power plants. Of this amount, the major consumption sectors are commercial at 43%, residential at 31%, industrial at 18%, and outdoor stationary sources at 8%.

Advantages of the technology:

High efficiency lighting systems generate savings in energy costs over their lifetime and provide a reliable lighting service. They also create jobs in manufacturing and retail. As electricity supply is still limited in many developing countries, reducing demand by providing more efficient lighting is a positive step for their economies. It also contributes to security of energy supply as they make a significant contribution to the reduction in electricity demand.

***Disadvantages of the technology**:*

Initial costs of the bulbs are high. However, due to other savings, they provide additional future benefits. Consumers may need to be provided with awareness-raising activities to understand this trend.

Implementation assumptions (How the technology will be implemented and diffused across the sub-sector)	Commercial and residential sector is a major part of consumer segment in electricity. Statistical numbers of 2010 show that total electric energy consumption of the residential sector was 5.075 million kWt/hours and 3.478 million kWt/hours in the commercial sector. The replacement of existing bulbs with 20-25 W compact fluorescent ones will result in 7.800 million kW-hours or 73% of electric power economy.

Impact statements (How the options impact countries development priorities)	
Countries social development priorities	• Improved livelihood of population by reducing energy costs.
Countries economic development priorities	• Contributes to security of energy supply. • Generates new manufacturing sector leading to reviving of that economic sector.
Countries environmental development priorities	• Contributes to government strategy to provide more environmentally sound energy supply.
Reduction in GHG emission by 2030	• Rough estimate of GHG reduction is 90 MT.
Costs	
Capital costs	Price of one bulb depends on quality and manufacturer. On average, price of one bulb is about 2-3 USD. Total capital costs in the case of full replacement (312 million bulbs) will be 936 million USD.
Operational & maintenance costs	none
Cost of GHG reduction	0.087 USD per kg CO_2.
Other costs	Additional costs may be needed to increase awareness level of consumers to promote the application of high efficiency lighting system.

Technological fact sheet (5)

Sector	Commercial and residential sector
Sub-sector	
Technology name	Heating pumps
Option name	
Scale	Small-scale
Availability	Available
Technology to be included in prioritization?	Yes

Background/notes

According to IEA Heat Pump Centre, in February 2006, a 30% market penetration of heat pumps into existing heating markets would reduce global CO_2 emissions by 6%. This is equivalent to 1,500 Mt of CO_2 per annum (IEA Heat Pump Centre, 1997 and 2006).

Heat pumps can improve security of energy supply by reducing energy demand, and the small amount of electricity used can also be supplied by renewable energy generation. There are large savings in operating costs compared to conventional heating or cooling systems, although the upfront capital costs are higher. Heat pumps can be applied in the following places:

- Swimming pools and other large-scale low-temperature uses (*e.g*. greenhouses);
- Hotels;
- Schools;
- Government buildings;
- Commercial buildings;
- Apartment buildings;
- Domestic space and water heating.

In the year 1990, 21,399 Gcal of thermal energy was produced in Azerbaijan. Statistical data shows that by 1998 this volume decreased by 68%, 12% of which was due to the housing sector.

Advantages of the technology:

The system is more energy efficient.

***Disadvantages of the technology**:*

Although running costs are lower, investment costs for the equipment is high.

Implementation assumptions (How the technology will be implemented and diffused across the sub-sector)	During the economic transition period (1995-2005) most heating systems were completely destroyed or not operated properly. There have been developments in this sector in recent years and most of the newly constructed buildings are equipped with modern heating systems. However, additional assessments are required in order to estimate current level of application of the system. Rough estimates provided for the capital city of Baku show that rehabilitation of heating and hot water supply systems would provide the annual saving of 383 thousand CFT of fuel and the reduction of 600 thousand tons of CO_2 emissions, on average.
Impact statements (How the options impact countries development priorities)	
Countries social development priorities	• Improved livelihood of population by reducing energy costs.
Countries economic development priorities	• Contributes to security of energy supply.
Countries environmental development priorities	• Contributes to government strategy to provide more environmentally sound energy supply.
Reduction in GHG emission by 2030	Rough estimate of reduction of GHG is 8 MT.
Costs	

Capital costs	Heat pumps are considerably more expensive than boilers, although running costs are much lower. Costs of the equipment depend on size of house or building. Rough estimates for application of combined heating system throughout the country is 1 billion USD (considering 4,000 USD cost per equipment).
Operational & maintenance costs	Amortization costs of the equipment may be considered as 10% of total cost per year.
Cost of GHG reduction	0.06 USD per $kgCO_2$.
Other costs	**

Technological fact sheet (6)

Sector	Commercial and residential sector
Sub-sector	
Technology name	Biogas for heating and electricity and efficient stoves
Option name	
Scale	Small-scale
Availability	Available
Technology to be included in prioritization?	Yes

Background/notes

Biogas for cooking and electricity and use of efficient stoves is mainly suitable for application in rural areas--mostly remote areas with no gas supply and dependant on wood resources. It will lead to less harm to forest resources and reduce subsequent GHG emissions.

Biogas is a gaseous mixture generated during anearobic digestion processes using wastewater, solid waste (e.g. at landfills), organic waste (e.g. animal manure), and other sources of biomass. Biogas can be produced on a very small scale for household use, mainly for cooking and water heating.

A small domestic biogas system will typically consist of the following components:

- Manure collection: raw, liquid, slurry, semi-solid and solid manure can all be used for biogas production;
- Anaerobic digester: the digester is the component of the manure management system that optimizes naturally occurring anaerobic bacteria to decompose and treat the manure while producing biogas;
- Effluent storage: the products of the anaerobic digestion of manure in digesters are biogas and effluent. The effluent is a stabilized organic solution that has value as a fertilizer and other potential uses. Waste storage facilities are required to store treated effluent, as the nutrients in the effluent cannot be applied to land and crops year round;
- Gas handling: piping; gas pump or blower; gas meter; pressure regulator; and condensate drain(s);
- Gas use: a cooker or boiler.

Advantages of the technology:

Biogas can make a positive contribution to multiple goals in government programmes. It has the potential to become one of the most efficient and economical sources of renewable fuel with anaerobic digestion, and economically viable technology for small-scale rural applications in developing countries.

Disadvantages of the technology:

Possible negative aspects of the biogas installations are the potential reduction in soil fertility since animal dung is now used as feedstock for the biogas installation instead of for fertilization. Another potential problem is related to the possible build-up of pathogens (worms, protozoa and some fatal bacteria such as salmonella) in the biogas system.

Implementation assumptions (How the technology will be implemented and diffused across the sub-sector)	In Azerbaijan, there is a huge potential for application of biogas in rural areas, particularly in remote communities still not supplied with gas. Along with social benefits, application of biogas reduces the amount of GHG emission.

	There are a number of initiatives under different projects for the application of biogas in rural areas of the country. ALTEN GROUP, a private company, is pioneering biogas plant production in Azerbaijan.
Impact statements (How the options impact countries development priorities)	
Countries social development priorities	• Improves livelihood of rural population. • Provides sustainable energy supply.
Countries economic development priorities	• Contributes to socio-economic development program in various regions of the country. • Improves security of energy supply.
Countries environmental development priorities	• Keeping manure and waste in a confined area and processing them in the digester reduces the amount of pollutants in the immediate environment and increases sanitation; • Households no longer need to extract wood for cooking, which can reduce deforestation levels in areas where people heavily rely on wood fuel; • The sludge remaining after digestion is a good fertilizer, increasing land productivity (and farm incomes); • The release of methane is avoided, thus contributing to climate mitigation.
Reduction in GHG emission by 2030	Rough estimate of reduction of GHG is 1.7 MT.
Costs	
Capital costs	A rough estimate of costs of a simple, unheated biogas plant, including all essential installations but not including land, is between 75-100 USD per m^3 capacity. About 35 - 40% of the total costs are for the digester. Price estimates for the cost of a small household unit is somewhere between 2000-2500 USD. Rough estimates for capital costs will be 1,800,000,000 USD.
Operational & maintenance costs	The equipment requires, on average, 10% operational or maintenance expenses – 180,000,000 USD.
Cost of GHG reduction	0.055 USD per $kgCO_2$.
Other costs	Additional expenses will be needed for raising awareness of rural population on application of the technology.

Annex II. List of stakeholders involved and their contacts

Steering Committee Members

No.	Position	Agency	Names
1.	Head of Steering Committee	Deputy Minister of Ecology and Natural resources	F.Aliyev
2..	Secretary of the Steering Committee	Head of international relations division MENR	E.Garabagly
3.	Steering Committee Member	UNFCCC focal point of Azerbaijan Republic	I.Aliyev
4.	Steering Committee Member	Director of National Hydrometeorology department	R.Mahmudov
5.	Steering Committee Member	Head of Environment department/ State Oil Company (SOCAR)	A.Aliyev
6.	Steering Committee Member	Deputy Director of State Company of Alternative and Renewable Energy Sources of Azerbaijan Republic	C.Melikov
7.	Steering Committee Member	Deputy director of phytosanitary Service of Ministry of Agriculture	Y.Ibrahimov
8.	Steering Committee Member	Head of environment department/ “Azerenergy” agency	Z.Mammadova
10.	Steering Committee Member	Environmental NGO “Ruzgar”	I.Mustafayev
11.	Steering Committee Member	Deputy director of Geography Institute under the National Academy of Sciences	R.Mamedov

Institutions involved in stakeholder consultation process

Institutions	Representative	Contacts
State organizations		
Ministry of Ecology and Natural Resources	O.Jafarov	o_jafarov@yahoo.com
Ministry of Economic Development	A.Cafarov	altay.cafarov@gmail.com
Ministry of Industry and Energy	F.Muradov	feyzulla.muradov@gmail.com
Ministry of Agriculture, Department of livestock production and processing, pedigree and pasture	C.Isayev	c.isayev@gmail.com
State Land and Cartography Committee, Head of Division at the Scientific Research Institute on Soil Science	G.Yagubov	gasham.yagubov@gmail.com
Climate change and Ozone centre under the Ministry of Ecology and Natural Resources	A.Mehtiyev	m_anar78@yahoo.com
National Academy of Sciences	X.Ragimov	khayyamr@yahoo.com
Municipality of Novxani settlement of Absheron district	F. Mammadov	Fexreddin.mammadov@yahoo.com
Public and private companies		
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State Oil Company (SOCAR)	H.Ahmadov	Hamlet.axmadov@socar.az
State Company of Alternative and Renewable Energy Sources of Azerbaijan Republic	C.Melikov	cmelikov@abemda.az
State Water Agency under Ministry of Emergency Cases	S.Hasanzade	sahib540@mail.ru
Sumgayit Technological Park	S.Musayev	s.musayev@gmail.com
NGOs		
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"Ecolife"	S.Hasanov	h.sadiq@mail.ru
"Ruzgar"	I.Mustafayev	i_mustafayev@mail.ru
Idependent expert (on energy and renewable energy sources)	Sh.Movsumov	movzumov@yandex.ru

TNA team contacts

TNA team	Position	e-mail
Issa Aliyev	National TNA coordinator, UNFCCC focal point in Azerbaijan	aliyev@iglim.baku.az
Mr. Bariz Mehdiyev	Adaptation expert	barizali@gmail.com
Mr. Gulmali Suleymanov	Mitigation expert	Gulmali_climate@yahoo.com , gulmali.climate@gmail.com

Annex III. TNA Committee Endorsement

Minutes of TNA Committee meeting

25 June 2012, Baku city

Chairman: F. Aliyev

Secretary: E. Garabagly

Participants: 11 members

On 25 June 2012, TNA Committee meeting was held at the Oarhus Center in Baku city. The following issues were on the Agenda:

1) Endorsement of prioritized technologies under adaptation/mitigation reports

2) Finalization of TNA preparation phase and shifting to Barriers Analysis and TAP preparation phase

The Chairman has opened the meeting and provided information on the current status of TNA report preparation. He noted that the TNA process was implemented in close cooperation with relevant stakeholders representing different sectors. As a result of comprehensive analysis provided under the assessment process of involved adaptation and mitigation experts and intensive discussions with respective stakeholders, final prioritization has been provided applying MCDA approach. Subsequently, the following sectors and technologies have been prioritized for adaptation and mitigation:

For mitigation:

For alternative energy sources sector:

- Grid-connected wind power
- Passive solar energy (hot water) and solar photovoltaic (electricity)
- Small hydro-powers on mountain rivers

For commercial and residential sector:

- Heating pumps
- High efficiency lighting systems
- Biogas for cooking and electricity and efficient stoves

For Adaptation:

Water sector:

- Rainwater Collection from Ground Surfaces—Small Reservoirs and Micro-catchments
- Flood warning
- Water reclamation and reuse
- Reducing water leakages in water management facilities

Agricultural sector:

- Optimizing of location and structure of agricultural lands with introduction of crop species resistant to expected climate changes
- Enhance the application of windbreaks
- Application of water saving technologies, such as drip or spray irrigation, at irrigated lands
- Application of conservative cultivation technologies

Then, intensive discussions were held between TNA Committee members on prioritized technologies, and adaptation/mitigation experts have clarified all unclear points related to applied approach and methodology. As a result of productive discussions, TNA Committee members have come to the following decision by common consent:

1) TNA Committee endorses prioritized technologies in adaptation/mitigation reports

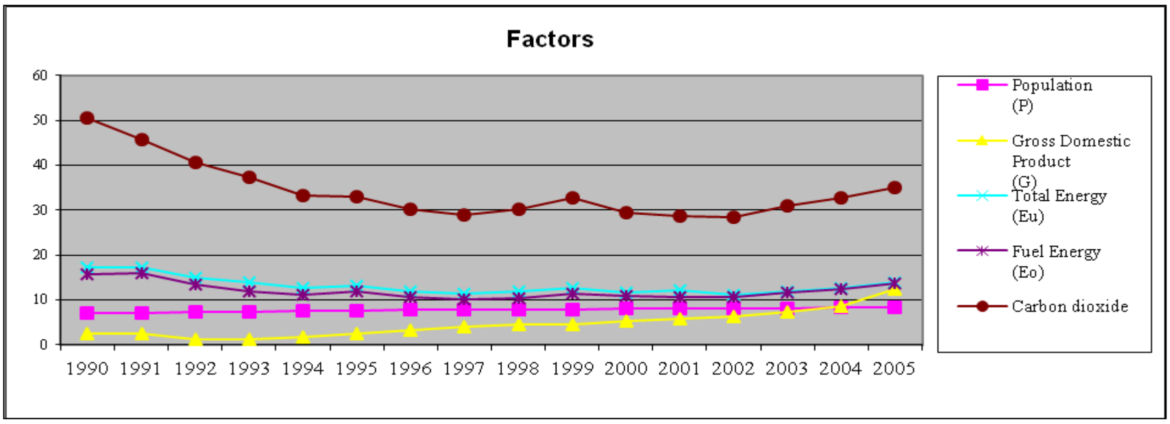
2) TNA Committee entrusts adaptation/mitigation experts to finalize TNA preparation phase and launch Barriers Analysis and TAP preparation phase

Annex IV. Greenhouse Gas Emissions (GHG) reductions forecasting

Macroeconomic indicators and prediction models for carbon dioxide emissions

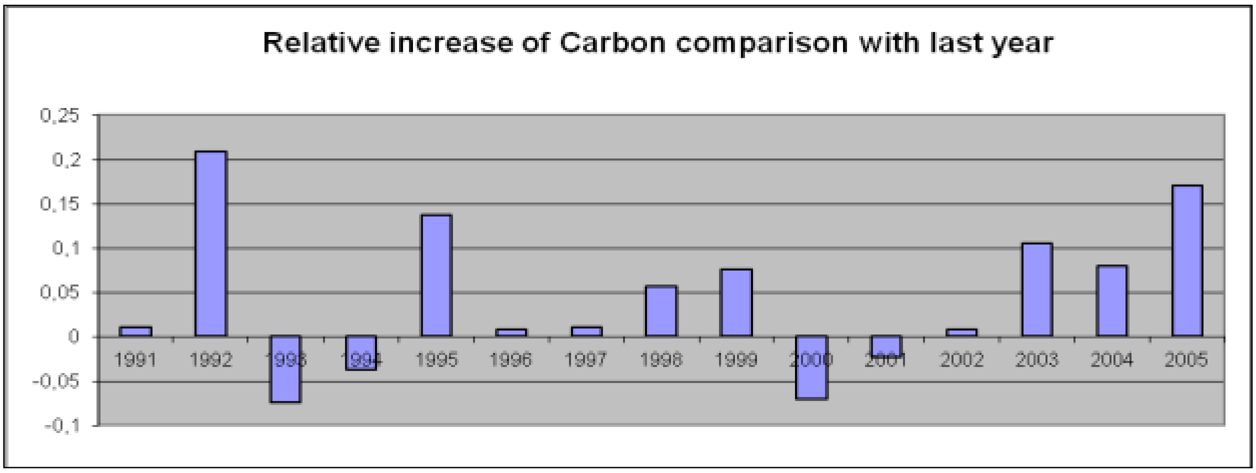
Different indices were widely used in scientific researches on the analysis of sustainable development of countries in recent years. It is more favorable to take the main macroeconomic factors such as population growth, Gross Domestic Product (GDP), total energy and fuel energy used in the country, which characterize the development of the society.

The amount of the country's carbon dioxide emission into the atmosphere is mostly related to the changes in these factors. These changes are given in the following figure:



The population and GDP increase almost every year, while the total energy, fuel energy use and carbon dioxide emissions increase intensively from 2002, onward.

The relative increase of carbon dioxide in comparison to previous years was given in the following histogram:



As it can be seen from the histogram, the relative increase of carbon dioxide in comparison to the previous years ranges in the interval of 1996-1999 and 2002-2005. The reason for this is the processes taking place in the energy, industry and transport sectors.

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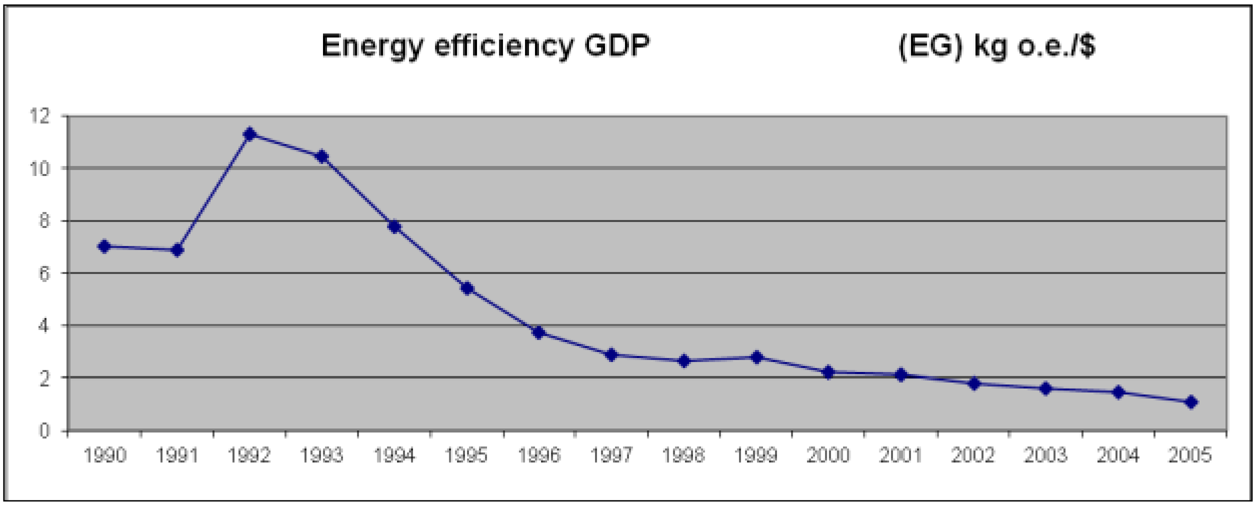
Azerbaijan's energy efficiency of GDP for the years 1990-2005 is given in the following figure:



As it can be seen from the figure, energy efficiency has been improving from year to year. However, despite Azerbaijan's energy efficiency, in contrast to developed countries it is insufficient and cannot be compared.

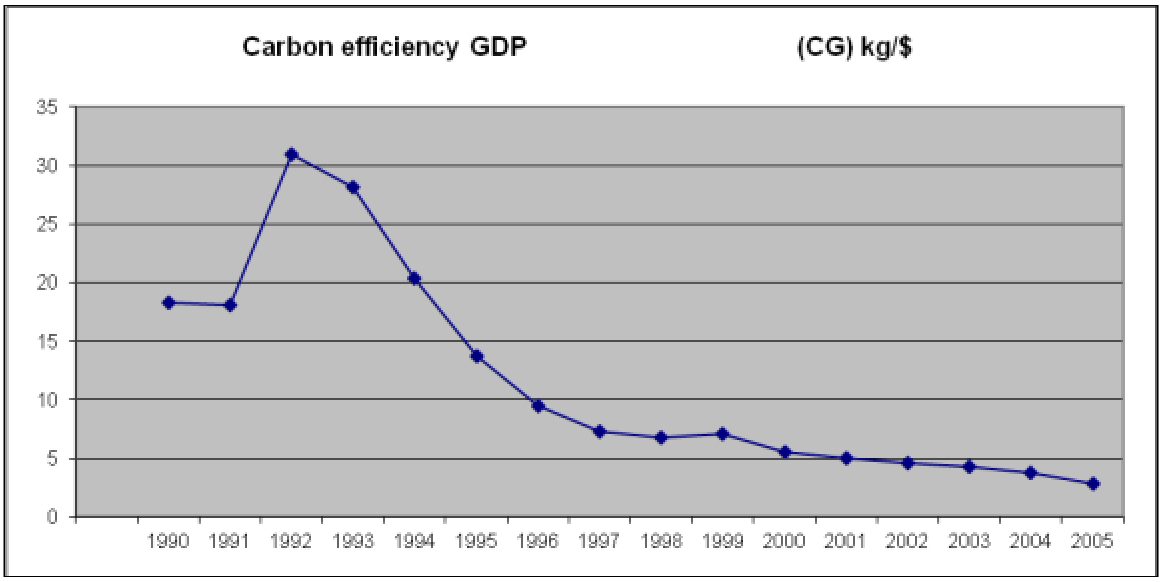
GDP-GDP/P per capita is one of the main indicators of the country's economic development. Even if the fuel types and energy efficiency do not change, per capita GDP growth may lead to increase of carbon dioxide emissions into the atmosphere.

Population growth also increases energy use and can lead to a potential increase of carbon dioxide emissions. Therefore, the change of all these parameters and factors may lead to changes of carbon dioxide emissions into the atmosphere.

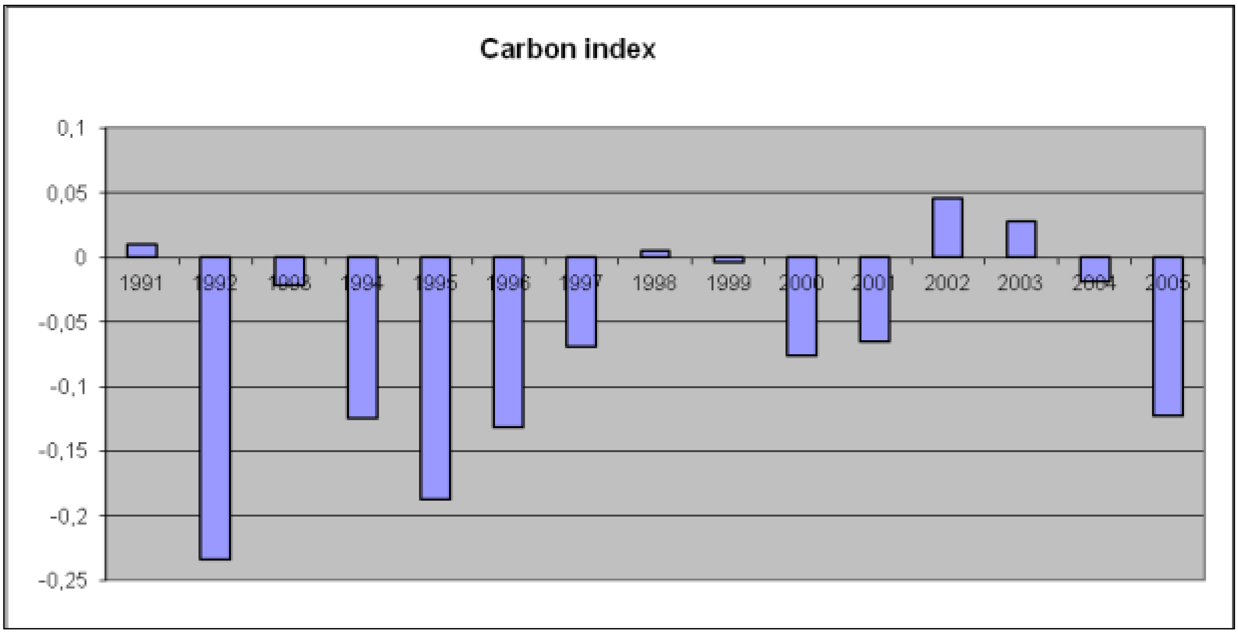
The country's carbon intensity is determined by the ratio of GDP to carbon dioxide emission and indicates the amount of carbon dioxide emission into the atmosphere during the production of a unit of GDP, which means:

$$C / GDP \quad (kg/USD) \qquad (6)$$

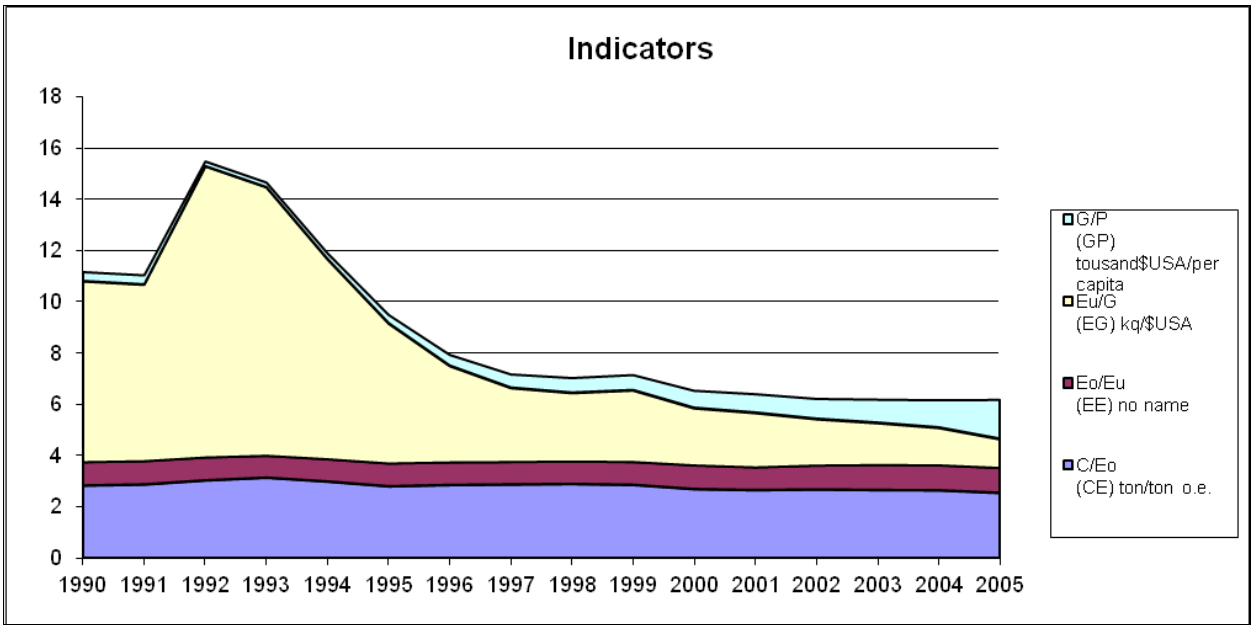
Carbon intensity of GDP of Azerbaijan is given in the following graphic:



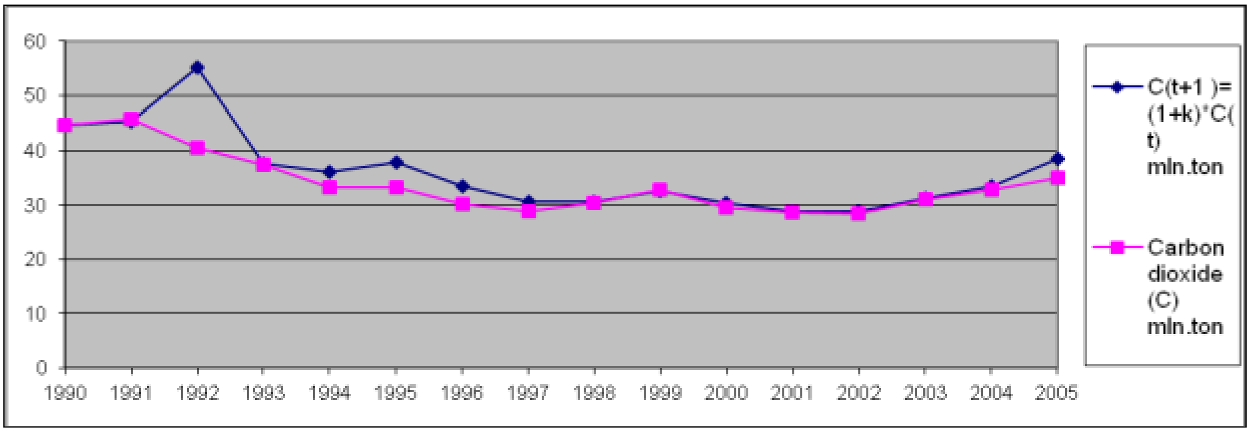
The change of dynamics of Azerbaijan in the carbonization index is provided in the following diagram:



The change of dynamics of main factors in Azerbaijan for the years 1990-2005 is given in the following diagram:



Carbon dioxide forecasting and calculated estimations are given in the following table:

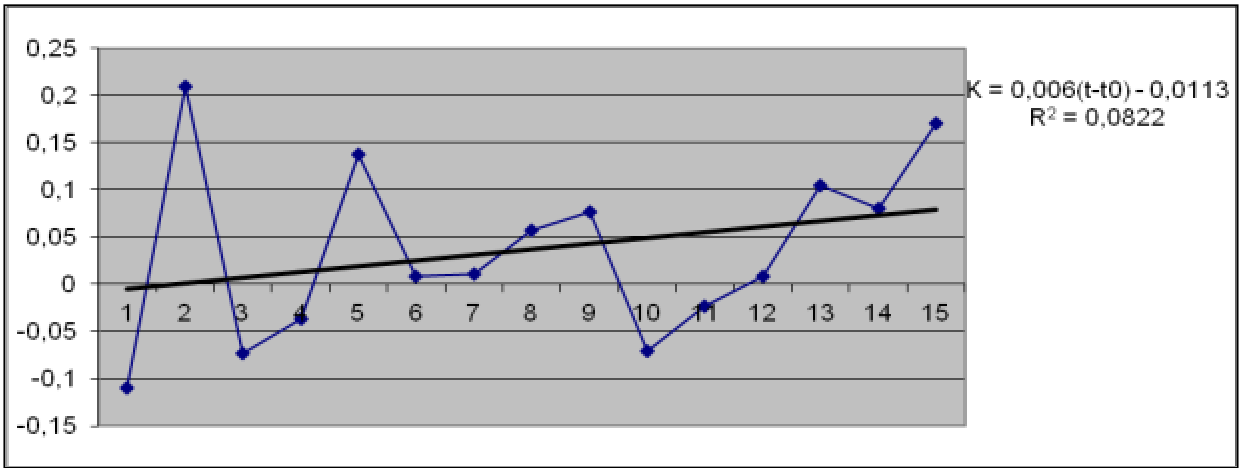


The reduction of carbon dioxide and other GHG emissions are based on possible projects to be implemented in different fields.

According to information from the years 1990-2005, the values of K coefficient were calculated and the following formula was obtained for the trend:

$$K = 0,006*(t-t_0) - 0,0113 \qquad (12)$$

The average squared error of the trend becomes R^2=0,0822 which indicates proximity of the trend to real values. The diagram is given below:



The forecasted values for carbon dioxide emissions on the calculated values of the trend of K according to (12) formula is given in the following graphic: