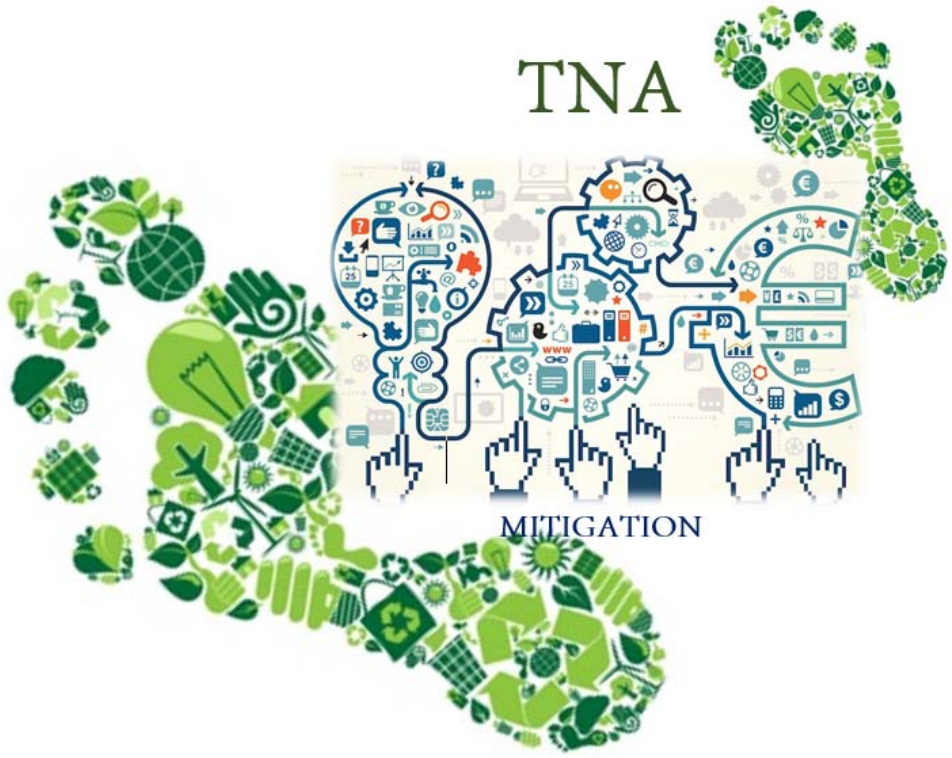
The Republic of Armenia

TECHNOLOGY NEEDS ASSESSMENT FOR CLIMATE CHANGE MITIGATION
REPORT I



TECHNOLOGY PRIORITIZATION

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TECHNOLOGY NEEDS ASSESSMENT REPORT
MITIGATION TECHNOLOGY PRIORITIZATION

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Foreword

The impact of Armenia on global climatic system is not significant, our share in global emissions is only 0.014%. Highlighting the need of countries to combine their efforts in contending against climate, Armenia as a developing country has obligation in limiting greenhouse gas emissions. The quantitative indicators of these contributions are summarized in the Intended Nationally Determined Contributions (INDC) of Armenia, which, as a result of comprehensive consultations, have been approved by both the Government of the Republic of Armenia and the civil society of Armenia and has been presented to the attention of Parties of the UN Framework Convention on Climate Change (UNFCCC). This document represents the official long-term Concept of our country aimed at implementation of the obligation under UNFCCC, and in addition to mentioned mitigation measures also includes climate change adaptation measures, as well as a component on transfer and development of technologies.

We consider the on-going UNEP/DTU TNA project as priority on mentioned technological mechanism, which will develop the path that will ensure continuous selection and implementation of modern and accessible technologies in Armenia, based on examples of several selected mitigation and adaptation projects. TNA project is also important for building of capacities on development and transfer of technologies, thus the results of its first phase are positive and promising.

First Deputy Minister of
Nature Protection of RA **Simon PAPYAN**

Preface

The Republic of Armenia (RA) ratified the UN Framework Convention on Climate Change (UNFCCC) in May 1993, and the Kyoto Protocol in December 2002. Armenia as a Non-Annex I Party to the Convention is regularly implementing obligations pursuant to its status.

The Third National Communication (TNC) on Climate Change of the RA was developed in 2015 according to UNFCCC and the Guidelines for national communications of Non-Annex I Parties to the Convention. TNC covering the period of 2007-2012 has extended the studies on and assessments of climate change-related issues. TNC describes the position of the RA for addressing climate change issues and measures implemented and planned, as well as the country's needs for further steps and activities.

According to the Decision adopted by Conference of Parties (COP), the Non-Annex I countries, consistent with their capabilities should submit Biannual Update Reports (BUR) in terms of financial support provided by the Convention financial mechanism. The first BUR submitted by Non-Annex I Parties covering, at a minimum, the inventory for the calendar year no more than four years prior to the date of the submission. The National Inventory of the RA BUR is updated as of 2012. According to the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines, the RA Biannual Update National Inventory Report (NIR) consists of the following sectors: Energy, Industrial Processes and Product Use (IPPU), Agriculture, Forestry and Other Land (AFOLU) and Waste.

Government of the RA recently approved Intended Nationally Determined Contributions (INDC) of the RA under the UNFCCC. The timeframe for the INDC is 2015-2030. INDC underlying the following principles:

- Limit global greenhouse gas (GHG) emissions to such a level that the global average temperature does not exceed 2^0C,
- Ensure distribution of the GHG emissions limitation burden between countries based on the principle of equity, taking into account the rights of present and future generations to use resources, and the equal rights of humans to affect the climatic system.
- Apply an ecosystem-based approach to mitigation and adaptation actions, giving preference to balanced and combined actions.
- As a developing country, the RA is prepared to propose a quantitative contribution to limit its GHG emissions growth based on the principle of equity, and subject to adequate financial and technical support from the international community.

The INDC is based on the principle of "Green economy" and is compatible with the social and economic development goals of the RA.

The main sectors included in the mitigation contribution are:

- Energy [including renewable energy (RE) and energy efficiency (EE)]
- Transport (including development of electrical transport)
- Urban development (including buildings and construction)
- Industrial processes (construction materials and chemical production)
- Waste management (solid waste, waste water, agricultural waste),
- Land use and Forestry (afforestation, forest protection, carbon storage in soil)

Define that considered GHG are Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Hydro fluorocarbons (HFCs). The emissions and absorption of mentioned gases are calculated in CO_2 equivalent, according to the “global warming potential” defined by IPCC Second Assessment Report ".

Armenia is actively involved in Technology Need Assessment (TNA). The policies of the RA on climate change mitigation are aimed at promoting energy efficiency and renewable energy sources in all sectors of the national economy, systematic afforestation activities and rational land management, promoting innovative approaches and environmentally friendly technologies and exploring carbon financing mechanisms.

The INDC and the TNA should ensure adequate technological assistance and create a favourable environment for technology development and transfer; Establish institutional mechanisms to overcome barriers for the introduction of innovative technologies for climate change mitigation and adaptation, including strengthening the system of legal protection of intellectual property right. Ensure an open and transparent system of technology introduction and transfer as a contribution to the INDC, such as through the cooperation and experience exchange with "Climate Technology Centre and Network" (CTCN) and through the establishment of a similar mechanism in the country (Arm CTCN).

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Abbreviations

ADB	Asian Development Bank
ADS	Armenia Development Strategy
AFOLU	Agriculture, forestry and other land use
AMD	Armenian Dram
BSEC	Black Sea Economic Cooperation
BUR	Biannual Update Reports
CCGT	Combined-Cycle Gas Turbine
CEEP	Caucasus Energy Efficiency Program
CHP	Combined heat and power production
CIF	Climate Investment Funds
CIS	Commonwealth of Independent States
CJSC	Closed joint stock company
CNG	Compressed natural gas
COP	Conference of Parties
CTCN	Climate Technology Centre and Network
E5P	Eastern Europe Energy Efficiency and Environment Partnership
EBRD	European Bank for Reconstruction and Development
EE	Energy Efficiency
EU	European Union
EST	Environmentally Sound Technologies
GGF	Green for Growth Fund
GDP	Gross domestic product
GEF	Global Environment Facility
GHG	Greenhouse gas
GSCM	Global System of Climate Monitoring
HPP	Hydropower plant
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
IFC	International Finance Corporation
INDC	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial process and product use
KfW	German Bank for Reconstruction and Development
LPG	Liquefied petroleum gas
LULUCF	Land use, land use change and forestry
MDBs	Multilateral Development Banks
MENR	Ministry of Energy and Natural Resources
MNPP	Metsamor Nuclear power plant
MSW	Municipal solid waste
N/A	Not available
N/E	Not estimated
NAMA	Nationally appropriate mitigation actions
NEEAP	National energy efficiency action plan
NGO	Non-governmental organization

NIR	National Inventory Report
NPP	Nuclear power plant
PPP	Purchasing power parity
RA	Republic of Armenia
RE	Renewable energy
R2E2	Renewable Resources and Energy Efficiency Fund of Armenia
SB	Standardized Baseline
SCF	Strategic Climate Fund
SREP	Scaling-up Renewable Energy Program
SDP	Sustainable Development Program
SNCO	State non-commercial organization
SPAN	Specially protected area of nature
SW	Solid waste
TNA	Technology Need Assessment
TNC	Third National Communication
TPP	Thermal power plant
TPES	Total Primary Energy Supply
UGSS	Underground gas storage station
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency of International Development
USD	United States Dollar
USSR	Union of Soviet Socialist Republics
VVER	Water-Water Energetic Reactor
WB	World Bank
WTO	World Trade Organization

Units of Measurement

m	metre
m^3	cubic metre
km	kilometre
km^2	square kilometre
ha	hectare
Gg	gigagram (10^9 g)
t	tonne
toe	tonnes oil equivalent
TJ	terajoule (10^{12} J)
PJ	petajoule (10^{15} J)
MW	megawatt (10^6 W)
GWh	gigawatt hour (10^6 kWh)
m/sec	metres per second
^0C	degree Celsius

Chemical Combinations

CO	Carbon monoxide
CO_2	Carbon dioxide
$CO_{2\ eq.}$	Carbon dioxide equivalent
CH_4	Methane
HFCs	Hydrofluorocarbons
N_2O	Nitrous oxide
NOx	Nitrogen oxides
NMVOC	Non-methane volatile organic compounds
SO2	Sulfur dioxide

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Executive Summary

The current process of TNA is a continuation part of systematic research on climate change in the RA. The TNA Project provides a great opportunity for RA to perform country-driven technology assessment to identify environmentally sound technologies that might be implemented with a substantial contribution in addressing climate change mitigation needs of the country.

The aim of TNA project is to support United Nations “Climate Change” framework Convention for developing countries to identify and analyse:

- The technology needs priority, which can be used in an environmentally safe technology package.
- Facilitate access to and transfer of environmentally sound technologies.
- Identify transmission initiated projects and programs.
- Facilitate the implementation of paragraph 4.5 of the UN "Climate Change" Framework Convention on know-how access.
- Define and prioritize the technologies, processes and techniques that are consistent with climate change mitigation and adaptation in the participating countries are consistent with national development goals and priorities.
- Identify barriers that prevent primary / preferred technology acquisition, implementation and dissemination.
- Develop technology action plan (TAP) to overcome barriers, which will define the scope of activities and a favourable environment that will facilitate the transfer of technology adoption and dissemination of the participating countries.

Technology prioritisation is a first step in technology transfer framework, which also includes technological information, enabling environment, capacity building and understanding the mechanisms for technology transfer.
Technology prioritisation is implemented by applying methodology proposed by the UNFCCC and TNA team.

The applied methodology has been adjusted to country-specific conditions. Technology prioritisation has been conducted through the following activities: preliminary overview of options and resources; institutional arrangements and stakeholder engagement; establishing decision context; priority sectors assortment; establishing criteria for selecting mitigation measures priorities; selecting priority measures; detailed analyses, assessment and stakeholder consultation; selection of high priority actions for further development and implementation.

The current report provides the existing national policies on climate change mitigation and development priorities of the country, inventory of GHG emissions, stakeholder engagement and institutional arrangements of TNA, sector prioritization process, identification of criteria, assessment of the technologies on the selected sectors by using the multi-criteria approach (MCA) and technology prioritization.

In this report prioritized technologies are described in more details, summary, description and main conclusions provided as well as. Technological fact sheets on technologies of are provided in Annex I.

The main sources of CO2 emissions in RA is the energy sector. The principal carbon sinks are represented by "Forestry and Other Land Use" subsector. GHG Inventory results for 2012 is listed below:

RA GHG Inventory results for 2012

GHG Source and Sink Categories	**Emissions 2012 (Gg CO_{2eq}.)**	**Emission share by sectors (%)**
Energy	6,913	70.3
IPPU	663	6.7
AFOLU	1,622	16.5
Waste	632	6.4
Total Emission	**9,829**	**100**
"Forestry and Other Land Use" subsector	-522	
Net emission	**9,307**	

Source: Biennial Update Report, 2015 [**Ref-2**]

Based on the results of the inventory of GHG by sectors and calculated GHG emissions forecasts (mitigation scenarios) to the year 2030, consistent time series for years 2000-2012, as well as identified economic, social and environmental development priorities, based on their GHG emissions mitigation potential and compliance with country development priorities and potential mitigating effect on climate change by sector the following subsectors/groups of technologies were selected:

- Energy (including transport)
- Industry (including chemical industry)
- Land use (including forestry)
- Waste management (including agriculture)

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

Energy sector (6 Criteria):	**Industry sector (6 Criteria):**
• Affordability (score 1-5) • Investment Cost (k$/Gg life time) • Social benefit (score 1-5) • Feasibility and Marketability (score 1-5) • GHG mitigation (GgCO2-e/year) • Commercial maturity (score 1-5)	• Affordability (score 1-5) • Investment Cost (k$/Gg life time) • Impact on Economy Development (score 1-5) • Increase in Employment (score 1-5) • GHG mitigation (GgCO2-e/year) • Commercial maturity (score 1-5),
Land use sector (7 Criteria):	**Waste management sector (6 Criteria):**
• Affordability (score 1-5) • Investment cost (USD /ha) • Operating (current) cost (USD /ha) • Economic benefit (score 1-5) • GHG mitigation (Gg CO2-e/ year ha) • Environmental benefit (score 1-5) • Social benefit (score 1-5),	• Affordability (score 1-5) • Investment cost (USD) • Economic benefit (score 1-5) • GHG mitigation (Gg CO2-e/ year ha) • Environmental benefit (score 1-5) • Social benefit (score 1-5).

Based on provided TNA methodology and MCA approach [**Ref 15**], the proposed long list of technologies (seven technologies were assessed for each selected sector) has been scored. Each criterion has been analyzed according to its qualitative and quantitative importance based on information provided in the TFSs. Calculation of swing value and provided weights, the latter have been normalized and appropriate values calculated. As a result, the following technologies received the highest values and were prioritized for the mentioned sectors:

Energy sector:

- Cogeneration, Small Scale Combined Heat and Power production.
- Improving energy efficiency in multi apartment buildings. Registry creation, development.
- Mandatory realization of the Industrial Energy Audit as a mitigation component.
- Reactive capacity (power) compensation in the RA electric energy system.
- Correspondence of natural gas tariff structure to the methodology approved by decision of Public Services Regulatory Commission (PSRC).

Industry sector:

- Production of synthetic rubbers from butadiene instead using natural gas (Chemical industry).
- Production and usage of photo luminescent materials with long-term lightening.
- New type of Entirely Plastic solar water heater.

Land use sector:

- Degraded Grassland radical improvement.
- Sustainable Forest management.
- New technology of cultivation of Perennial plants.

Waste management sector:

- Utilization of methane form Yerevan city landfill for electricity and heat production.
- Existing Lusakert biogas plant operation and reissuance organizational technology.
- Complex processing of Artik tufa mining waste and agricultural lands to prevent their further degradation.

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 24 December 2015 (Agenda of the meeting presented in Annex II).
At the meeting devoted to open discussion on prioritized technologies the experts expressed the common opinion that the selected technologies may be preliminary considered as ones final for promotion. Anyway, they should be further studied in the concrete implementation environment, taking into consideration their operation in a long-term context.

Stakeholders expressed The TNA ongoing process shows that technology identification and prioritization should be continuous process. As new ideas and new technologies may appear also after completing the prioritization process foreseen by the TNA project.
However, TNA and technology prioritization should be considered as nonstop process and desire or plan to found and forming, organizing, national inventory system for technologies in all spheres for climate change mitigation. It will be Grid like National Network or Centre for Climate Technologies or in other words National Directory, Catalogue of technologies and possibly linked to the CTCN.
In addition, abovementioned prioritized technologies are described in the report. All those technologies are available for possible financing.

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

Chapter 1 Introduction

1.1 About the TNA project

The promotion of the GHG reduction technologies is a continuing priority of the Ministry of Nature Protection of the RA. The RA stated its position on the limitation of greenhouse gas emissions in subsequent national communications to the UNFCCC and in the Republic of Armenia's Statement on Association with Copenhagen Accords. The climate change mitigation actions should not reverse the social and economic trends of Armenia, but contribute to the socioeconomic development of the country. These actions must be based on an "ecosystem approach", which is preferred by the RA, since it allows to maximize the synergies between mitigation and adaptation actions in most sectors of the economy, facilitating and contributing to fair regional cooperation [**Ref-10**]. Started 12 years ago in 2003, the RA has undertaken the first technological needs assessment. The Report "Capacity Building in the RA for Technology Needs Assessment and Technology Transfer for addressing climate change problems" was elaborated within the Project "Armenia – Country Study on Climate Change. Phase II" implemented by the Ministry of Nature Protection of the RA with financial support from Global Environmental Facility (GEF) and in cooperation with United Nations Development Programme (UNDP) in Armenia.

The objective of the project was capacity building in Armenia for solution to climate change problems to determine the priority technological needs of Armenia's economic sectors in the areas of reduction of GHG emissions, development of proposals for key technologies and assessment of possibilities for their practical application, development and assessment of specific technological projects. The document provided information about the status of the national sectors with highest GHG emissions and determined the technological needs for the development of the monitoring system and strengthening of the national monitoring network for participation in the Global System of Climate Monitoring (GSCM).

The second country driven technological needs assessment of the RA has been launched in 2014 within TNA Project RA "Technology Needs assessment and Technology Action Plans for Climate Change", having financial and guidance support of United Nations Environment Programme (UNEP).

The TNA project is being undertaken to identify technological needs for achieving a country's development priorities in a sustainable manner. The main objective is to identify and assess Environmentally Sound Technologies (EST), which can provide the required development services with low GHG emissions.
The current assessment, presented in this report, aims to:

- Identify, analyse, evaluate, and prioritize technology needs to mitigate GHG emissions and reduce the adverse impacts of climate change and to form the basis for a portfolio of EST projects and programmes,
- Identify a portfolio of technologies that have the potential to combat climate change, reduce environmental pollution, and contribute to Armenian sustainable development,
- Communicate Armenian climate change technology requirements to the global community,
- Facilitate the access to international sources of funding for the implementation of mitigation activities,
- Support Armenian position in climate change negotiations in the area of technology transfer.

If properly considered and implemented, a TNA can achieve a number of additional desirable results, namely contributing to enhanced capacity to acquire ESTs, developing important links among stakeholders to support

future investment and barrier removal, and diffusing high priority technologies throughout the sectors of national economy. Hereafter the purpose of the TNA is to establish a baseline for a portfolio of programmes and projects to facilitate the transfer and access to ESTs and know how in the implementation of Armenian economic development programmes.

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.

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 GHG emissions.

Economic development of Armenia requires technological advancement in all fields of economy. Introduction and dissemination of climate change technologies can become a significant factor of sustainable economic development of the country in line with its international objectives. Current TNA process has served as an important tool for realization of the priorities and preferences in this field and preparing the grounds for their implementation.

1.2 Existing national policies on climate change mitigation and development priorities

State structure

The RA was established on 21 September 1991. Yerevan is the capital city of the RA. According to the Constitution, the RA is a sovereign, democratic, and social state governed by the rule of law. State power exercised in the RA is based on the principle of the separation and balance of the legislative, executive and judicial powers. The RA is a member state of the United Nations since 2 March 1992. It is a member of the Commonwealth of Independent States (CIS) since 21 December 1991; the Black Sea Economic Cooperation (BSEC) since 1 May 1999; the Council of Europe since 25 January 2001, the World Trade Organization (WTO) since 5 February 2003 and Eurasian Union since 1 January 2015. Since 1993, the RA is a party to the United Nations Framework Convention on Climate Change (UNFCCC). In 2002, Armenia ratified the Kyoto Protocol. As of 2013, the RA has established and is maintaining diplomatic relations with 160 states around the world. [**Ref-25**]

Geographical position

The RA is located in the northeast of the Armenian Highlands, at the border of the Caucasus and Western Asia. In the north, Armenia borders with Georgia, in the east with Azerbaijan, in the west and southwest with Turkey, and in the south with Iran. The territory of the RA covers 29,743 km^2. Armenia is a mountainous country: 76.5% of the territory is in the altitudes of 1,000-2,500 meters above sea level [**Ref-25**].

Climate

Armenia is a country of climatic contrasts: because of intricate terrain, one can find high climate diversity over even a small territory. The country has almost all types of climate, from arid subtropical to cold high mountainous climates. The average annual ambient air temperature is 5.5°C. The highest annual average temperature is 12-14°C. The average annual temperature is below zero in altitudes above 2,500 m. The summer is temperate: the temperature at the end of July is 16.7°C, while in Ararat valley it ranges between 24-26°C. The recorded absolute highest temperature is 43.7°C. Winters are cold. January is the coldest winter month,

with an average temperature of -6.7°C. The recorded absolute lowest temperature is -42°C. Winters in the northeastern and southeastern parts of the country are temperate [**Ref-25**].

Population

The population of the RA as of the end of 2012 was 3,027,000, and the average population density was 102 persons/km^2. The distribution of the population is very uneven, which is due to the mountainous terrain of the country and various levels of regional economic development. The maximum population density is 686 persons/km^2 living in altitudes up to 1,000 m, while the minimum (22 persons/km^2) is recorded in altitudes of 2,000-2,500 m. The urban and rural population is 63.3% and 36.7% respectively (2012). The largest cities include Yerevan (1,066.3 thousand residents), Gyumri (121.3 thousand residents), and Vanadzor (87.7 thousand residents). These cities account for 66.4% of the urban and 42% of the total population of Armenia. Men and women constitute 48% and 52% of the population respectively (2012). The average life expectancy is 74.3 years: 70.9 years for men and 77.5 years for women. The number of the economically active population is 1,173 thousand (2012) [**Ref-25**].

Armenia Development Strategy for 2014-2025 (ADS)

(Annex To RA Government Decree # 442 - N on 27 March 2014).

This provides a major set of social and economic development priorities of the country, its objectives, main obstacles and limitations to development, key reforms, and policy mechanisms for the realization of priority goals.

The ADS covers the period of 2014-2025 and is the country's main socioeconomic development strategy and the basis for medium-term, sectoral and other program documents.

ADS is the primary guide of the government and is based on the following four priorities:

Priority 1. Growth of employment;

Priority 2. Development of human capital;

Priority 3. Improvement of social protection system;

Priority 4. Institutional modernization of the public administration and governance.

The Sustainable Development Program (SDP) had three sets of objectives [**Ref-1**]:

- Reduction of poverty in 2008-2021 to the extent that poverty will not be a problem of economic development, and extreme poverty will be totally eliminated and will no longer be a significant social phenomenon.
- Elimination of human poverty and ensuring accelerated human development, as a result of which, in a few years, the country should have moved from the group of countries with average human development to the group of countries with high level of human development1.
- Mitigation of disproportions of the territorial development and acceleration of economic growth of underdeveloped regions by developing and implementing a relevant territorial policy.

In order to achieve the mentioned objectives, SDP envisaged three sets of priority strategies:

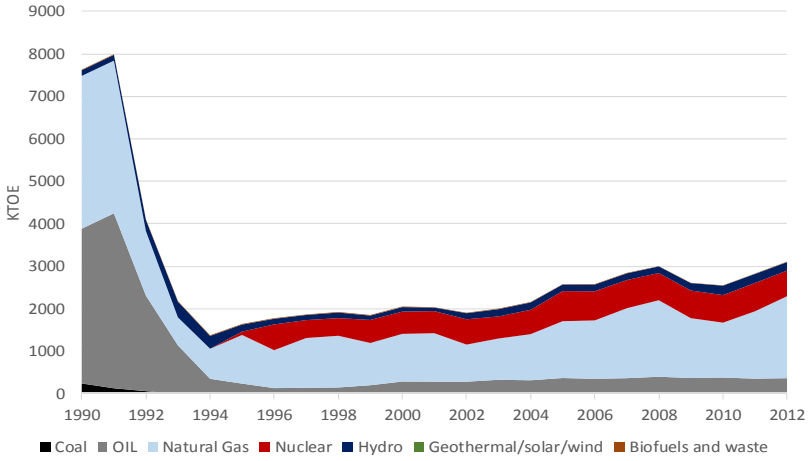
- Economic policy for ensuring sustainable and accelerated economic growth;
- Active social and income policy for vulnerable groups of population (including the poor);
- Modernization of governance system, including improved effectiveness of state governance and ensuring accelerated growth of the resource envelope at the disposal of the state.

Energy Situation in Armenia

Meanwhile total primary energy supply (TPES) to Armenia collapsed along with the Soviet Union as oil and oil product supply dropped 90% and the supply of natural gas was halved. TPES in 2012 was still 62% below the level in 1990 (**Figure 1**.). Over the last 20 years however, efforts has been made to renovation the Armenian

energy sector. Since 2002, Armenian TPES has increased by 58%, driven primarily by a 120% increase in natural gas supply, and 40% increase in hydropower production [**Ref-11**].

Figure 1. Total primary energy supply 1990-2012

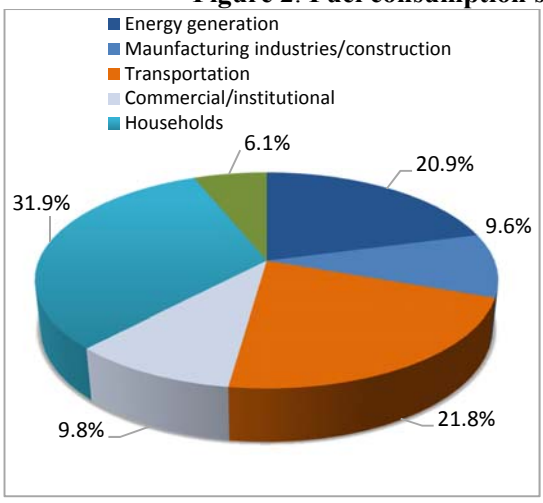


Source: International Energy Agency (IEA), Country report Armenia, 2015 [**Ref-11**]

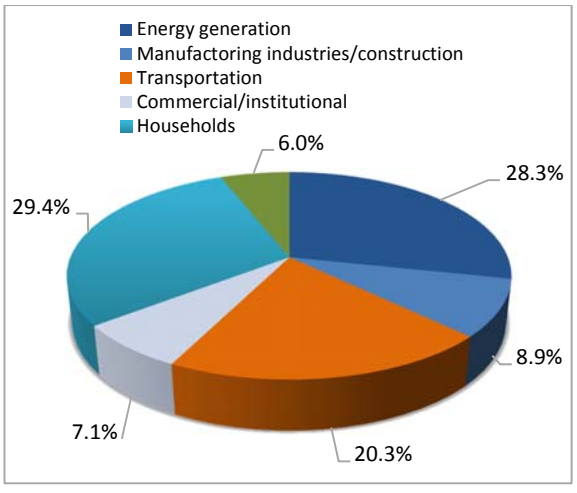
As a UNFCCC Non-Annex I country, Armenia does not have quantitative commitments for GHG emission reduction. However, to support the objective of the Convention and, given that slowing GHG emissions is in line with the country's economic, energy, and environmental objectives, Armenia is implementing and, in its development perspectives, is planning climate change mitigation measures.

Figure 2 provides fuel consumption structures in Armenia for 2011 and 2012 respectively, by subcategories. As it comes from the figures, most energy in 2011 is consumed by households (32%), transportation (22%) and energy generation (21%) categories accounting for 75% of aggregate consumption. Same three subcategories remain large fuel consumers also in 2012 accounting for 78% of the total.

Figure 2. Fuel consumption structures in Armenia for 2011 and 2012



2011 fuel consumption structure by subcategories



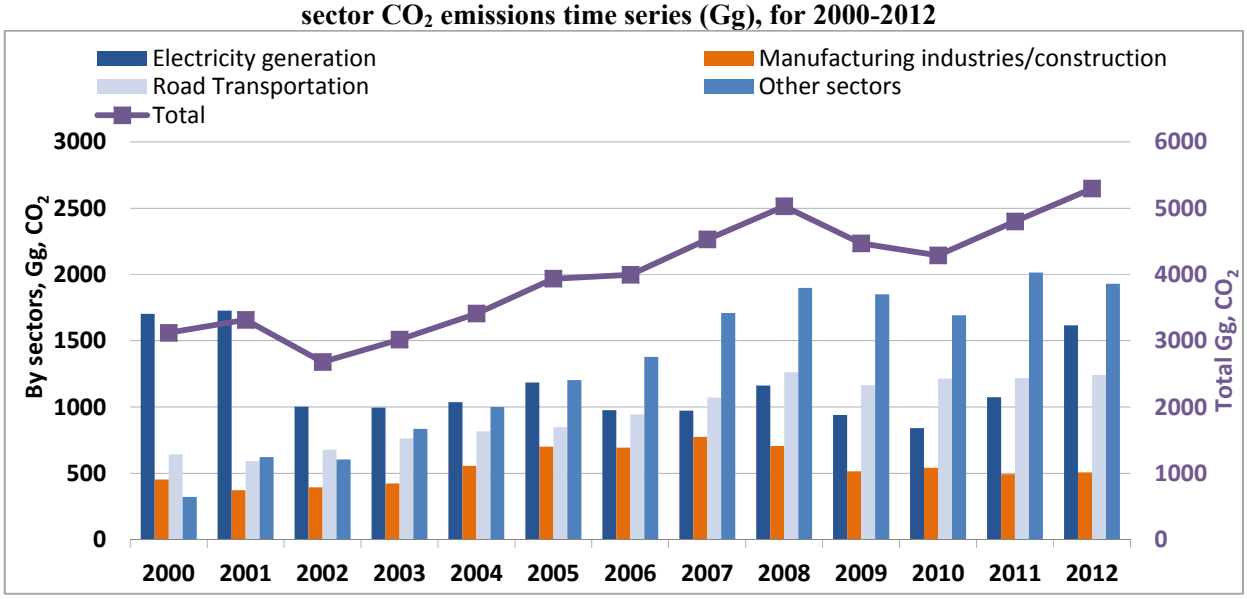
2012 fuel consumption structure by subcategories

Source: National Greenhouse Gas Inventory Report of the RA 2015 [**Ref-16**]

The estimated results demonstrate a significant increase in emissions reported in 2007 and 2008, which was due to an unprecedented expansion of gas distribution system in these years resulting in dramatic increase in

natural gas consumption particularly by households. Almost similar increase was recorded in transportation sector boosting the consumption of natural gas and other oil products. Significant increase in emissions in 2011 and 2012 compared with 2010 was due to increase in power generation by Thermal Power Plants (TPPs): it amounted to 3,398 million kWh in 2012, while in 2010 it was 1,443 million kWh. Power generation by TPP in 2012 versus 2010 increased reaching to 135%. Such rapid growth in electric energy generation by TPPs is due to generation of required quantity of electric energy pursuant to implementation of Armenia-Iran interstate "Electric Energy for Gas" agreement: 1.58 billion kWh electric energy was transmitted to Iran in 2012 [**Ref-13**]. Cumulative GHG emissions series and their structure by subcategories are provided in **Figure 3.**

Figure 3. 2000-2012 cumulative GHG emissions series and their structure by subcategories. Energy sector CO_2 emissions time series (Gg), for 2000-2012



Source: National Greenhouse Gas Inventory Report of the RA 2015 [**Ref-16**]

Legislation

In recent years, Armenia has adopted a number of laws and regulations, and elaborated and implemented national and sectorial programmes based on sustainable and low-carbon development principles. Although neither of the mentioned documents explicitly refers to climate change mitigation measures, the enforcement and implementation of these laws and programmes facilitate reducing GHG emissions, as well as forging a path to develop of Nationally Appropriate Mitigation Actions (NAMA).

The Law of the RA on Atmospheric Air Protection. The primary objective of the law is to ensure clean atmospheric air, and reduce and prevent chemical, physical, biological and other hazardous impacts on atmospheric air. The law defines safe levels of hazardous substances' emissions (GHGs and gases with indirect greenhouse effects (NOx, CO) and SO_2). Amendments to the law made in 2008 restrict open burning of crop stubble, as well as in areas covered by crop residues and dry plants, plants in pastures and grasslands neighbouring agricultural and forest lands, and Specially Protected Area of Nature (SPAN). This provision is intended to preserve and accumulate organic carbon in soil and aboveground plants, and protect soil from exhaustion, erosion and desertification.

The Law of the RA on Energy and the **Law of the RA on Energy Saving and Renewable Energy** (adopted as HO-122-N of 9 November 2004 and amended as HO-130-N of 14 April, 2011. Currently, the draft law on

making amendments is included into the agenda of National Assembly). These laws define the main principles of state policy in the energy sector, including:

- Effective use of local energy resources and alternative sources of energy, and the application of economic and legal mechanisms for that purpose;
- Energy independence and energy security of Armenia;
- Creation of new industries, organization of new services, implementation of national target programmes, and the use new technologies to promote the development of renewable energy and energy saving;
- Introduction of energy efficient and energy saving technologies, reducing environmental impact.

Amendment to RA Energy Law (adopted, 2014). The Energy Law mandates that, during the first 15 years of operations, 100% of electricity produced from new renewable energy systems must be purchased at tariff levels set by the PSRC. This Amendment extending the Power Purchasing Agreement from renewable sources [with the exception of small Hydro Power Plant (HPP)] from 15 to 20 years aimed at promotion of renewable energy generation. Creates regulatory incentives for development of wind, solar, geothermal and biomass technologies development that along with on lending provided by local commercial banks in programs supported by the WB, EBRD and KfW will promote renewables in Armenia.

The Law of the RA on Waste. This law regulates waste collection, transportation, handling, processing, utilization, disposal, quantitative reduction and other relevant issues, as well as the legal and economic basis for the prevention of impact on human health and environment.

The Forest Code of the RA. This code regulates the sustainable management of forests and forestlands and the relationships governing maintenance, protection, restoration, forestation and effective use, as well as inventory, monitoring, and supervision of forests and forestlands. Implementation of the provisions of the code will contribute to the improved capacities of forests as sinks for carbon dioxide removal.

The Law of the RA on for the safe utilization of atomic energy for peaceful purposes. This Law settles relations concerned with state regulation of atomic energy utilization field, safety of nuclear facilities and ionizing radiation sources. As well as, protection against ionizing radiation, radioactive waste management, physical protection of atomic energy utilization objects, nuclear damage and compensation for nuclear damage and other relations in atomic energy utilization with the purpose to protect personnel, public and environment as well as the safety related interests of the RA.

Government Decisions

- On Approval of Maximum Permissible Concentration of Air Polluting Substances in Settlements and Maximum Permissible Norms of Hazardous Substances in Emissions from Vehicles Operated in the RA (Decree No. 160-N dated 2 February 2006);
- On Implementation of Projects within the Framework of the Clean Development Mechanism of the Kyoto Protocol under the United Nations Framework Convention on Climate Change (Decree No. 974-N dated 13 July 2006,);
- On Approval of the Procedure on Examination of Design of Maximum Permissible Emission Norms for Organization with Stationary Sources of Atmospheric Air Pollution and on Granting Emissions Permits (Decree No. 953 –N dated 21 August 2008);

- On Approval of Order on Projection, Notification of, and Response to Dangerous Hydro-meteorological Events Affecting Extra-normative Pollution of Atmospheric Air, Climate Change, and Ozone Layer Conditions (Decree No. 1186-N dated 16 October 2008);
- On Approval of Action Plan to be implemented by the RA under commitments of a number of Environmental Conventions (Decree No. 1594-N dated 11 October 2011).
- On implementation of energy saving and energy efficiency improvement measures in facilities being constructed (reconstructed, renovated) under the state funding (adopted, 2014). In 2002 the RA law "On urban development" (dated 5 May 1998) was amended in a way that fulfilment of requirements stated by urban planning normative-technical documentation is obligatory for all entities engaged in urban development activity. However, the basis of normative-technical documentation for energy efficiency in buildings was missing. For that propose, 2l (mostly international (ISO) and European (EN)) standards on energy efficiency of buildings have been harmonized over the last decade. This activity resulted in adoption of the RA government decision "On implementation of energy saving and energy efficiency improvement measures in facilities being constructed (reconstructed, renovated) under the state funding (adopted on 25 December 2014, protocol decision #1504-N).

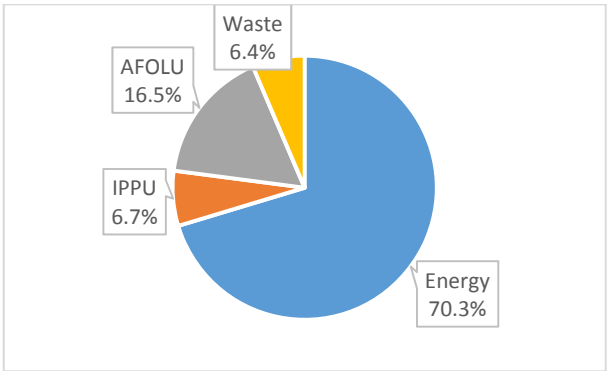
1.3 Sector selection

Following the TNA handbook, as a first step in the sector prioritization process, sectors and subsectors with GHG relevance have been obtained from TNC, NIR, BUR and other relevant documents.

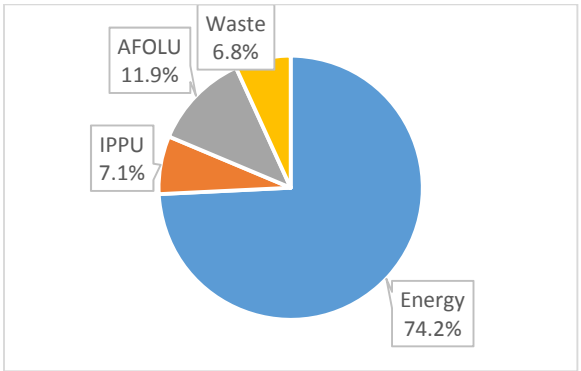
GHG Inventory

During the preparation of the National Greenhouse Gas Inventory Report of the RA for 2012, the highest priority was given to estimation of emission of gases with direct greenhouse effect, i.e. CO_2, CH_4 and N_2O from key sources of emissions. Estimation was also made for emissions of gases with indirect greenhouse effect, i.e. CO, NO_x, NMVOCs and SO_2, as well as for emission of HFC compounds.
Figures below indicates the breakdown of GHG emissions and removals by gases and by sectors (in **CO2 eq.**)

Figure 4 GHG emissions and removals by sectors (in CO2 eq. in 2012)



Distribution of GHG Emissions (without Removals)



Distribution of GHG Emissions and Removals by Sectors

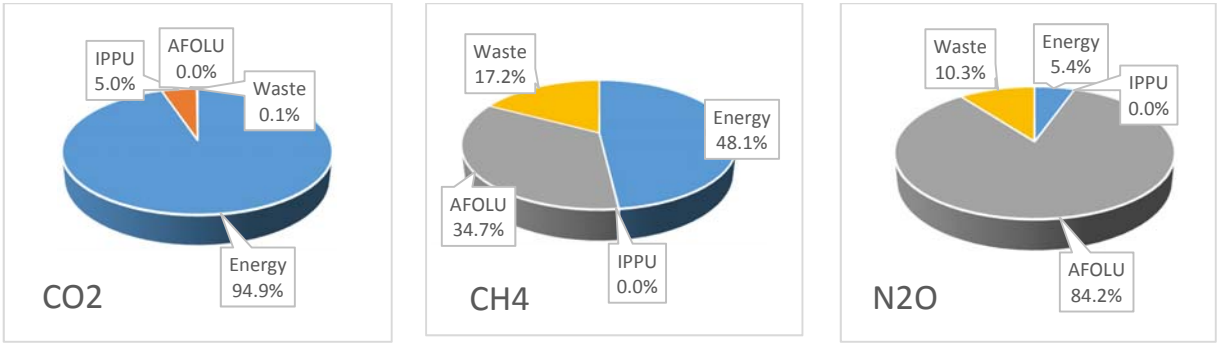
Source: National Greenhouse Gas Inventory Report of the RA 2015 [**Ref-16**]

In 2012, total national emissions increased in comparison with 2010. It is mostly due to the increase of emissions in the sectors of "Energy" and "Agriculture, Forestry and Other Land Use".

The major part of the emissions is from the "Energy" Sector with about 74 percent (considering Removals) and 70 percent (without Removals), the next sector is AFOLU with its 11.9 (considering Removals) and 16.5 percent (without Removals).

As it can be seen from the Figures CO_2 emissions are mainly linked with, "Energy" sectors due to the emissions from the subcategories of Energy industries, gaseous fuels (emissions form thermal power plants), other sectors gaseous fuels (population) and Road transportation.

Figure 5 GHG Emissions per Sectors and Gases for 2012

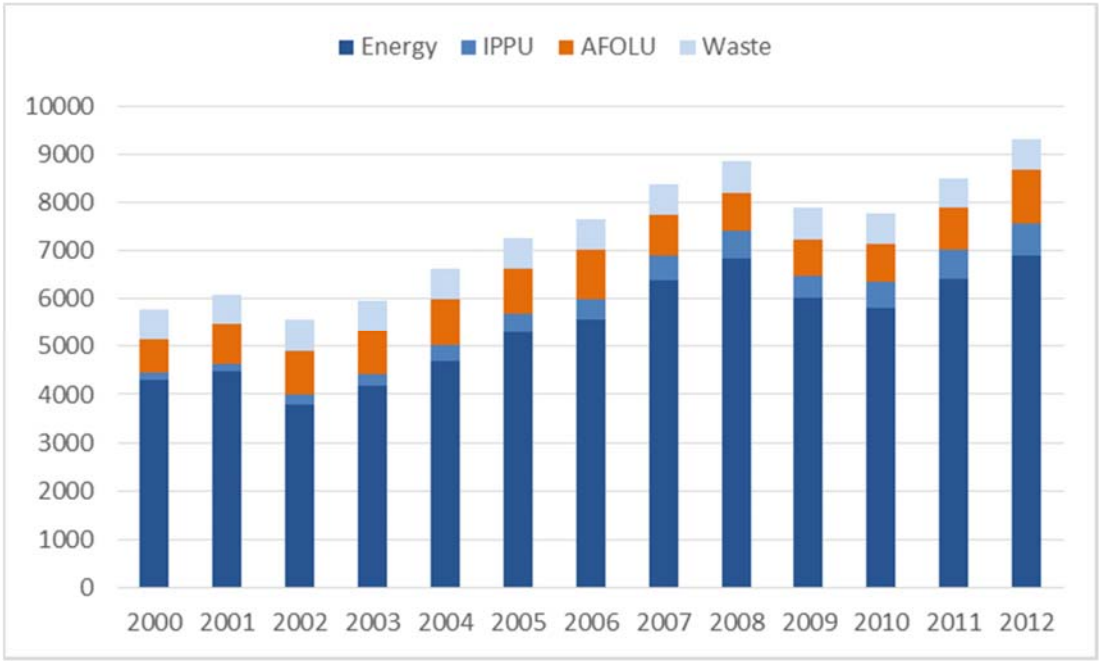


Source: National Greenhouse Gas Inventory Report of the RA 2015 [**Ref-16**]

Methane emissions are also mostly form the "Energy" sector, due to the fugitive emissions of the natural gas. The second one is AFOLU sector, due to the emissions from enteric fermentation and the third one is "Waste" sector.

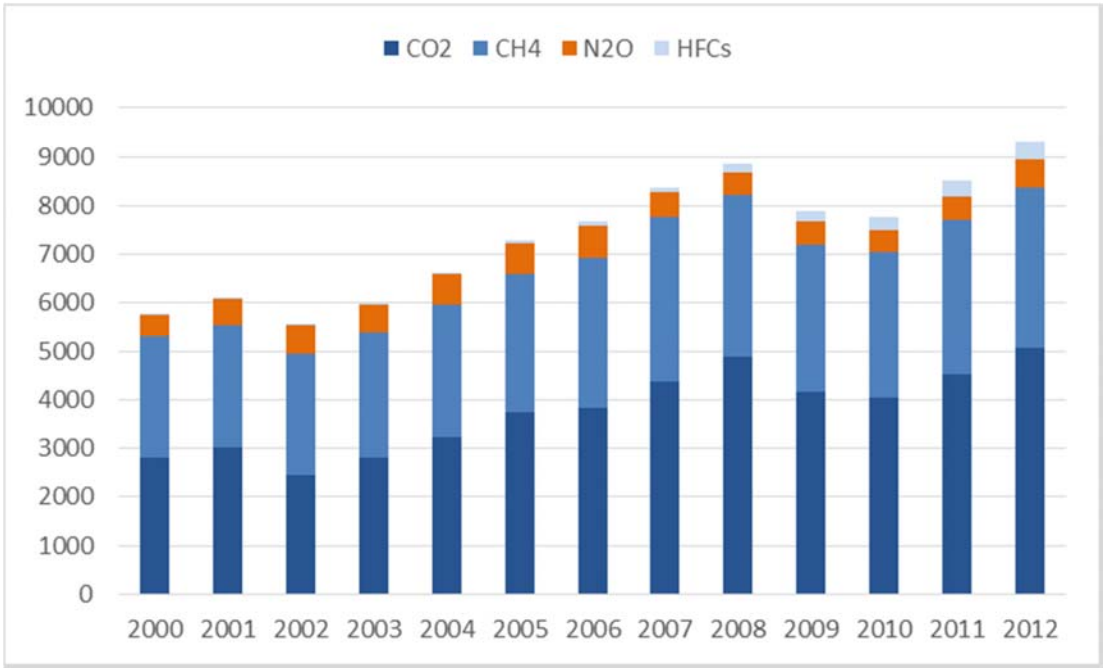
Most of nitrous oxide emissions are broken down to the AFOLU sector. Particularly this is due to the direct and indirect N_2O emissions from managed soils.

Figure 6 GHG Emission Trends per Sectors (Gg CO_2 eq.)



Source: National Greenhouse Gas Inventory Report of the RA 2015 [**Ref-16**]

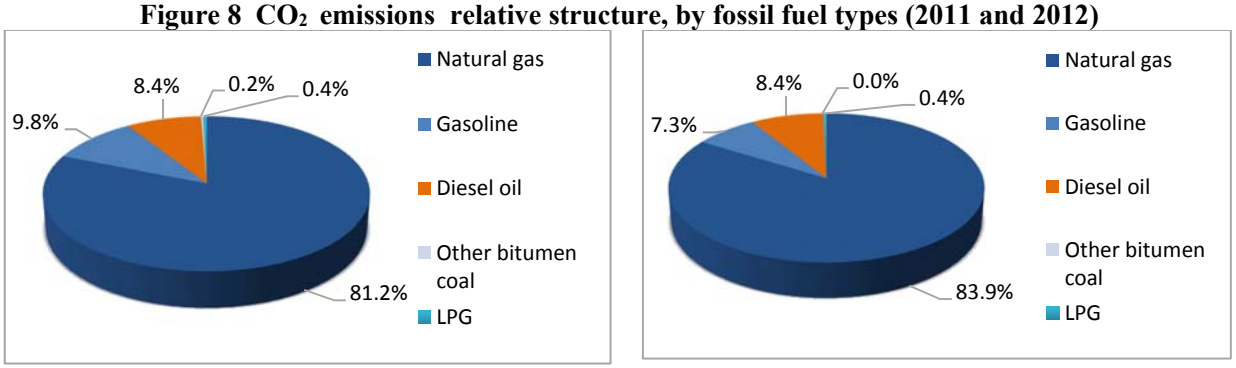
Figure 7 GHG Emission Trends per Gases (Gg CO_2 eq.)



Source: National Greenhouse Gas Inventory Report of the RA 2015 [**Ref-16**]

As it is shown in **Figure 8** below, natural gas is the main component in fuels accounting for 81.2% and 83.9% of GHG emissions from fossil fuels in 2011 and 2012 respectively. This is due to the fact that access to natural gas is fairly high in the country about 95%. It should be noted that natural gas is also largely used in road transportation as it is 2.5 times cheaper than gasoline and there is a developed compressed natural gas (CNG) filling stations network in the country. Relative structure of CO_2 emissions and fuel types are describe in **Figure 8** below.

Figure 8 CO_2 emissions relative structure, by fossil fuel types (2011 and 2012)



Source: National Greenhouse Gas Inventory Report of the RA 2015 [**Ref-16**]

1.3.1 An overview of sectors, projected climate change, and GHG emissions status and trends of the different sectors

1.3.1.1 Energy Sector

Sectorial measures contributing to the mitigation of climate change in Energy Sector are being implemented in key programmes, including:

Strategy for Development of the Energy Sector within the Context of Economic Development of Armenia. This strategy covers the period until 2025 and has the following objectives: facilitation of sustainable economic development and energy security of Armenia, including diversification of imported and local energy resources; maximum utilization of renewable and alternative sources of energy; promotion of energy saving; environmentally friendly energy supply in line with the international commitments of Armenia. It describes projected indicators for energy consumption for sectors of economy divided by implementation periods, and provides a list of projects for the development of electric-energy, gas, and heat supplies [**Ref-1**].

Action Plan of the Ministry of Energy of Armenia provided for in the provisions of the National Security Strategy. This envisages the construction of generating facilities and measures to be taken by 2025, including: construction of new 540 MW HPPs (including 260 MW small HPPs); construction of 200 MW wind turbines; upgrading of the currently operational two TPPs using gas-turbine installations with a total capacity of 648 MW; construction of a new 1,000 MW power unit in MNPP; modernization of electricity transmission and distribution networks to reduce losses; construction of Iran-Armenia gas pipeline; restoration of 150 million m^3 capacity of underground natural gas storage; restoration of heat supplies with the maximum use of geothermal, biogas, solar and other renewable energy sources; organization of large-scale introduction of sustainable measures to ensuring energy saving. The work plan includes timeframes and financing sources for the implementation of measures.
The following planned activities have been accomplished as of 2012: the Iran-Armenia gas pipeline; high-performance power units in Yerevan and Hrazdan TPPs (with total generating capacity of 648 MW); 130 small HPPs (with total generating capacity of 204 MW); 2 co-generation systems for centralized heat supply; 458 high-performance autonomous heating systems for public buildings; a number of small generation plants using renewable energy (with total generating capacity of 1.3 MW) [**Ref-25**].

National Programme for Energy Saving and Renewable Energy. This provides for the assessment of energy-saving potential in the power sector, heat and gas supply systems, industrial production, transport, and housing, as well as renewable energy potential and measures for the cost-effective utilization of energy-saving potential [**Ref-25**].

Action Plan of the Government for Implementation of the National Programme for Energy Saving and Renewable Energy. The main objectives are the facilitation of further formulation of energy-saving policies in Armenia and the finalization of specific steps for their implementation. It provides for specific activities to be implemented by sector (residential buildings, services, manufacturing, transport, water), as well as horizontal and inter-sectorial activities aligned to quantitative targets (percentage compared to the baseline) that can be gradually achieved by 2020 [**Ref-25**].

RA Renewable Energy Development Roadmap and **Renewable Energy Development Guideline of Armenia.** Those documents describes the technical accessibility, and the economic and financial feasibility and benefits of RE potential, and evaluates RE potential in transport and electrical and thermal energy generation in the short term (until 2013), midterm (until 2015), and long term (2020 and after). The roadmap refers to investment needs and costs according to RE types and sector. The future share of RE generation in long-term plans is estimated at 16.3% [**Ref-19**].

Small Hydropower Plants Development Scheme. This is designed to promote the construction of small HPPs and includes hydro energy indicators for more than 100 HPPs [**Ref-25**].

Main Issues, Status, Development Barriers, and Future Development of Small Hydro Power. This focuses on assisting the energy sector of Armenia to improve potential for supply independence and security. It presents 115 possible resource sites with a capacity of 147 MW, and with annual generation capacity of 540 GWh. It

provides detailed indicators of 65 licensed (yet not constructed) small HHPs with potential capacity of 158 MW and with annual generation of 500 GWh. It also presents data for various financial indicators and possible financing schemes [**Ref-25**].

Power Transmission Rehabilitation Project. This project, financed by The Asian Development Bank (ADB), is intended to improve the efficiency and power supply reliability of power systems in Armenia. The project includes two major components: extension of dispatching control and data collection systems; rehabilitation of eight existing 220 kV sub-stations with respective replacement of aged transformers, circuit breakers and other equipment [**Ref-25**].

The Concept for Ensuring Energy Security of the RA and a number of programme documents define Energy sector development strategy and the means for creating safe, effective and sustainable operating conditions. The strategy is envisaged to develop renewable, alternative, and nuclear energy, and ensure energy saving.

National Energy Security Concept

The concept identifies the promotion, development and investment in renewable energy and energy efficiency as critical to achieving energy security.

The Green for Growth Fund (GGF), Southeast Europe, the EBRD's ongoing Caucasus Energy Efficiency Program (CEEP), the IFC Armenia Sustainable Energy Finance Project and KfW provide financing for on-lending of RE and EE projects through local commercial banks. Eastern Europe Energy Efficiency and Environment Partnership (E5P) provides grants to enable implementing the most important EE projects [**Ref-20**].

The Concept for Ensuring Energy Security. Tasks include:

- Establishment of preconditions for sustainable economic development;
- Self-sufficiency and export potential of Armenia's energy system in the region;
- Creation of an attractive environment for investment for renewable, alternative and nuclear energy;
- Energy efficiency and energy conservation;
- Reduction of GHGs;
- Development of fundamentals to ensuring the target level of energy security for Armenia.

The concept defines domestic and external challenges and threats for energy security that may undermine the implementation of measures for meeting the energy demands of the country, as well as tasks for energy-security management systems. It sets forth the following measures for ensuring energy security:

- Enhancement of energy security insurance systems;
- Effective use of renewable energy resources and energy conservation;
- Development of nuclear energy;
- Diversification of energy resource supplies and the regional integration of energy systems;
- Energy sector financing and established levels of economic effect;
- Energy security in emergencies and in wartime.

It also sets forth the following actions:

- To reach the 20% target of primary RE in total energy consumption;
- To construct a new 1,000 MW power unit in MNPP, in parallel ensuring safe operation of the existing nuclear unit until its decommissioning;
- To promote energy saving in buildings, to upgrade thermal energy facilities by introducing gas and combined cycle thermal and electric energy generation (co-generation) systems, and to reduce energy losses in networks/the grid;

- To establish petroleum product strategic reserves. To construct a gas pipeline from the Islamic Republic of Iran to Armenia, and to start bio-ethanol (bio-butanol) production;
- To strengthen Armenia-Iran and Armenia-Georgia overheat transmission lines by constructing new 400/500 kV lines, to rehabilitate the existing 220 kV line to Kars, to organize a regional market for electricity and capacity, and to integrate with energy markets in CIS countries;
- To develop and use ecologically clean technologies for vehicles alongside the parallel development of electric transport infrastructure.

Sevan-Hrazdan Cascade Hydropower System Rehabilitation Project. Under this project, financed by the ADB, the rehabilitation and upgrade of four out of seven HPPs in the Sevan-Hrazdan Cascade Hydropower System is planned, as well as the rehabilitation of water outflow canals in three plants and the replacement of electrical equipment in the four HPPs. [**Ref-19**]

Rehabilitation, modernization and expansion of the gas supply system in Armenia. Measures periodically implemented by "Gasprom-Armenia" CJSC allow for significant reduction in current and future fugitive emissions of natural gas (methane).

Investment Plan for the **Scaling-up Renewable Energy Program (SREP**, **2014)** [**Ref-20**]
The Investment Plan identifies renewable energy technologies and projects that can best contribute to Armenia's energy, economic and environmental development goals and outline the activities that must be carried out to realize the projects. The most important, the Investment Plan identifies the financing modalities under which the RE projects can be realized and the ways in which SREP can help to leverage concessional and private sector financing.

Energy Security Action Plan (adopted, 2014) [Ref-13]
Identifies the concrete steps towards achieving the objectives of the National Energy Security Concept and the SREP. Served as the basis for the development of the "Armenia Least Cost Energy Development Plan"
Strategic Climate Fund (SCF), which is one of two funds within the framework of the Climate Investment Funds (CIF), provided USD 40 million for SREP funding.
The US$ 40 million of SREP funding is expected to catalyse roughly 4.5 times as much investment, most of it from the private sector (as equity or debt), and the commercial lending windows of the Multilateral Development Banks (MDBs) including ADB, EBRD, and WBG

Armenia Least Cost Energy Development Plan, (2015). Currently a new Energy Strategy is under development. The Government of Armenia with USAID/LEDS project assistance is implementing the Least Cost Generation Plan, which will define the development strategy to meet the criteria of energy security at the lowest cost. According to the above mentioned official papers reflecting the RA energy strategy, the future of development of the Armenia energy system is mainly expected to be based upon nuclear energy and modern gas fired generation plants, development and expansion of economically viable and technically available renewable energy sources, and diversification of fuel supply chains. All these options were examined in the Plan preparation [**Ref-3**].

National Energy Balance (Implementation of a regular national "Energy Statistic"). USAID LEDS Program supported development of national energy balance according to IEA and Eurostat requirements for years 2010-2012 [**Ref-4**].
This activity will support development of National GHG Inventory and contribute to its improvement thus contributing to the improvement of reporting on mitigation actions.

Development of Standardized Baseline (SB) Entry into force in 2015, valid until 2018. Aimed at easing implementation of EE and RE projects [**Ref-21**].

Second National Energy Efficiency Action Plan (under development)
The second NEEAP is considered a key document in setting up the energy saving targets and measures that should be implemented for period of 2015-17 to reach these targets.

1.3.1.2 Transport Sector

Sectorial measures contributing to the mitigation of climate change in Transport Sector are being implemented in key programmes, including:

Action Plan for Reducing Emissions of Hazardous Substances from Vehicles. This provides for measures designed to conduct environmental monitoring and inventories of hazardous emissions, improve road transport and transportation flows, develop public transport (including electric transport), and promote the use of clean-engine fuels [**Ref-25**].

Yerevan Master Plan for 2006-2020. According the plan, emissions from vehicles will be reduced by 20% by 2020 due to developments in electric public transport and increased passenger load in the metro (from 5.2% to 11.9%) in trolleybuses (from 2.7% to 24.1%), big and small buses (from 8.3% to 45%), and reductions in passenger load in minivans (from 83.8% to 19%). It also envisions a new transport scheme for the city and the application of neutralizers for vehicle emissions. The increase in the share of natural gas as engine fuel and the use of biogas after 2020, as well as programmes designed to improve roads will contribute to the reduction of GHG emissions from road transport [**Ref-25**].

1.3.1.3 Land use and Forestry Sector

Sectorial measures contributing to the mitigation of climate change in Land use and Forestry Sector are being implemented in key programmes, including:

Forest Policy and Strategy of RA and **National Forest Programme of RA**. The main objectives of these are to ensure the rehabilitation of degraded forest ecosystems, and develop the sustainable use of forests and their useful features.

The plan for 2009-2020 is to restore an area of 2-2.5 thousand ha of degraded forest ecosystems; reforest 5-5.5 thousand ha of forestlands; establish 0.6-0.65 thousand ha of forest zones for field protection [**Ref-25**].

1.3.1.4 Waste management Sector

Sectorial measures contributing to the mitigation of climate change in Land use and Waste management Sector are being implemented in key programmes, including:

Armenia, in cooperation with international organizations, is implementing a number of projects designed to improve Municipal solid waste (MSW) systems and build new regional sanitary landfills that will create the pre-conditions for landfill gas capture.

Waste Management – Waste Governance-ENPI East regional project. The main objective of the project is, through regional cooperation, to assist participating countries (including Armenia) to reduce the risks caused by improper waste management, as it creates environmental pollution risks to communities and natural resources. The piloting phase of the project covers Lori marz, where an inventory of all large and medium sources of MSW was made and 15-year waste management strategy developed (with the EU) [**Ref-25**].

Integrated Solid Waste Management System for the City of Vanadzor, Armenia. The main objective of this programme is to develop an integrated solid waste-management strategy for the city of Vanadzor and neighbouring communities. The strategy will include the decommissioning of the existing Vanadzor solid waste landfill and a feasibility study for introducing the proposed new waste management system (with KfW Bank) [**Ref-25**].

Armenia Solid Waste Management Improvement Project. The main objective of this project is the development of a national waste management strategy that defines technical, institutional, and financial conditions for implementation (involving the private sector). This project plans to shut down 48 existing MSW disposal sites and open 5 new regional MSW disposal sites with 10 reloading points for waste sorting. There will be landfill gas capturing and flaring in closed large (Yerevan, Gyumri and Vanadzor) SW disposal sites (with the ADB) [**Ref-25**].

1.3.2 Process and results of sector selection

Armenia has already identified development priorities as part of above mentioned national development strategies, sector policies as well as poverty reduction strategies. TNA National Team has generated a list of possible development priorities, based on those laws and regulations, elaborated national and sectorial programmes, which they consider applicable to the country's sustainable development, for the purpose of guiding technology needs assessment. The list of development priorities (listed below) has been discussed with key stakeholders (listed below) in order to identify key development economic, social and environmental priorities.

During meetings, intensive debates were held on selection of sectors. Obviously Energy sector is the largest producer of GHG emissions in the country. Moreover, Energy sector, according to the 2006 IPCC Guidelines, includes mainly fossil fuel combustion for energy generation and fugitive emissions from natural gas but also fossil fuel combustion in Indusrtry, Transport and Residential subsectors as well. The main source of $CO_{2eq.}$ emissions in RA apparently is the energy sector. GHG Inventory results for 2012 is presented in **Table 1**.

Table 1. RA GHG Inventory results for 2012

GHG Source and Sink Categories	Emissions 2012 (Gg $CO_{2eq.}$)	Emission share by sectors (%)
Energy	6,913	70.3
IPPU	663	6.7
AFOLU	1,622	16.5
Waste	632	6.4
Total Emission	9,829	100.0
CO2 removal	-522	
Net emission	**9,307**	

Source: Biennial Update Report, 2015 [**Ref-2**]

Analyses of information from the TNC, ongoing NIR and BUR show that emissions from the Energy sector are much higher than other sectors. Nevertheless, the Industry, Land use, forestry, and Waste management are also becoming increasingly important, as the country's economy grows foreseen by ADS.
Consequently, after a number of discussions, all mentioned sectors have been identified as very important sectors for mitigation.

Based on the results of the inventory of GHG by sectors and calculated GHG emissions forecasts (mitigation scenarios) to the year 2030, consistent time series for years 2000-2012, as well as identified economic, social and environmental development priorities, based on their GHG emissions mitigation potential and compliance

with country development priorities and potential mitigating effect on climate change by sector the following subsectors/groups of technologies were selected:

- Energy (including transport)
- Industry (including chemical industry)
- Land use (including forestry)
- Waste management (including agriculture)

Based on methodology provided in the TNA Handbook and in accordance with the abovementioned global and sectoral strategic documents, based on "ecosystem approach" the working group on mitigation agreed on three main priorities for prioritizing the sectors and technologies. 1). Economic Development Priorities (including, but not limited to): Sustainable development, Contribution to sustainable economic development, Infrastructure development, Promotion of investments, Energy security, Low-carbon development. 2). Social Priorities (including, but not limited to): Poverty reduction, Reduction of unemployment, Creation of work places, Increase of income, Food security, Favorable living conditions, Public participation and awareness-raising. 3). Environmental Priorities (including, but not limited to): Conservation and rational use of natural resources, Reduction of natural disasters, Climate change prevention, Biodiversity conservation, Atmosphere air protection, Protection of forests, Prevention of soil degradation, Improvement of solid industrial and household wastes, Combating desertification, Water pollution prevention.

The two highly significant for climate change mitigation aspects in Armenia are Nuclear energy and Renewable Energy further development. The priority of mentioned two spheres is adopted on the highest level in RA. Following are brief remarks and observations regarding mentioned sectors.

Nuclear energy

Nuclear energy development is adopted as a priority in Armenia by RA Law [**Ref-1**], [**Ref-11**], and therefore is out of discussion in this TNA Report. According to the ADS during the implementation of the program, the main directions of the policy implemented in the energy sector will be as follows:

- Maximum use of own sources, specially renewable sources of energy;
- Further development of nuclear energy, in particular construction of new energy block and enhance in security of Armenian nuclear power station's 2nd energy block and extension of its utilization period;
- Replacement of physically and morally depreciated power plants with those furnished with new technologies;
- Diversification of energy supplies and regional integration;
- Promotion of energy efficiency in all sectors using energy resources;
- Increase of the level of safety and reliability of the electro energetic system.

The government originally plans to build a new 1000 MW nuclear plant as replacement in 2026, but following in-depth surveys it is decided that 600 MW power unit will become more flexible in terms of operation and maintenance, however financing remains a challenge and no concrete progress has been made to date.
Nuclear energy is vital to Armenian energy security. Landlocked and without endemic natural gas or oil resources, Armenia relies on Metsamor Nuclear power plant (MNPP), a Russian-built Water-Water Energetic Reactor (VVER) 440 reactor, for approximately a third of its electricity generation. The scheduled decommissioning of Metsamor in 2026 presents a substantial problem to Armenian energy independence, requiring a serious discussion about Armenia's long-term energy security. The Armenian government has made the construction of a New NPP a primary energy and security priority.

Many countries such as Japan rely on nuclear power despite their locations in seismic zones. The 2011 meltdown of the Fukushima plant following a 9.0 earthquake off the coast of Japan, considered the worst nuclear disaster since Chernobyl, has altered the discussion of nuclear safety in the past four years. The risks associated with seismic activity cannot simply be brushed aside. They must be considered by procurers and investors.

Construction of New NPP in Armenia is a priority for Russia as well. Armenia's new nuclear unit of energy will occupy about 74 hectares of land; the number of employees will reach to 900. In addition, the construction will be held in a way that will minimize the environmental impact. Operating and planned nuclear power reactors in Armenia are presented in **Table 2.** [**Ref-7**], [**Ref-13**].

Table 2. Operating and planned nuclear power reactors in Armenia

Reactor Type	Net capacity	Status	First power	Planned close
VVER-440	376 MW	Operating	1980	2026
VVER-1000	1,060 MW	Planned	Expected 2026	
Total operating	376 MW			

Source : http://www.world-nuclear.org/information-library/country-profiles/countries-a-f/armenia.aspx

One Russian VVER-440 nuclear power plant operates at Metsamor, 30 km from the capital Yerevan. While nameplate capacity is 407.5 MW, it has been licensed since 1995 at 92% of this - 376 MW.

Two model V-230 reactors, each of 407.5 MW gross (376 MW net), were built at Metsamor on solid basalt and supplied power from 1976 and 1980 respectively. Design life was 30 years.

In December 1988, a powerful earthquake, resulting in the deaths of at least 25,000 people, occurred in northwestern Armenia. The MNPP 75 km from the epicenter continued operating normally with no damage, but both units were subsequently shut down in 1989 due to safety concerns regarding seismic vulnerability.

Unit 1, after 13 years' operation, is now being decommissioned. In 1993, it was decided to restart the second unit due to the severe economic crisis and this was achieved in 1995, after 6.5 years' shutdown. Since then the International Atomic Energy Agency (IAEA) has been participating in safety improvements at the plant, which was scheduled to close in 2016 but will now continue until the new unit is commissioned. In September 2013 Russia announced an agreement to undertake works to extend the life of the plant by ten years, and in May 2014 Russia agreed to provide $300 million for upgrading the plant to enable life extension to 2026.

An intergovernmental agreement was signed in December 2014. In May 2015 parliament agreed to accept a $30 million grant from Russia and approved a $270 million loan for 15 years at 3%.

To effect the upgrade, the plant will be shut down for six months in 2017 to undertake major works, which will include turbine modernization to increase power by 15-18%, to 435-440 MW net. All fuel is supplied by Russia.

The present Metsamor plant is a concern to the European Union (EU) and to neighboring Turkey, 16 km away. There have been various calls to shut it down before 2016, but Armenia is very dependent on it and has said that it will remain open until a replacement is commissioned.

In October 2012 the government confirmed approval for a 10-year life extension, and reiterated this in March 2014 and July 2015, while it sought the money to build a new one.

In 2007, Armenia adopted a new energy strategy focusing on security of supply through diversification and the use of nuclear energy as well as renewable energy sources.

Renewable Energy

The renewable energy sector is a priority area in the RA based on the laws adopted in this sphere. The energy sector of Armenia has achieved significant results through reforms and restructuring. The sector has strong

payment discipline with collections for electricity at 100% of sales. There are no explicit or implicit subsidies to the energy sector and the sector entities are among the largest taxpayers in the country. There is a competent and independent regulatory agency for the sector PSRC.

The level of development of the world energy sector, its impact on the environment made many countries, including Armenia to reflect on the issue of utilization of own renewable natural resources, which are clean from the environmental point of view. The countries started revising their energy strategies, began adapting them to world and European standards in order to achieve the common goal – to avoid global warming catastrophic for the population of our planet. Estimated Renewable Energy Technical Potential in Armenia is presented in **Table 3**.

For that purpose, the main and necessary legal base was established in Armenia for development of renewable energy and application of energy efficient technologies.

Table 3. Estimated Renewable Energy Technical Potential in Armenia

Technology Type	Capacity
PV	>1000 MW
Wind	300-500 MW
Geothermal	50 MW
Small Hydro	250-300 MW
Solar Thermal	>1000 MW
Heat Pumps	>1000 MW
Biofuel	100 thousand tons/year

Source: Renewable Energy Roadmap for Armenia, R2E2 Fund, [**Ref-19**]

Armenia has significant indigenous renewable energy resources, and an educated workforce with extensive scientific and engineering expertise. Furthermore, the Government has taken active steps in recent years to create policies and regulations designed to reform the power sector to enable private sector involvement in renewable energy technology development. However, Armenia's renewable energy sector faces a number of important barriers to renewable energy deployment, primarily related to the availability of financing, the regulatory framework for renewable energy, the high cost of renewable energy technologies and public awareness of the potential benefits of renewable energy technologies.

The renewable energy sector is a priority area in the RA based on the laws adopted in this sphere. The goal of the laws is to establish in the energy sphere principles of the state policy and mechanisms for its implementation, including those for implementation of energy efficiency measures and development of renewable energy.

In addition, necessary by-laws were adopted. Summarizing the legal acts, we may note that the RA created numerous mechanisms for promotion of use of renewable energy sources, for example:

According to the Law on Energy, all electricity generated by power plants that use renewable energy sources is subject to be obligatory purchased within 15 years from the date the license for generation of electricity was granted. Amendment to The Energy Law (adopted in 2014) extending the Power Purchasing Agreement from renewable sources from 15 to 20 years aimed at promotion of renewable energy generation.

The PSRC set tariffs for producers of electricity that use renewable energy sources. The tariffs were set for hydro, wind electricity, and for electricity generated from biomass. As of 2015 still there is no tariff for solar electricity. Meanwhile Armenia is among high solar potential countries. The average annual radiant flux per 1 m^2 of flat surface stands at 1,720 kWh/m^2 (the European average is about 1,000 kWh/m^2). The share of direct radiation is also considerable at 65-70%, which is very notable from the prospective of implementation of focusing concentrators. The development of the solar potential in Armenia is chiefly following two paths: the

manufacture and installation of photovoltaic converters; and the manufacture and installation of flat-plate solar collectors for water heating.
As a result of creation of such mechanisms, small hydro energy began its active development. As of 1 January 2012, electricity is generated by 115 SHPPs with total installed capacity about 158 MW, and annual output of electricity about 520 million kWh (it is about 6.5% of the total generated electricity).
Licenses for construction were received by 88 SHPPs more, with total installed capacity about 177 MW, and annual electricity output about 637 million kWh.

The Proposed in June 2014 **Investment Program for Armenia SREP** led by the Ministry of Energy and Natural Resources (MENR) and supported by the MDBs, has identified three areas for strategic investment. The areas were identified through comprehensive analysis.

Scale-up potential by SREP
The scale-up potential of each RE technology in Armenia depends ultimately on how much of a resource is available, how much of that resource is commercially viable, and what the transmission grid can sustain. **Table 4** below shows the total estimated commercially viable technical potential for renewable energy technologies in Armenia.

Table 4 Renewable Energy Resource Commercial Potential in Armenia by Technology

Technology	Capacity (MW)	Generation (GWh/yr)
Wind	300	650
Utility scale solar PV	830– 1,200*	1,700 – 2,100a
Concentrating solar power (CSP)	1,200	2,400
Distributed solar PV	1,300	1,800
Geothermal power **	at least 150	at least 1,100
Landfill gas	2	20
Small hydropower	100	340
Biogas	5	30
Biomass	30	230
Total (electricity) * **	**3,800 –4,300**	**7,400 – 8,700**
Solar thermal hot water	200	260
Geothermal heat pumps	3,500	4,430
Total (heat)	**3,700**	**4,690**

Source: Scaling-up Renewable Energy Program (SREP, adopted, 2014) [**Ref-20**]

* The resource potential depends on which solar PV technology is deployed: Fixed PV, Single-Axis, Tracking PV or Concentrating PV

** Assumes flash technology is used. The actual capacity cannot be known without exploratory drilling. The geothermal capacity estimates are based on results of estimates for three potential sites, for which some geo-technical information was available. The potential can be significantly larger given several other potential sites, which have not been explored at all.

*** Solar PV and CSP were evaluated as options for development in the same areas. Therefore, the total resource potential includes only the generating potential for one of these technologies (Solar PV). For this reason, the total is not the same as the sum of the resource potential listed for each technology.

Small Hydropower
Small hydropower is the most widespread renewable energy technology deployed to date in Armenia except for large hydropower. Small hydropower contributes approximately 6 % of Armenia's annual electricity

generation. As of April 2013, Armenia had 136 small hydropower plants (small HPPs) with a total capacity of 221 MW and annual generation of 665 GWh. Roughly 60 % of this capacity has been added since 2008. Additionally, the PSRC has licensed the construction of 77 new projects, which could potentially add approximately 168 MW of small HPP capacity and 592 GWh of annual generation. Over 90 MW of undeveloped small hydropower projects with a potential for generating almost 300 GWh have been identified throughout Armenia in addition to the operating and licensed projects.

Wind

Armenia has a number of areas with promising wind resources. The most promising areas that have been identified and characterized to date are Zod Pass, Karakach Pass, Pushkin Pass, Sisian Pass and the Fontan region. Together these sites are estimated to have 150 MW of developable resource potential, with estimated capacity factors ranging from 21 to 31 %, depending on the site. Armenia's only operating wind project is the 2.64 MW Lori 1 plant. Lori-1 was built in December 2005 under a grant from Iran. The plant has a capacity factor of approximately 11 % and generates 2.5 GWh per year.

Geothermal Power

Armenia has no installed geothermal power plants, but comprehensive geo-technical studies suggest that geothermal resources suitable for power production may exist at a number of sites, including the most promising Karkar, Jermaghbyur, and Grizor sites, as well as along the Armenian-Georgian border.

Solar PV

Armenia has good solar PV resources, with annual average global horizontal irradiation (GHI) ranging from 1,490 kWh/m2 to over 2,100 kWh/m2. By comparison, average annual GHI in Europe is 1,000 kWh/m2. The total resource potential for utility-scale solar PV is over 6,500 MW. Assuming polycrystalline solar PV modules mounted at a fixed angle to the sun are deployed in ground-mounted utility-scale plants, solar PV systems could achieve capacity factors of 20 to 24 in Armenia (dependent on location). If single-axis tracking solar PV technology is deployed, capacity factors could be as high as 30 %. In addition to utility-scale solar PV, distributed solar PV mounted on building rooftops could also be deployed throughout Armenia, although these plants would likely have higher costs and lower capacity factors than large-scale, ground-mounted plants.
Solar PV deployment in Armenia to date has been limited to relatively small-scale rooftop-based installations at schools, hospitals, office buildings and municipal sites throughout Armenia. It is estimated that less than 100 kW of solar PV is currently operational.

As of today, amendments to the laws of "Energy" and "Energy Efficiency and Renewable Energy" are included at the National Assembly of Armenia. Those regulate the relation between Renewable Energy Autonomous producers and Electric energy distribution licensee, via electric power purchase and reverses. Autonomous energy producers are considered those that are exclusively generators for their own needs, as well as renewable energy producers with up to 150 kilowatts of installed capacity (except small hydroelectric power plants). Those mentioned amendments offer the tariff for solar: The acquisition of delivered electricity (at annual basis, for the electricity amount delivered over own needs) by the Electric energy distribution licensee would be done at 50% level of PSRC prescribed tariffs for consumer groups per month.

The technologies identified by SREP

Each of the potential renewable energy resources were evaluated against five criteria, and prioritized accordingly. The five criteria reflect the Government's strategic objectives, and the clear recognition that SREP funding should be used to overcome barriers to technologies that will have the potential to have a transformative

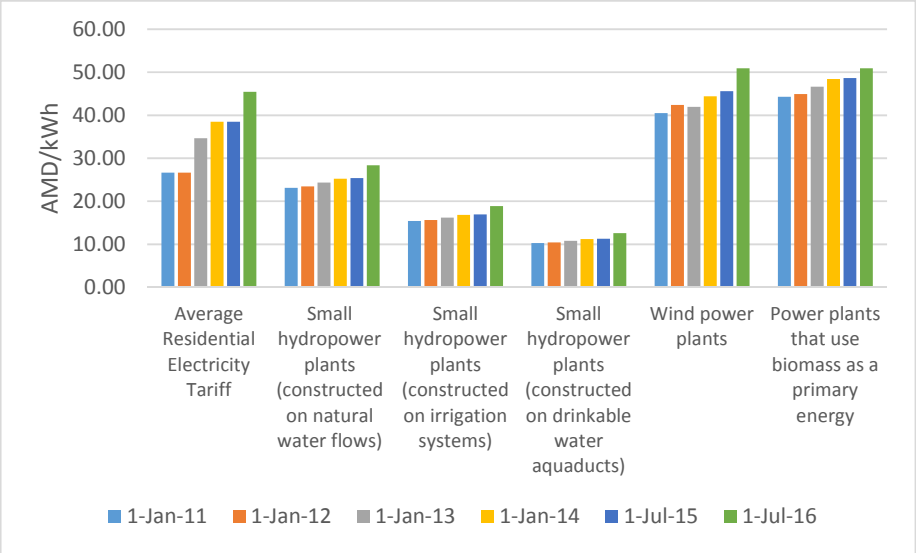
impact on the energy sector. The criteria considered were: cost-effectiveness of the technology, the potential for scaling up the technology, the maturity of the market, the potential for job creation, and the effect of each technology on the stability of the grid. These were evaluated on a scale of 1 to 4, with 1 indicating that the resource met the criteria best of all resources and 4 indicating that it met the criteria worst of all resources [**Ref-20**]. Three investment priorities emerged from the analyses and the discussions with stakeholders. These are as follows:

- **Geothermal Power Development.** By using grant funding for drilling, the Government can help reduce the risk of developing the site. This support can help make geothermal power a financially attractive investment for private investors and an affordable source of electricity.
- **Development of Utility-Scale Solar PV.** The rapid decline in solar PV costs in recent years has made utility-scale solar PV more competitive with the other power generation options available to Armenia. Therefore, it is strategically beneficial for Armenia to develop its capacity to scale-up this technology.
- **Development of Distributed Geothermal Heat Pump and Solar-Thermal Projects.** Financial analysis of the cost of geothermal heating and solar thermal technologies suggests that they are currently cost-competitive with electric heating in Armenia, and may be competitive with natural gas heating.

Tariff policy for RE in RA

Armenia is pursuing a tariff policy to support the creation of favourable conditions for developing RE and attracting investment. There are purchase guarantees and feed in tariffs set for power generated by small HPPs, wind turbines, and biogas plants. The dynamics of feed-in tariffs for Renewables in Armenia for recent years is shown in **Figure 9.** Feed-in tariffs for Renewables in Armenia for 01.07.2015 to 01.07.2016 are adopted by PSRC Decision 29.05.2015 N "157 N".

Figure 9 Feed-in tariffs for Renewables in Armenia (AMD, 2011-2016)



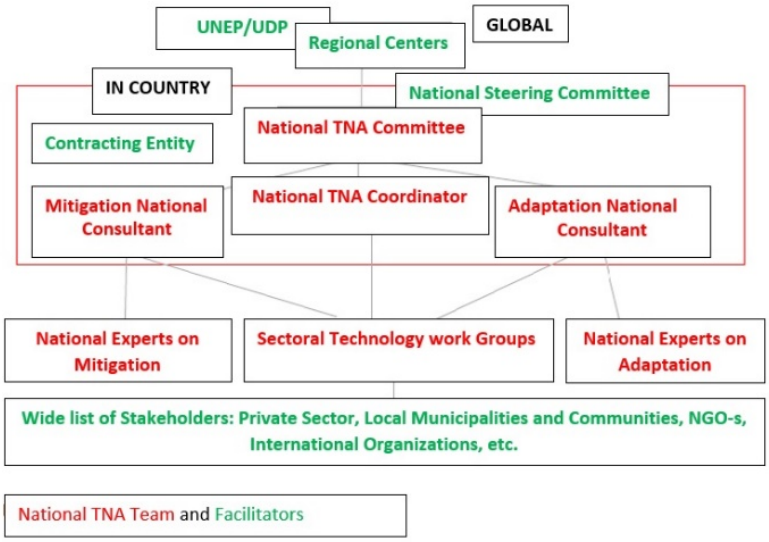
Source: PSRC http://www.psrc.am/ [**Ref-18**]

Chapter 2 Institutional arrangement for the TNA and the stakeholder involvement

2.1 National TNA team

An Agreement for Conducting a Technology Needs Assessment in Armenia was signed between the RA Ministry of Nature Protection of Armenia and UNEP DTU Partnership (UDP). After this, the TNA National coordinator UNFCCC focal point in RA Mr. Aram Gabrielyan was appointed.
In this regard, there has been established a Project Steering Committee, the responsibilities of which have been assigned to the working group of Interagency Council for coordination of requirements and provisions of UN Framework Convention on Climate Change established by Decree N 955-A of Prime Minister of RA of 2 October, 2012. Main responsibilities of the Committee are to monitor the project implementation, give strategic guidance to the team and make prioritization of sectors for adaptation and mitigation.
The diagram of TNA national team structure and Institutional arrangement of the Project is provided in **Figure 10**. The national team consists of two groups: Adaptation and Mitigation. The Adaptation team leader, Mr. Vardan Melikyan, and Mitigation team leader, Mr. Tigran Sekoyan, were appointed. Other experts under adaptation: Mr. Samvel Avetisyan and Ms. Arevik Hovsepyan and mitigation groups Mr. Mkrtich Jalalyan, Mr. Anastas Aghazaryan, Ms. Arevik Hovsepyan were involved from October 2015.
Contracting facility is Environmental Project Implementation Unit State Institution.

Figure 10 TNA National coordination and participation, Institutional structure for the project



"Environmental Project Implementation Unit" State Institution is the successor of previously operating "Natural Resources Management and Poverty Reduction Project" EPIU State Institution and "Environmental Project Implementation Unit" SNCO reformed on the bases of the latter. The main objective of the institution is the provision of efficient implementation of the RA environmental sector projects. The principal spheres of the center activity include programs and works of the RA Ministry of Nature Protection and territorial administration bodies, the RA State budget of environmental sector, as well as developed due to the means provided to the RA by grant and international creditor organizations of foreign states approved by the RA Government. 1. Provision of implementation of state sector projects of reasonable usage and reproduction of the RA environment: lithosphere, soil, water, atmosphere, fauna and flora, as well as natural recourses and preservation of specially protected areas. 2. Fulfillment of state sector projects and state orders on management

of natural recourses and environment conservation 3. Implementation of preliminary and investing international projects in environment sector.
The national team leader consultants and experts worked in close collaboration with the National TNA committee and various work groups. They support the entire TNA process, by leading and undertaking activities such as research, analysis and synthesis in support of the TNA project.

2.2 Stakeholder Engagement Process followed in the TNA – Overall assessment

During several formal and informal meetings, Project team has presented the TNA process to all interested parties. This helped to ensure broader involvement in the planning, decision-making processes and will later potentially help with promotion of Project results and involvement of donors in implementation of prioritized project ideas. During the discussion of key development priorities TNA National Coordinator mainly presented the "ecosystem approach" as a basis for all available sectors and technologies prioritization also widely offered economic development details in Chemical industry and Combined heat and power production (CHP). Considering also sustainable development, energy security, low-carbon development in energy sector, development of infrastructure, food security, Improvement of solid and industrial wastes, Combating desertification, Water pollution prevention etc.
Experts presented economic growth also social and environmental priorities mainly Contribution to sustainable economic development, Promotion of investments, as well as Creation of work places, Increase of income, and rational use of natural resources.
After intensive discussions on the long list of sectors, experts prioritized the sectors using designated priorities. The selected priority sectors were Energy (including transport), Industry (including chemical industry), Land use (including forestry) and Waste management (including agriculture) sector.
Intensive debates were held, particularly on the selection and prioritization of the technologies within the Energy and Waste sectors (detailed information is provided in the chapters 3 and 6). Stakeholders were effectively involved in the MCA process.
TNA National Coordinator opened the decision background, established the aims, and considered the context and goals defined broader objectives of the technologies that technologies would contribute.

Figure 11 Scheme of cooperation and creation of the database on TNA

Mitigation team leader presented in details the Performance matrix of prioritizing technologies for each sector. He created a description on how the prioritization process will be conducted and gradually provided for each sector the list of nominated technologies, criteria selection, option evaluation, weighting of criteria, calculation of scores and summary of results as well [**Ref-8**] (provided in respective sections).

As a result of work of sector experts and stakeholders there have been identified 28 technologies for 4 sectors, which have been included in the analysis. For these there have been developed TFSs, in respective formats, for presenting to stakeholders. Afterwards there has been organized a meeting with stakeholders to present the TFSs and discuss the assessment criteria pre-selected by sector experts together with expert team leaders and project coordinator. (total 28 TFSs, or 7 TFSs for each sector).

In parallel with sector experts, some of the stakeholders have also worked on development of TFSs that have later been used in technology prioritization process. Besides, some of the stakeholders have contacted Project team to present their ideas on potential technologies and these have also been developed into TFSs or integrated into others TFSs.

Over 50 stakeholders have participated in a meeting held in Yerevan on 17 November 2015 (Agenda of the meeting presented in Annex II), during which Mitigation experts presented (one by one) the technologies and clarified each technical and professional peculiarities of the each technology to the stakeholders. The MCDA tool for prioritization of technologies was applied. The prepared TFSs have been analyzed by the stakeholder groups. Finally, possible mitigation technologies have been prioritized (detailed information is provided in the chapters 3; 4; 5 and 6).

Stakeholders approved the assessment criteria, the short-list of technologies and made the assessment, cumulative scores were given to sector technologies by stakeholders, which have later been endorsed by the project steering committee during a follow-up meeting in 24 December 2015 (Agenda of the meeting presented in Annex II). TNA National Coordinator, Mitigation team leader and Mitigation experts accompanied their speeches with Power Point Presentations.

There were also some debates on the status of the transport sector concerning GHG emissions. The transport sector is also one of the major challenging sectors. There was criticism that Yerevan Metro expansion should be also considered as priority. However, stakeholders expressed that TNA should be continuous process.

As new ideas and new technologies may appear in the future.

Suggestions that TNA and technology prioritization should be considered as nonstop process would have led to organize national inventory system for technologies in all spheres for climate change mitigation. It can be Grid like National Network or Centre for Climate Technologies or in other words National Directory, Catalogue of technologies and possibly linked to the CTCN.

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.

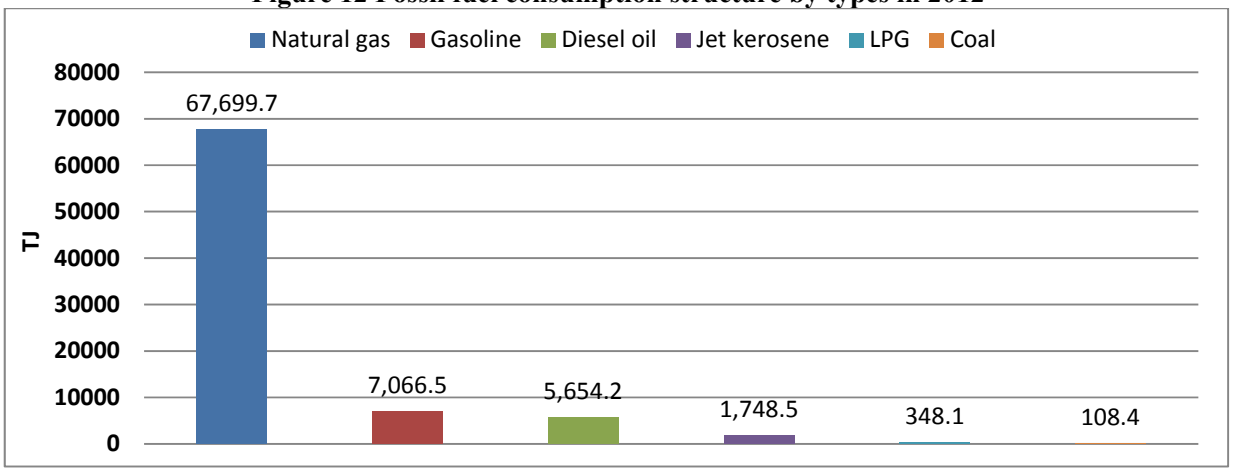
Chapter 3 Technology prioritisation for Energy Sector

3.1 GHG emissions and existing technologies of Energy Sector. Decision context

Following the TNA handbook [**Ref-17**], as a first step in the sector prioritization process, sectors and sub-sectors with GHG relevance have been obtained from TNC [**Ref-25**], NIR [**Ref-16**], BUR [**Ref-2**], INDC [**Ref-10**] and other relevant reports [**Ref-3**], [**Ref-13**], [**Ref-14**]. Based on TNA methodology [**Ref-22**], [**Ref-23**], [**Ref-24**] main categories and sectors, as well as sources of GHG emissions are presented and discussed.

There are no local fuel resources in Armenia and the country meets its fuel demand through imports. Primary energy resources available in the country (hydro-energy and nuclear energy) meet about 36% of total demand. The main fuel is natural gas.

Figure 12 Fossil fuel consumption structure by types in 2012



Source: Source: National Greenhouse Gas Inventory Report of the RA 2015 [**Ref-16**]

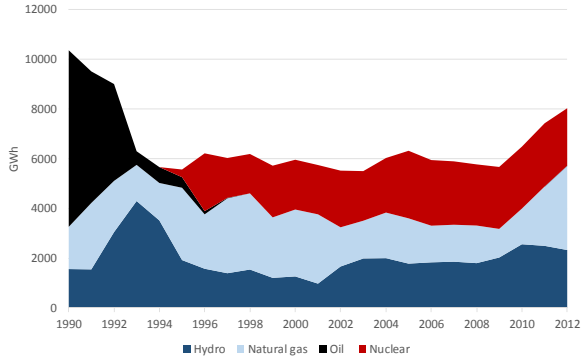
In 2012, total energy consumption in Armenia amounted to 121.3 PJ (36% of the 1990 level). Armenia's economy has gone through a substantial transformation since independence in 1991. After the collapse of the Soviet Union, GDP dropped 53% in just three years from 1990 to 1993, accompanied by a period of hyperinflation and unemployment leading to sizeable outward migration and a sharp increase in poverty.
Through implementing strong monetary and fiscal policies, combined with several structural and institutional reforms, foreign investments, remittances, and funding from donors, economic growth averaged 5.3% from 1994 to 1999, and accelerated to 11.2 % during the period 2000 to 2008. The financial crisis caused GDP to fall back 14.2% in 2009, but growth has averaged 4.2% annually since 2010 [**Ref-7**].
The main fuel consumers include housing (31.3%), transport (26.3%), and power generation (20.1%).
Figure 12 above describes fossil fuel consumption structure by types. Natural gas accounted for more than 80% of total energy carrier's consumption, while gasoline, diesel oil and natural gas together accounted for over 97% [**Ref-16**].

Electricity generation

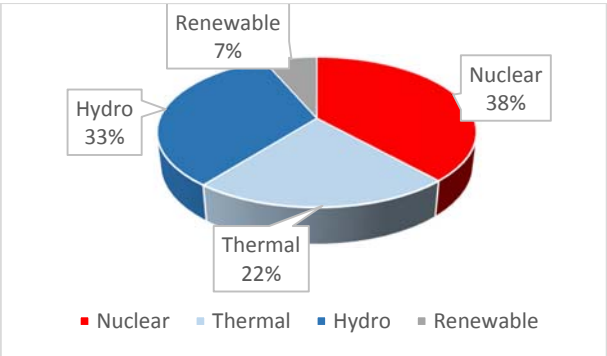
Power is generated by TPPs, MNPP and HPP. Power generation in 2012 totalled 8,036 GWh, including: 42% generated by TPPs, 29% generated by NPP, and 29% generated by HPPs [**Ref-2**], [**Ref-16**], [**Ref-18**].
The economic and energy crisis in 1992-1994 and the cancellation of subsidies resulted in the collapse of the heat-supply system. In 2010, the total heat-energy production for industrial and municipal needs amounted to only 15% of the 1990 volume. Apartment-level gas-fired and electrical appliances are mainly installed for heating and hot water in the housing sector. Electric energy generation structure and energy generated by plant type is described in **Figure 13**.

Figure 13 Electric energy generation structure by source 1990-2012 (GWh) and Electric energy generation structure by plan types in 2010; 2011; 2012 (%)

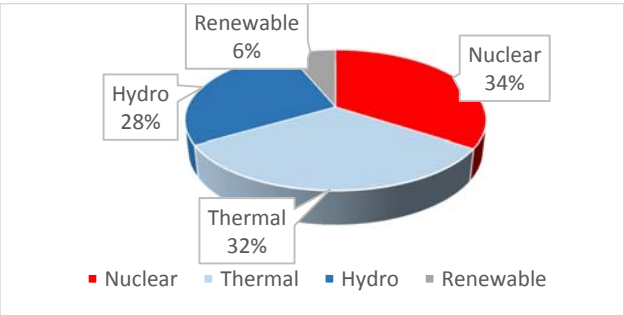
Electricity generation by source 1990-2012 (GWh)



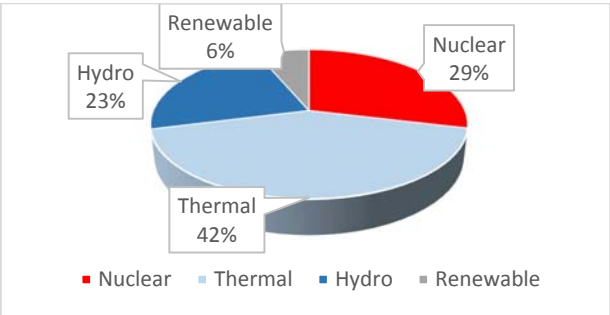
Electric energy generation structure by plant types in 2010



Electric energy generation structure by plant types in 2011



Electric energy generation structure by plant types in 2012



Source: IEA, Country report Armenia, 2015 and National Greenhouse Gas Inventory Report of the RA 2015 [**Ref-11**], [**Ref-16**],

In 2012, electricity production remained 22.5% below the level in 1990, but since 2002 has increased by 45.5%, primarily due to increased supply of natural gas and gas-fired generation capacity. Generation in 2012 totalled 8,032 GWh, distributed approximately across hydro and nuclear (30%) and gas-fired thermal [**Ref-11**], [**Ref-16**].

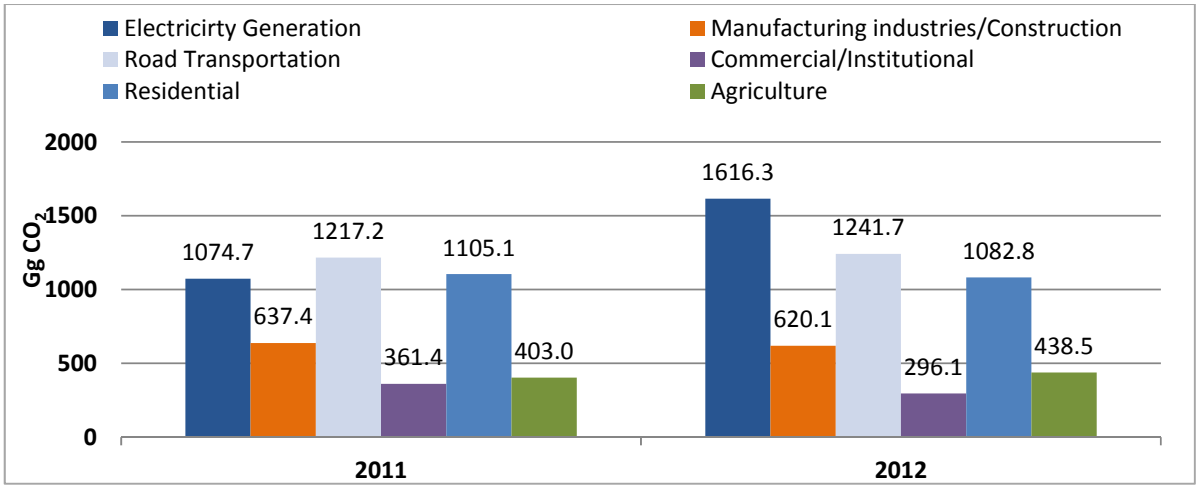
As shown in **Figure 13** there was a rapid growth in thermal electric energy generation and its share in total generation compared with 2010. In 2012 it totalled to 3,398 million kWh, or 42%, while in 2010: 1.443 million kWh, or 22% of the total. The growth in electric energy generation by thermal power plants in 2012 vs 2010 reached to 135%. Such rapid growth in electric energy generation by thermal power plants is due to generation of required quantity of electric energy pursuant to implementation of Armenia-Iran interstate "Electric Energy for Gas" agreement: 1.58 billion kWh electric energy was transmitted to Iran in 2012 [**Ref-2**], [**Ref-16**].

Installed electric generating capacity in Armenia was 4,147 MW in 2014, comprising 2,476 MW of gas-fired TPPs, 1,252 MW of hydropower and 407 MW nuclear. Despite an estimated 4,300 MW of renewable energy capacity potential in Armenia, installed wind and biogas capacity was a modest 12.6 MW, with negligible solar photovoltaic installations. In the coming years, power system assets need to be replaced and upgraded following the government's plan to retire its oldest TPP by 2017 [**Ref-13**].

The RA energy system's installed electrical energy generation total capacity at least twice exceeds the upmost requirement for the electricity load in the country. Besides, according to the annual energy balances [**Ref-4**], RA is self – sufficient with electricity, and the TPP generate about 30% of electric energy comprising exports to Iran and Georgia (total annual electric energy exports in million kWh accordingly in 2010: 68, in 2011: 114, in 2012 137) [**Ref-5**].

All the thermal power stations work on a condensation mode and have the following Efficiency Coefficients: Yerevan [Combined-Cycle Gas Turbine (CCGT) 242 MW] (gas and steam power plant) 47%, Hrazdan 5 unit (CCGT 445 MW) TPP 45-44%, Hrazdan TPP 33% (the 4x200 MW aggregates of the latter have been operated for over than 40 years). It is obvious that the latter inefficient capacities should be modernized [**Ref-13**].
The rapid rate of gas-supply/distribution-system development is an important factor in sustainable energy supply. In 2010, gas-supply/distribution-system coverage reached 96%. As of 2012, emissions in this Sector accounted for 70.3% (without removal) and 74.2% (with removals) of total GHG emissions of the country.
According to 2012 National Inventory, emissions in 6 subcategories of "Energy" Sector totalled to 72.8 % from main sources of emissions [**Ref-16**].
This significant increase in Carbon emissions indicator for Energy Generation subcategory in 2012 compared with 2011 is due to increase of electric energy generated by TPPs.
Energy sector CO2 emissions structure, by subcategories in 2011 and 2012 are shown in **Figure 14.**

Figure 14 Energy sector CO2 emissions structure, by subcategories in 2011 and 2012



Source: National Greenhouse Gas Inventory Report of the RA 2015 [**Ref-16**].

Fugitive emissions from fuels

Methane fugitive emissions in Armenia occur from operation of natural gas delivery system (accidental leakage, emissions because of maintenance works, technological losses). According to official data natural gas fugitive emissions from transmission and distribution systems accounted for 6.5% and 5.7% in 2011 and 2012 respectively. Armenia imports natural gas from Russia via Georgian territory, and from Iran. Gas delivery system includes high-pressure trunk gas pipelines and underground gas storage station (UGSS) [**Ref-2**].
Total length of gas delivery system with gas trunk line and grid is 1,841.2km. In recent years, there was an unprecedented expansion of natural gas distribution system. Currently 95 % of Armenia has access to natural gas. Gas distribution system operates 3,838 km long high and medium pressure pipelines and 7,508 km long low pressure lines. There are 2,555 units of gas control points and 6,650 units of individual gas regulators for operating gas distribution system [**Ref-16**].

Fuel combustion in mobile facilities

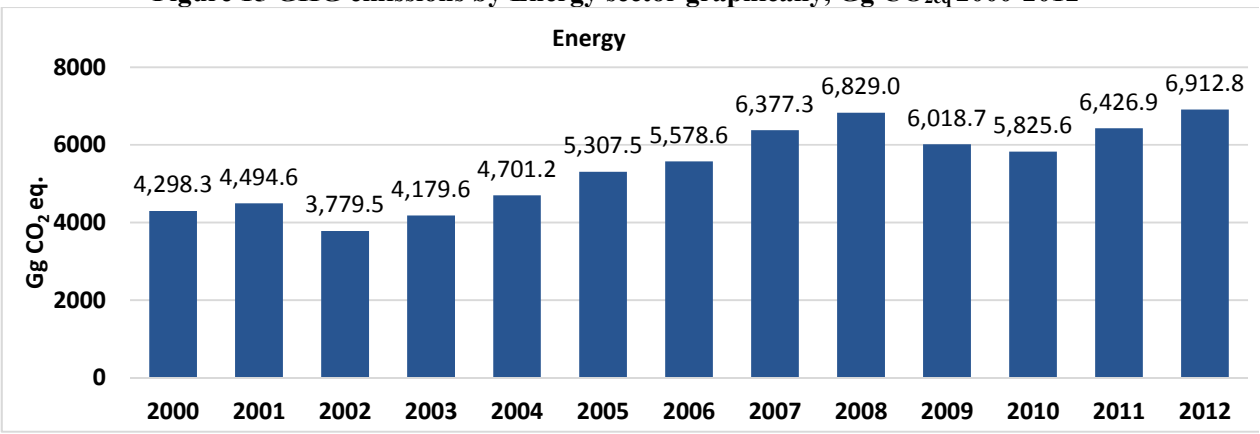
The Transport sector in Armenia includes railways, road, air, and pipeline transportation mains.
Since 1990, the Armenian Transport sector has undergone significant changes because of the collapse of USSR, the poor economic environment, significant structural changes in the economy, and the transport blockade. Compared to 1990, cargo transportation in 2012 (without pipeline mains) was 27-fold less, and the overall cargo turnover less by factor of 7.3. Overall passenger transportation fell by a factor of 2.7 [**Ref-25**].

In 2012, the share of main pipeline transportation in the total volume of cargo turnover amounted to 69.1%, railway transport: 20.9%, road transport: 9.6% and air transport: 0.5%. For overall passenger transportation, the share of road transport was 70.6%, air transport: 20.9%, and rail transport: 1.5%. The Transport sector accounts for 26% of total energy consumption in the country [**Ref-25**].

Fuel combustion in road transportation

Fuels used in road transportation of Armenia include: CNG, gasoline, diesel oil, liquefied petroleum gas (LPG), while the consumption structure is quite specific, i.e. the share of CNG accounts for 70% (as of 2012), as it is 2.5 times cheaper than gasoline and there is an expanded network of compressed natural gas filling stations in the country. Armenia is lack of its own fossil fuel and energy resources and their processing industry, as well as large liquid fuel storages [**Ref-2**]. Consistent time series for years 2000-2012 for GHG emissions by Energy sector presented in **Figure 15.**

Figure 15 GHG emissions by Energy sector graphically, Gg CO_{2eq} 2000-2012



Source: National Greenhouse Gas Inventory Report of the RA 2015 [**Ref-16**].

According to UNEP guidelines on TNA, the MCA methodology was used to assess the needs of technologies for mitigation. The MCA provided a framework for prioritizing technologies within sectors using stakeholder consultations were facilitated by the consultants [**Ref 15**].

3.2 An overview of possible mitigation technology options in Energy Sector and their mitigation potential and other co-benefits

Based on proposed TNA methodology, Energy national expert have prepared a long list of possible technologies in Energy sector. Previously, on 3 September 2015 the Mitigation TFS template supplementary to the clarification letter introducing TNA in Armenia was sent to long list of involved stakeholders. After consultations in the working groups Energy national expert prepared 7 TFSs for presenting at "Workshop discussions with stakeholders" on 17 November 2015 in Manugean Hall, American University of Armenia (Agenda of the meeting presented in Annex II) .

Criteria for prioritization of technologies have been clustered under Social, Social Economic, Economic, Environmental, Ecology, Technology groups. Based on current national strategy documents and expert judgments, the subsequent criteria were selected for prioritization of mitigation technologies in Energy sector. Selected Technology Options in Energy Sector are presented in **Table 5.**

Table 5: Selected Technology Options in Energy Sector	
N	**Options**
Option 1	Cogeneration, Small Scale Combined Heat and Power production
Option 2	CO_2 emissions reduction technology for emission of gas engines in Vehicles
Option 3	Natural gas combustion process regulation in water heating boilers
Option 4	Correspondence of natural gas tariff structure to the methodology approved by decision of Public Services Regulatory Commission (PSRC)
Option 5	Mandatory realization of the Industrial Energy Audit as a mitigation component
Option 6	Reactive capacity (power) compensation in the RA electric energy system
Option 7	Improving energy efficiency in multi apartment buildings. Registry creation, development.

Armenia's economy has gone through a substantial transformation since independence in 1991. Through implementing strong monetary and fiscal policies, combined with several structural and institutional reforms led to economic growth and relative sustainability. The energy sector of Armenia has achieved significant results through reforms and restructuring. The sector has strong payment discipline with collections for electricity and natural gas at 100% of sales. There are no explicit or implicit subsidies to the energy sector and the sector entities are among the largest taxpayers in the country.

In Soviet times, Armenia had rather high level of centralized heat supply: 35% of housing resources and 90% of multi-storied residential and public buildings were provided with heat-supply. The heat-supply of the residential sector of the republic was done both from the major centralized heat sources such as TPP (in Yerevan, Hrazdan and Vanadzor) and district boiler plants (35%), and from the medium and small capacity local heating boiler houses (65%). The economic and energy crises, the acute escalation of fuel prices have had adverse consequences in the whole energy field of Armenia. The worse changes have taken place in the heat-supply sphere - the centralized generation of heat power dramatically decreased and does not work any longer. [**Ref-** http://www.nature-ic.am/municipal-heating/]

Centralized heating system in RA broke-up, like former Soviet system for many years. The idea of Autonomous heating (small gas-based boiler scheme for one to several buildings heat supply) have collapsed for 15-20 years horizon. Wall hung natural gas boiler based domestic heating option is considered to be the most convenient and modern style of apartment heating.

Restoration of civilized heating supply in RA may be achieved via Small Scale Cogeneration (CHP) (Option 1). CHP is a highly efficient form of energy conversion and it can achieve primary energy savings of approximately 40% by compared to the separate purchase of electricity from the national electricity grid and a gas boiler for onsite heating. CHP plants are typically embedded close to the end user and therefore help reduce transportation and distribution losses, improving the overall performance of the electricity transmission and distribution network. For power users where security of supply is an important factor for their selection of power production equipment and gas is abundant, gas-based cogeneration systems are ideally suited as captive power plants (i.e. power plants located at site of use).

There are more than 18,000 apartment buildings (27.0 million square m a total area of 435 thousand apartments) in RA. Due to efficient use of energy resources, environmental protection and the need to reduce greenhouse gas emissions: energy saving and energy efficiency of the apartment buildings considered a priority policy for the government [**Ref-5**].

Energy saving problems are more significant in the context of continuously increasing energy prices and are an essential element of energy security of the country.

More than 35% of electrical energy generated and up to 25 % of Natural Gas imported to the RA are consumed in the housing sector and more than 40% GHG emissions as well [**Ref-16**].

The measures to reduce greenhouse gas emissions in the buildings are significantly linked to availability of multi-structured and accurate data on technical specifications of buildings through the creation of housing register (may be the first step).
The necessity of Registry establishment is defined in the Government Decree on 29 September 2011, resolution multi-protocol N38 on housing management, maintenance and operation of the five-year strategic improvement plan (Option 7).

Proper heat insulation has always been the most efficient method of ensuring energy saving and reducing energy costs in buildings. Currently, relatively new generation of construction insulation materials are getting to be widely used in Armenia; these are of a considerable capacity of improving buildings' energy efficiency significantly. In Armenian market, perlite, mineral and basalt micro-fibre, foam polystyrene, foam polyurethane, cellulose system and flax fibre made heat insulation materials are available as well as heat reflector materials envisaged for radiation heat transfer protection [**Ref-** http://www.nature-ic.am/res/pdfs/publications/EEB-database_insulation/database_eng.pdf].
More than hundreds of energy audits were implemented in Armenia in the last five years, mainly of residential and public buildings, heating systems, street lighting and industrial sectors. Energy audits are mainly carried out in the frames of the following energy efficiency related projects financed/implemented by international organizations. In the frames of "Improving Energy Efficiency in Buildings" UNDP-GEF/00059937 project, energy audits of more than 10 multi-apartment buildings were implemented. Based on National Standard on Building Energy Passport, energy passports for 15 buildings compiled [**Ref-** http://www.nature-ic.am/improving-ee-in-buildings-reports-and-publications/; http://www.nature-ic.am/wp-content/uploads/2013/10/Avan-DSK-Audit-Report-ENG.pdf]. Specialists of Armenian R2E2 Fund performed energy audits in public buildings in the regions of Armenia to determine their eligibility for a loan from the World Bank for improving building energy performance [**Ref-** http://r2e2.am/en/2011/06/r2e2-projects-2/].
Energy audits in the RA are implemented in accordance with the RA law "On Energy Saving and Renewable Energy". The general procedure of implementing energy audit is specified by "Energy Audit Implementation Procedure" (approved by decision #1399-N of 31 August, 2006 of the Government of the Republic of Armenia and edited by decisions #1105-N of 4 August, 2011 and #1026-N of 10 September, 2015).
Energy audit Implementation is voluntary; however, there is a list of measures of energy efficiency and energy saving for mandatory application in facilities being constructed with the state funding, as approved by decision #1504-N of 25 December, 2014. Energy audit in Armenia can be implemented by certified entities. Certification, including that of physical persons, according to the procedure, can be performed by state accredited bodies. Armenia has specialists in energy who received training/course participation certificates on energy audit of industrial facilities, residential and public buildings, and development of energy efficiency bankable projects.
As per industrial audits, loan contracts recently signed can be highlighted: of GGF with three Armenian banks (AraratBank, InecoBank, ACBA-Credit Agricole Bank) and of ADF (French Development Agency) with Armenian First Mortgage Company. The goal of the credit tool is to finance energy saving loans that are given based on energy audit results.
Mandatory Energy Audit implementation (Option 5) for the larger enterprises classified by their energy intensity, thermal energy and power consumption will highly contribute to energy efficiency and GHG reduction polices. The benefits seems to be Formation of energy efficiency and energy saving culture, Decrease of expenses, Increase of the production competitiveness. As well as, Reduction of primary fuel expenses, consequently reduction of GHG emissions.
After the collapse of the Soviet Union, the issue of compensating reactive power for energy consumers in the RA energy system is not regulated, meanwhile it has a significant potential for increasing energy efficiency

(reducing active power losses). Reactive power is not registered/metered in energy consumers and consequently there is no accurate information about power coefficient values.
The solution to this problem (Option 6) can be performed by complex measures: by reactors regulating compensation of capacitive reactive power, while the problem of energy consumers of inductive reactive power can be solved by placing auto regulating capacitor batteries.
While active power is the energy supplied to run a motor, heat a home, or illuminate an electric light bulb, reactive power provides the important function of regulating voltage. If voltage on the system is not high enough, active power cannot be supplied. Reactive Power is a By-product of Alternating Current (AC) System.
Using compensating reactive power technologies in the chain from manufacturers to consumers will bring to:

- reduction of active energy losses
- increased efficiency of producing generators and transmission lines usage
- increased conductivity of transmission lines and transformers reduction of voltage falls.

In recent years there was an unprecedented expansion of natural gas distribution system. Currently gasification level is 95%. Entire power generation in TPP in RA is based on natural gas combustion. The share of CNG in road transportation accounts for 70% (as of 2012 [**Ref-16**]). On 8 August 1997, the PSRC decision #7 determined the natural gas tariffs with the following sharing: gas consumers up to 10,000 m^3 per month and 10,000 m^3 and more. Despite the fact that on 21 December 2004 the same Commission by decision #168A determined a methodology for calculation of natural gas tariffs based on the best international practice, it has not been applied yet, presumably because of some objective reasons (Option 4). Natural Gas tariffs were last reviewed in July 2013 and were determined, accordingly: 156 AMD / m^3 and 115.5 AMD / m^3 (calculations were made at the exchange rate 1 USD = 416.56 AMD) [**Ref-18**]. It is not difficult to guess that those customers who consumed 7,400 m^3 and those who consumed 10,000 m^3 will pay the same amount of money. Studies showed that in the heating season a number of boiler houses with low and average installed thermal capacity (200-450 kW) face a dilemma when it is possible to pay the same amount of money increasing the consumption by 2,000-2,500 m^3. It is obvious that the current tariffs structure does not contribute to the realization of energy saving measures by the Natural Gas consuming facilities. To encourage Armenian State Policy Authorities to reject the current tariffs structure and to base on the methodology adopted in 2004 (Decision #168A) by PSRC will led to more fair and justified tariffs for Natural Gas. All mentioned options are detailed in Annex I.

3.3 Criteria and process of technology prioritisation for Energy sector

When applying MCA after Option selection at first a set of criteria have to be decided. Criteria were based on current research that estimated potential effects of criteria on searching suitable technologies. Each technology's contribution to GHG mitigation was included as one of the central criterion in the assessment.
After discussing a sets of criteria: [Costs: Capital cost, Investment cost per life time GHG reduction, Operation and maintenance cost), Benefits: Amount of GHG emissions reductions (per year and in the long term perspective), Environmental: Reducing air, land and water pollution, Social: work places and income increase, improved living conditions, Economic: Feasibility, Marketability, Contribution to sustainable economic development, Energy Saving, Promotion of investments etc.] the mitigation team and working group agreed on a set of criteria for assessing priority mitigation technologies in energy sector and presented to the stakeholders on the Workshop.
The mitigation expert team has also provided assessment of current national priorities identified in national strategic programs, sector policies, action plans and other documents, including the TNC and BUR. As a result of intensive discussions with the stakeholders group, the following sets of criteria were defined to prioritize

technologies for energy sector. Criteria selection for Technologies Options in Energy Sector are presented in **Table 6.**

Table 6 Criteria selection for Technologies Options in Energy Sector

Criterion	Criteria category	Unit Chosen	Value Preferred
Affordability	Social and Economic	Low to high	High
Investment Cost	Economic	USD/Gg CO_{2eq}. life time	Low
Social benefit	Social	Low to high	High
Feasibility, Marketability	Economic	Low to high	High
GHG mitigation	Environment	Gg CO_{2eq}. /year	High
Commercial maturity	Technology	Low to high	High

Based on criteria above, technologies were given score and weighted for each criterion and arranged in priority order. The scores were previously discussed and prepared by the mitigation work group members and finally evaluated at the joint meeting of the stakeholders held at "Workshop discussions with stakeholders" on 17 November, 2015 (Agenda of the meeting presented in Annex II) followed by further electronic consultations. To assess the benefits of the proposed technologies the prioritization matrix has been used. The assessment was conducted on units, scale and preferred value and the weighting factor (w) of each criterion was considered are presented in the **Table 7** and **Table 8**.

Table 7 Option evaluation in Energy Sector

Option/Criterion	Life time	Affordability	Investment Cost	Social benefit	Feasibility, marketability	GHG mitigation	Commercial maturity
Units	**year**	**Low to high (5-1)**	**USD/Gg CO2eq. life time**	**Low to high (1-5)**	**Low to high (1-5)**	**Gg CO2-e/year**	**Low to high (1-5)**
Preferred value		**High**	**Low**	**High**	**High**	**High**	**High**
Cogeneration, Combined Heat and Power production	25	4	119.6	5	5	11.7	4
CO_2 emissions reduction technology for emission of gas engines	5	3	5.5	3	3	4.0	1
Natural gas combustion process regulation in water heating boilers	10	4	0.09	2	3	11.5	3
Correspondence of natural gas tariff structure to the methodology approved by decision of Public Services Regulatory Commission (PSRC)	5	4	0.29	2	4	3.5	5
Mandatory realization of the Industrial Energy Audit as a mitigation component	5	5	0.26	3	4	3.83	4
Reactive capacity (power) compensation in the RA electric energy system	20	3	2.52	3	3	16.9	5
Improving energy efficiency in multi apartment buildings. Registry creation, development.	20	2	81.76	5	4	25.5	4

Justification to the choice of the scores are as follows: Options 1 and 7 have good and best scores in the Social benefit, Feasibility and GHG mitigation criterion, mainly because are related to residential sector with high actual emissions and challenging social issues, medium scores in Affordability and Commercial maturity ones and worst scores in Investment cost criterion. Anyway, the high Investment costs did not bother those to get the highest weighted scores. The stakeholders due to their significant role in the Energy sector also consider options 4, 5 and 6 vital.

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

3.4 Results of technology prioritisation for Energy sector

The key idea is to construct scales representing preferences for the consequences, to weight the scales for their relative importance, and then to calculate weighted averages across the preference scales.
Weighting reflects importance of each criterion in decision-making. Assign weights for each of the criterion to reflect their relative importance to the decision. It considered differences between the upper and lower of the elevation of point and the level of group interest. The criteria became important when all options had been weighted. The main assumption embodied in decision theory is that decision makers wish to be coherent in taking decisions. Ensuring independence is necessary when giving point to each criterion. Weighting of criteria in Energy Sector is presented in **Table 8.**

Table 8 Weighting of criteria in Energy Sector

Criterion	Allocation of budget Weight, %
Affordability	10%
Investment Cost	15%
Social benefit	15%
Feasibility, Marketability	25%
GHG mitigation	20%
Commercial maturity	15%
Total allocated	**100%**

Taking into account the lack of exact and precise information about some actual costs and benefits, other data from introduced selected technologies, the criteria ranged and the productivity of technology was considered by categorized information in selecting technology, knowledge and views of experts.
The results of scoring for each technology within each criterion under selected sector are provided in **Table 9**.

Table 9 Calculation of scores in Energy Sector

Criteria Options	Affordability	Investment Cost	Social benefit	Feasibility, Marketability	GHG mitigation	Commercial maturity	Weighted scores of each option
Units	**Low to high**	**k$/Gg life time**	**Low to high**	**Low to high**	**tCO2-e/year**	**Low to high**	
Preferred value	**High**	**Low**	**High**	**High**	**High**	**High**	
Weight	**10%**	**15%**	**15%**	**25%**	**20%**	**15%**	
Cogeneration, Combined Heat and Power production	66.67	0.00	100.00	100.00	37.27	75.00	65.37
CO_2 emissions reduction technology for emission of gas engines	33.33	95.47	33.33	0.00	2.27	0.00	23.11
Natural gas combustion process regulation in water heating boilers	66.67	100.00	0.00	0.00	36.36	50.00	36.44
Correspondence of natural gas tariff structure to the methodology approved by decision of Public Services Regulatory Commission (PSRC)	66.67	99.83	0.00	50.00	0.00	100.00	49.14
Mandatory realization of the Industrial Energy Audit as a mitigation component	100.00	99.86	33.33	50.00	1.50	75.00	54.03
Reactive capacity (power) compensation in the RA electric energy system	33.33	97.97	33.33	0.00	60.91	100.00	50.21

Improving energy efficiency in multi apartment buildings. Registry creation, development.	0.00	31.66	100.00	50.00	100.00	75.00	63.50

As a result of the technology needs assessment process the two technologies: Option 1 and Option 7 yielded approximately the equal highest weighted score. Simultaneously other three technologies: Option 5, Option 6 and Option 4 have a little lower and also approximately equal weighted score. The selected technologies are presented in **Table 10**. All TFSs are available in Annex I.

Table 10 Summary of results in Energy Sector

Ranking of options

Rank	Option	Weighted Score
1	**Cogeneration, Small Scale Combined Heat and Power production**	**65.4**
2	**Improving energy efficiency in multi apartment buildings. Registry creation, development.**	**63.5**
3	**Mandatory realization of the Industrial Energy Audit as a mitigation component**	**54.0**
4	**Reactive capacity (power) compensation in the RA electric energy system**	**50.2**
5	**Correspondence of natural gas tariff structure to the methodology approved by decision of Public Services Regulatory Commission (PSRC)**	**49.1**
6	Natural gas combustion process regulation in water heating boilers	36.4
7	CO_2 emissions reduction technology for emission of gas engines in Vehicles	23.1

Cumulative scores were given to sector technologies by stakeholders, which have later been endorsed by the project steering committee during a follow-up meeting in 24 December 2015 (Agenda of the meeting presented in Annex II).

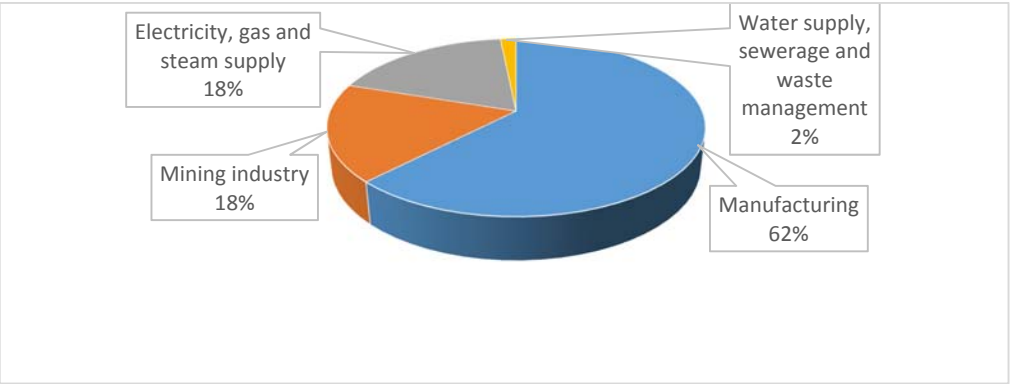
Chapter 4 Technology prioritisation for Industry Sector

4.1 GHG emissions and existing technologies of Industry Sector. Decision context

In 2012, industrial output in Armenia amounted to 102% of the 1990 level. Priority issues for the economic development of the country are addressed in the ADS of the RA.

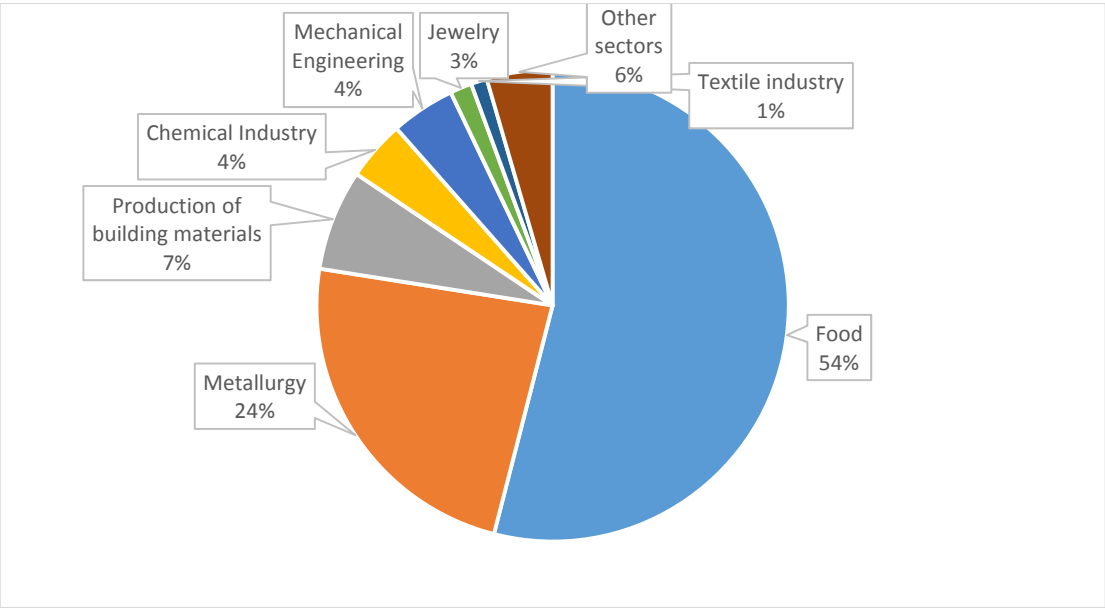
The structure of industrial output in Armenia by types is presented on **Figure 16**. And The structure of manufacturing sector is shown on **Figure 17.**

Figure 16 The structure of industrial output in Armenia by types



Source: Third national communication on climate change (2015) [**Ref-25**]

Figure 17 The structure of manufacturing sector



Source: Third national communication on climate change (2015) [**Ref-25**]

By overcoming the difficulties of the transition period after the dramatic economic decline in 1991-1993, Armenia was able to ensure economic stability and growth. Annual economic growth in 1995-2000 was 5.4%, and in 2001-2006 it was 12.4%. The economy declined by 14.1%, caused by the 2009 global economic crisis. The average annual economic growth in 2007-2012 was 3.3% [**Ref-25**].

Armenia's gross domestic product (GDP) in 2012 amounted to AMD 3,998 billion (USD 9,950 million, equivalent to USD 19,700 million in purchasing power parity (PPP)); per capita PPP was USD 6,508. Structural changes of the economy resulted in changes in GDP structure, with a decrease in manufacturing and an increase in services. In 2012, GDP had the following structure: manufacturing: 17.9%, agriculture: 19.1%, construction: 13.2%, services: 42.7%, and net taxes: 7.8% [**Ref-25**].

Industrial Process and Product Use Sector of the National GHG Inventory of Armenia includes the following emission source subcategories:

- Mineral industry, which considers: Cement production,
- Metal production, which considers: Ferro-alloy production, Copper production,
- Non-energy products from fuel and use of Solvents, which considers: Solvents use, Bitumen asphalt production and use
- Use of ozone layer depleting substance, which considers: Production and use of other substances, Food and alcoholic beverage production.

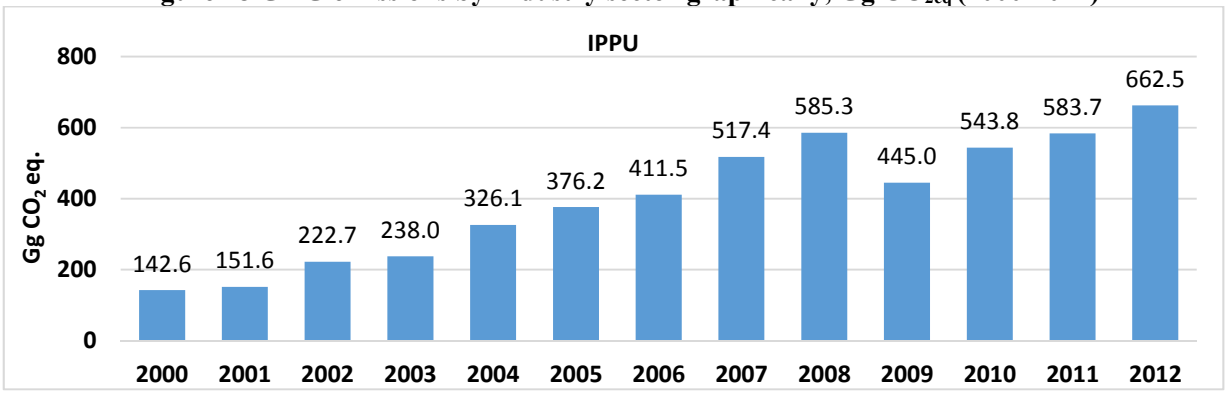
Emissions from this sector come from mineral industry (cement production) 277.9 Gg CO_2, product use (substances substituting ozone layer depleting substances) 384.58 Gg $CO_{2eq.}$ hydro fluorinated carbons.

In this sector, there are also gases with indirect impact, i.e. non-methane volatile organic compounds and sulphurous gas [**Ref-16**].

Cement production, refrigeration and air-conditioning are key sources of GHG (carbon dioxide and HFCs respectively) emissions in Armenia. Emissions of carbon dioxide from cement production account for country's 2.98% of GHG emissions in CO_{2eq}, and refrigeration and air-conditioning generate 4.13 percent of HFCs emissions [**Ref-16**].

Mineral production in Armenia is presented by the cement production. In Armenia cement is produced by two plants: "Mika-Cement" CJSC and "Araratcement" CJSC. Consistent time series for years 2000-2012 for GHG emissions by IPPU sector presented in **Figure 18**.

Figure 18 GHG emissions by Industry sector graphically, Gg CO_{2eq} (2000-2012)



Source: National Greenhouse Gas Inventory Report of the RA 2015 [**Ref-16**].

In the Soviet times, Armenia used to be a Republic with highly developed chemical industry. The largest plants (the most important among which is, certainly, "Nairit"), chemical complexes in Vannadzor, Kapan etc. provided with their products not only the Soviet Union, but also the countries all over the world. A lot of chemical plants and plants in other branches of industry were known to operate based on "Nairit's" production. There were seventeen large enterprises working on the basis "Nairit's" output and production residues. Science was promoted in our scientific-research institutes, which in contrast to the plants, shut down in the 90th, have mainly remained intact and keep on working up to now. These are Institute of Non-organic Chemistry, Institute of Organic Chemistry, Institute of Fine Organic Chemistry, Institute of Chemical Physics etc. These Institutes still exist along with the personnel capable of working for development of chemical science in Armenia [**Ref-6]**.

The "Nairit" chemical plant is based in the city of Yerevan and was commissioned in 1936 and possesses technology for production of 20 types of polychloroprene rubber and latex based on both acetylene (natural gas based) and butadiene feedstocks. Its key product is synthetic rubber. During the Soviet times, the plant accounted for a large share of global synthetic rubber production. Specifically, in 1987, the plant accounted for 15% of global supply. The plant was shut down in 1989 and restarted operations at a smaller capacity in 1993. Several attempts were made to re-commission the plant to its full capacity, but most of these attempts failed given the underlying economics. The plant has not been operational since 2011 and is in major financial distress. "Nairit" was the only plant in the entire Central and Eastern European region for polychloroprene rubber. At present, the plant is shut down and additional investment is required before production may be resumed [**Ref-6**].

4.2 An overview of possible mitigation technology options Industry in Sector and their mitigation potential and other co-benefits

Based on proposed TNA methodology, Industry national expert have prepared a long list of possible technologies in Industry sector. Previously, on 3 September 2015 the Mitigation TFS template supplementary to the clarification letter introducing TNA in Armenia was sent to long list of involved stakeholders. After consultations in the working groups Industry national expert prepare 7 TFSs for presenting at "Workshop

discussions with stakeholders" on 17 November, 2015 in Manugean Hall, American University of Armenia (Agenda of the meeting presented in Annex II).

Criteria for prioritization of technologies have been clustered under Social, Social Economic, Economic, Environmental, Ecology, Technology groups. Based on current national strategy documents and expert judgments, the subsequent criteria were selected for prioritization of mitigation technologies in Industry sector. Selected Technology Options in Industry Sector are presented in **Table 11.**

Table 11: Selected Technology Options in Industry Sector

N	Option title
Option 1	Production of synthetic rubbers from butadiene instead using natural gas in Chemical Production
Option 2	New technology of processing copper sulfide concentrate
Option 3	New technology of processing molybdenum concentrate
Option 4	Production and usage of photo luminescent materials with long-term lightening
Option 5	Cement production
Option 6	Thermal insulation materials production
Option 7	New type of Entirely Plastic solar water heater

Until independence, Armenia's economy was based largely on industry: chemicals, electronic products, machinery, processed food, synthetic rubber and textiles; it was highly dependent on outside resources.
The mineral industry is one of the main sectors of the Armenian economy and as of 2011 accounted for over half of the country's exports.
Armenia is a major producer of molybdenum. The Zangezur copper-molybdenum complex possesses large molybdenum reserves that are concentrated in the Kajaran deposit. Besides molybdenum, Armenia has significant deposits of copper and gold; smaller deposits of lead, silver, and zinc; and deposits of industrial minerals, including basalt, diatomite, granite, gypsum, limestone, and perlite. In spite of the global economic crisis of 2008, mining production and revenues grew significantly in 2009 due to a rise in global prices of copper, gold, and other base metals.
[**Ref-** http://w3.cenn.org/wssl/uploads/documents/Mining_in_Armenia_A_Comprehensive_Overview_Eng.pdf].

After gaining independence, Armenia "inherited" unviable economy from the Soviet system and found itself in the heaviest situation of all countries of Transcaucasia. From the agrarian-industrial country with developed metal working, mechanical engineering, chemical, light, the food-processing industry Armenia turned into a small state which could not boast neither rich natural resources nor favourable geographical position or fertile soils. Since 1991 the privatization began. The first were agricultural grounds, then came small and mid-sized industrial enterprises, and in 1995 the major ones were privatized.
In 1994 after the conclusion of armistice with Azerbaijan and obtaining funds from IMF and the World Bank the national economy was gradually stabilized. Inflation rate decreased, the GDP went up a little. A number of industrial enterprises were put into operation. The leading industries are mechanical engineering and metal working, chemical and petrochemical, nonferrous metallurgy, manufacture of building materials (including the ones based on the deposits of tuffs, pearlites, limestones, granites and marbles), foodstuffs and light industries.
Anyway, chemistry is of strategic importance to the country, that is why the importance to revive chemistry (Option 1). This resuscitation attempted first to "Nairit". The market research shows that there is need for its production: rubbers from butadiene in the world market and the output will be sold out. In Armenia, there are good prospects for small-scale chemistry as well, for development of which a good scientific and research

basis, specialists and an opportunity to train new personnel are available. However, the scientific and technical basis is already outdate and the upgrade requires large funds [**Ref-6**].
Impact on Economy Development considered the main criterion for Industry sector and was linked to chemical industry and apparently to "Nairit". The concept of economic growth is one, which has attracted the interest and focus of stakeholders. Industry expert state that economic growth is "the most fundamental indicator of an economy's health". Stakeholders define it as the rate of growth of the national income of a country, measured by the annual percentage rate of change of country's gross domestic product. Economic growth is one of the reasons why advanced countries have become richer and have improved standards of living. Economic growth has also attracted attention because of the positive impact it has on society, as it has been associated with benefits such as increased wealth, standards of living, reduction in poverty.

New technologies of processing molybdenum and copper sulphide concentrates (Options 2 and 3) has been developed in the Kapan laboratory of metallurgy Institute of Chemical Physics of RA. Those have been developed in local mines using a special environment friendly copper sulphide concentrate mode (Know- How). This completely new technology guarantees a high-level extraction of copper, iron, sulphur and precious metals, besides it is economically sound and corresponds to the modern ecological standards. A new complex measure of molybdenum concentrate processing is a no-waste technology. It is able to replace the molybdenum processing technologies in Armenia as well as abroad due to its high technical and economic indices and correspondence to the ecological standards.
Production and usage of photo luminescent materials with long-term lightening (Option 4) seems to be attractive taking into account the potential scale of the application, particularly for urban economy, it will significantly reduce energy consumption and capital costs. Marking the roads, boards, underground crossings and building entrance stairs with photo luminescent materials will increase the safety level for pedestrians and drivers.
Cement and thermal insulation materials production process optimization and energy-saving technologies are also very essential as are based on local raw materials (Options 5 and 6).
Arrangement of new type of Entirely Plastic solar water heaters production (Option 7) will allow the low-income people to buy and use these systems and to obtain hot water in summer time for washing and for everyday use. This is especially important because the cost of gas and electricity hikes. Besides, it could create new jobs for population. The price of commercial solar water heaters in Armenian market is rather high and consequently the sales are small. The price of entirely plastic solar water collectors should be much cheaper and could be incomparably available to a wider population. In addition, it is envisaged that there should be great demand in such systems also for food processing facilities, restaurants, hotels, schools, chemical enterprises as well. All mentioned options are detailed in Annex I.

4.3 Criteria and process of technology prioritisation for Industry sector

Criteria were based on current research that estimated potential effects of criteria on searching suitable technologies. After discussing a sets of criteria the mitigation team and working group agreed on a set of criteria for assessing priority mitigation technologies in Industry sector and presented to the stakeholders on the Workshop. The mitigation expert team has also provided assessment of current national priorities identified in national strategic programs, sector policies, action plans and other documents, including the TNC and BUR.
As a result of intensive discussions with the stakeholders group, the following (**Table 12**) sets of criteria were defined to prioritize technologies for Industry sector.

Table 12 Criteria selection for Technologies Options in Industry Sector			
Criterion	**Criteria category**	**Unit Chosen**	**Value Preferred**
Affordability	Social and Economic	Low to high	High
Investment Cost	Economic	k$/Gg life time	Low
Impact on Economy Development	Social Economic	Low to high	High
Increase in Employment	Social	Low to high	High
GHG mitigation	Environment	GgCO2-e/ year	High
Commercial maturity	Technology	Low to high	High

Based on criteria above, technologies were given score and weighted for each criterion and arranged in priority order. The scores were previously discussed and prepared by the mitigation work group members and finally evaluated at the joint meeting of the stakeholders held at "Workshop discussions with stakeholders" on 17 November 2015 (Agenda of the meeting presented in Annex II) followed by further electronic consultations. To assess the benefits of the proposed technologies the prioritization matrix has been used. The assessment was conducted on a units, scale and preferred value and the weighting factor of each criterion was considered are presented in the **Table 13** and **Table 14**.

Table 13 Option evaluation in Industry Sector						
Option/Criterion	**Affordability**	**Investment Cost**	**Impact on Economy Development**	**Increase in Employment**	**GHG mitigation**	**Commercial maturity**
Units	**Low to high**	**k$/Gg life time**	**Low to high**	**Low to high**	**GgCO2-e/ year**	**Low to high**
Preferred value	**High**	**Low**	**High**	**High**	**High**	**High**
Production of synthetic rubbers from butadiene instead using natural gas in Chemical Production (life time 20 year)	1	12.7	5	5	225.0	5
New technology of processing copper sulfide concentrate (life time 20 year)	2	2.16	3	4	3.48	3
New technology of processing molybdenum sulfide concentrate (life time 20 year)	1	1.61	3	4	4.67	3
Production and usage of photo luminescent materials with long-term lightening (life time 20 year)	5	3.13	4	3	3.2	3
Cement production (life time 20 year)	3	10.5	2	4	80.5	4
Thermal insulation materials production (life time 20 year)	5	8.2	3	3	106.4	3
New type of Entirely Plastic solar water heater (life time 10 year)	4	2.05	3	3	3.9	4

Option 1, i.e. Development or Rehabilitation of Chemical Production in RA obtained best scores in Impact on Economy Development (criteria with the biggest 25% weight), as well as Increase in Employment, GHG mitigation, (each with 20% weight) and Commercial maturity. Justifications are the good prospects for small-scale chemistry improvement in RA, availability of good scientific and research basis in the sphere, and experienced specialists as well. This option has worst score for Affordability and Investment cost criteria, nevertheless Option 1 is unequivocal leader in the Industrial sphere. The stakeholders due to their significant role in the Industry sector also consider option 4 and 7 important.

4.4 Results of technology prioritisation for Industry sector

MCA is both an approach and a set of techniques, with the goal of providing an overall ordering of options, from the most preferred to the least preferred option. The options may differ in the extent to which they achieve several objectives, and no one option will be obviously best in achieving all objectives. MCA is a way of looking at multifaceted problems that are characterized by any mixture of monetary and non-monetary objectives, with different units, of breaking the problem into more manageable pieces to allow data and decisions to be brought to bear on the pieces, and then of reassembling the pieces to present a comprehensible overall picture to decision makers [**Ref 15**].

Table 14 Weighting of criteria in Industry Sector

Criterion	Allocation of budget, Weight, %
Affordability	10%
Investment Cost	15%
Impact on Economy Development	25%
Increase in Employment	20%
GHG mitigation	20%
Commercial maturity	10%
Total allocated	**100%**

Taking into account the lack of exact and precise information about some actual costs and benefits, other data from introduced selected technologies, the criteria ranged and the productivity of technology was considered by categorized information in selecting technology, knowledge and views of experts. The results of scoring for each technology within each criterion under selected sector are provided in **Table 15**.

Table 15 Calculation of scores in Industry Sector

Criteria Options	Affordability	Investment Cost	Impact on Economy Development	Increase in Employment	GHG mitigation	Commercial maturity	Weighted scores of each option
Units	**Low to high**	**k$/Gg life time**	**Low to high**	**Low to high**	**GCO2-e/ year**	**Low to high**	
Preferred value	**High**	**Low**	**High**	**High**	**High**	**High**	
Weight	**10%**	**15%**	**25%**	**20%**	**20%**	**10%**	
Production of synthetic rubbers from butadiene instead using natural gas	0.00	0.00	100.00	100.00	100.00	100.00	75.00
New technology of processing copper sulfide concentrate	25.00	95.05	33.33	50.00	0.13	0.00	35.12
New technology of processing molybdenum sulfide concentrate	0.00	100.00	33.33	50.00	0.66	0.00	33.47
Production and usage of photo luminescent materials with long-term lightening	100.00	86.31	66.67	0.00	0.00	0.00	39.61
Cement production	50.00	19.83	0.00	50.00	34.85	50.00	29.94
Thermal insulation materials production	100.00	40.56	33.33	0.00	46.53	0.00	33.72
New type of Entirely Plastic solar water heater	75.00	96.00	33.33	0.00	0.32	50.00	35.30

As a result of the technology needs assessment process the one technology: Option 1, Rehabilitation of chemical industry in Armenia yielded the highest weighted score. All remaining six technologies have significantly lower and also approximately equal weighted score. The selected technologies are presented in **Table 16**. All TFSs are available in Annex I.

Table 16 Summary of results in Industry Sector

Ranking of options

Rank	Option	Weighted Score
1	**Production of synthetic rubbers from butadiene instead using natural gas in Chemical Production**	**75.0**
2	**Production and usage of photo luminescent materials with long-term lightening**	**39.6**
3	**New type of Entirely Plastic solar water heater**	**35.3**
4	New technology of processing copper sulfide concentrate	35.1
5	Thermal insulation materials production	33.7
6	New technology of processing molybdenum sulfide concentrate	33.5
7	Cement production	29.9

Cumulative scores were given to sector technologies by stakeholders, which have later been endorsed by the project steering committee during a follow-up meeting in 24 December 2015 (Agenda of the meeting presented in Annex II).

Chapter 5 Technology prioritisation for Land use and Forestry Sector

5.1 GHG emissions and existing technologies of Land use and Forestry Sector. Decision context

Pursuant to 2006 IPCC following subcategories of GHG emissions and removals are considered in "Land" category: Forest Land, Forest Land remaining Forest Land, Land concerted to Forest Land, Cropland, Cropland remaining Cropland, Land converted to Cropland, Grassland, and Grassland remaining Grassland, Land converted to Grassland, Wetland, Settlement, and Other Land.

At present, forestland (including forests in SPAN) in Armenia covers an area of 457.5 thousand hectares, of which about 350 thousand hectares (ha) are forest-covered areas. Dependent on climatic conditions and anthropogenic factors, forestland in Armenia is distributed unevenly and includes 4 zones. 62.2% of forest is in the northeaster forestry zone, 12.6% in the large central forestry zone, 2.2% in the southern forestry zone, and 23% in the south eastern forestry zone [**Ref-25**].

Because of privatization process implemented in the beginning of 1990s agriculture management practice, format and content was totally changed, which directly affected different types of land and ecosystem situation. Enlargement of cattle farms, livestock reduction, economic decline and poverty increases, inflation and emigration have negatively affected the development of the livestock sector, which led to a chain of under usage or over usage processes of natural pastures, and as a result they became degraded and classified as under the erosion and desertification risk.

According to the balance of the land, the total area of agricultural land is 2,049.4 thousand hectares, including 121.7 thousand hectares of grassland, and 1054.2 thousand hectares of pastureland. According to a number of researches, a wide range of natural pastures around 60% is under the desertification and erosion risk [**Ref-25**].

Important to mention, that degradation of natural pastures is mostly have two reasons; Remote pastures lost their qualitative specifications and thus became degraded due to absence of management and not usage, and

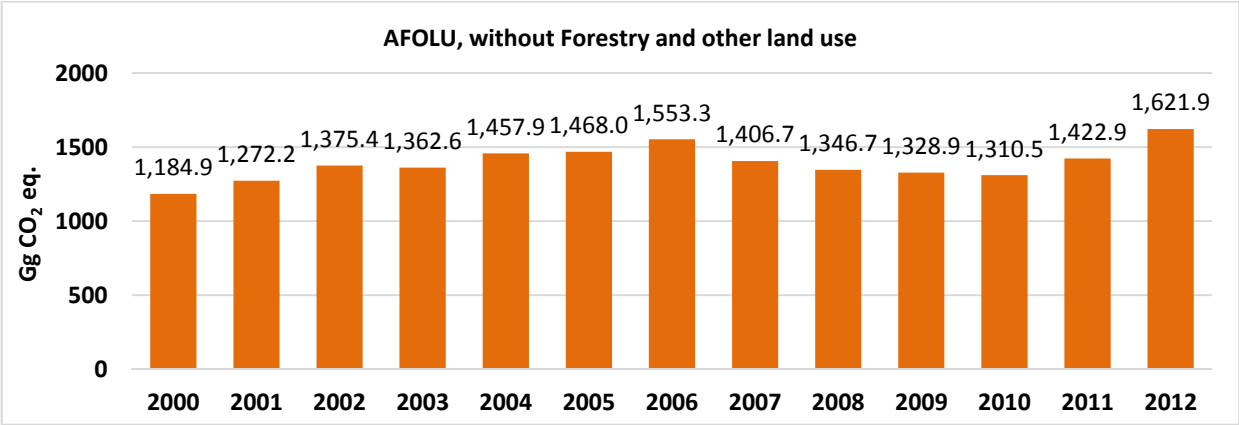
the livestock overgrazing in areas close to the community are exposed due to erosion and desertification risk. Therefore, as the main reason for the degradation of natural pastures cannot be considered the bad weather conditions, but it is mostly due to irregular and wasteful use of land, as well as almost total absence of relevant measures of improvement, maintenance and care. In addition to the economic and social consequences, such a situation, leads to the destruction of natural pastures as carbon sinks and stores. Along with the anthropogenic influence, due to climate changes (increase in temperature and decrease in precipitation), vertically movement of natural ecosystems' borders have been forecasted. It was grounded that in foreseeable future alpine and sub-alpine ecosystems will be in particular vulnerable situation (up to 3000 meters above sea level), where many species of plants and animals can be completely pushed out.

As a result of economic and energetic crisis in the beginning of 1990s over exploitation of forest was registered, due to which a notable decrease in forestry surface was followed (according to expert estimations value of forest cutting in that period was around 800,000 to 1,000,000 m^3). According to the positive scenario developed within the UN Millennium Development programmer, forest volume in 2015 (because of forest recovery activities in the RA) should have been made 12% of the size of the Republic whereas as of 2014 it was made only 11.2% or around 350 thousand ha [**Ref-25**].

According to 2006 IPCC Guidelines [**Ref-12**], GHG emissions/removals are estimated from forest areas according to RA Forest Stock soils and from areas converted to forestlands. Because of lack of complete information on Forest Sector in Armenia, emissions and removals of GHG are estimated only for carbon stock change in biomass (over ground and underground).

It should be mentioned, that manure is largely used as fuel in rural areas of Armenia. In 2012 total manure accounted for 6,211.7 thousand tons, of which burned portion was 524.6 thousand tons or 6084.9 TJ [**Ref-2**], [**Ref-16**]. Consistent time series for years 2000-2012 for GHG emissions by AFOLU sector presented in **Figure 19**.

Figure 19 GHG emissions by AFOLU sectors graphically, Gg CO_{2eq} (2000-2012)



Source: National Greenhouse Gas Inventory Report of the RA 2015 [**Ref-16**].

5.2 An overview of possible mitigation technology options in Land use and Forestry Sector and their mitigation potential and other co-benefits

Based on proposed TNA methodology, Land use and Forestry national expert have prepared a long list of possible technologies in Land use and Forestry sector. Previously, on 3 September 2015 the Mitigation TFS template supplementary to the clarification letter introducing TNA in Armenia was sent to long list of involved stakeholders. After consultations in the working groups Land use and Forestry national expert prepare 7 TFSs for presenting at "Workshop discussions with stakeholders" on 17 November, 2015 (Agenda of the meeting presented in Annex II) in Manugean Hall, American University of Armenia.

Criteria for prioritization of technologies have been clustered under Social, Social Economic, Economic, Environmental, Ecology, Technology groups. Based on current national strategy documents and expert judgments, the subsequent criteria were selected for prioritization of mitigation technologies in Land use and Forestry sector. Technologies Option selection in Land use and Forestry Sector are presented in **Table 17**.

Table 17 Technologies Option selection in Land use and Forestry Sector

N	Option title
Option 1	Sustainable Forest management
Option 2	New technology of cultivation of Perennial plants
Option 3	Degraded Grassland radical improvement
Option 4	Grassland sustainable management
Option 5	Use of non-cultivated land
Option 6	Grassland surface improvement
Option 7	Target use of cropland

As a result of economic and energetic crisis in the beginning of 1990s over exploitation of forest was registered, due to which a notable decrease in forestry surface was followed (according to expert estimations value of forest cutting in that period was around 800,000 to 1,000,000 m^3). According to the positive scenario developed within the UN Millennium Development programmer, forest volume in 2015 (because of forest recovery activities in the RA) should be 12% of the territory of RA whereas as of 2014 it was only 11.2% or around 350 thousand ha [**Ref-5**], [**Ref-** http://armstat.am/en/?nid=586&year=2015].

Since the beginning of 1990s due to privatization, processes in agriculture sector some transformations were registered which have negative impact on this sector future development. Particularly:

- Agricultural lands desecrated (over 1.2 million plots), which resulted a decrease in the cultivation efficiency.
- Most areas of perennial plants turned into grain crop areas. Only in recent years has seen a growth area of orchards.
- Notably reduced consumption volumes of inorganic and organic fertilizers. In comparison with the pre-economic reform period now consumption of inorganic fertilizers was reduced almost 7-8 times, consumption of organic fertilizers and means of plant protection18 times.
- Use of advanced technology remained out of practice.
- Irrigation system became deteriorating, costs and volume of uncultivated land had increased, etc.

From the other side, economic decline, high level of poverty and decrease of population incomes became the reasons, which lead to the engagement of rural population in crop cultivation having higher potential consumer "liquidity" in the market. That is why perennial, technical and other liquid crop fields were gradually expanded. Because of privatization process implementing in the beginning of 1990s agriculture management practice, format and content was totally changed, which directly affected different types of land and ecosystem situation. De-enlargement of cattle farms, livestock reduction, economic decline and poverty increases, inflation and emigration have negatively affected the development of the livestock sector, which led to a chain of under usage or over usage processes of natural pastures. As a result, they became degraded and classified as under the erosion and desertification risk [**Ref-5**] [**Ref-** http://armstat.am/en/?nid=82&year=2015].

Because of Sustainable Forest management (Option 1) technology implication firstly forest biomass growth will increase the volume of takeovers, while decrease in illegal cuttings and volumes of firewood will lead to the reduction in CO_2 emissions. The full implementation of Sustainable Forest management technology will contribute to the increase in relevant areas of jobs, but also could have a negative impact on the social situation of many poor households. According to various research results, 31-34% of households in Armenia use

firewood and manure for heating and other purposes as the main source of energy. Reduction in the volume of illegally cut firewood will force households to use more expensive, payable energy sources, which will become a significant burden on their budgets [**Ref-5**], [http://armstat.am/en/?nid=82&id=1606]. On the other hand, the proposed technology could ensure additional stocks/reserves of construction materials and firewood, which will have positive impact on other sectors of economy, simultaneously it will ensure less expensive energy source for households. The Environmental benefits of the technology implication are: Positive impact on forest and other ecosystems and biodiversity, climate improvement, decrease of dust content in atmosphere, land protection and decertification risk reduction, reducing the risk of floods and landslides.

Vineyards and fruit cultivation because of the introduction of new technology of cultivation of Perennial Plants (Option 2) in this category of land use will increase carbon absorption due to the rapid growth in biomass.

In case of annual and perennial crops and uncultivated land technology, no significant change in emissions/removals will be registered (due to change in biomass), however, will increase the stock of organic carbon in soil and improve soil quality. Full implementation of technology will contribute to the employment and income growth in agriculture, which implies the reduction of rural poverty and migration. Community budget incomes will increase. Role of civil society in community administration and management process will increase as well. Sufficient resources will be available to solve community's social issues [**Ref-5**], [**Ref-** http://armstat.am/en/?nid=82&id=1705].

The technology of cultivation of Perennial Plants will generate the following Economic and Environmental benefits:

- Growth of agricultural production, development of food processing production.
- Competitive and environmentally friendly agricultural products and processed food will be exported to other countries.
- Additional financial flows for community development.
- Positive impact on natural ecosystems and biodiversity,
- Reduction of land erosion and desertion risks, floods and landslides,
- Positive impact on water resources circulation

Implementation of Degraded Grassland radical improvement (Option 3) technology will result in natural growth of biomass and effective management of natural pastures will contribute to GHG emission reduction by effective management of storage resources, accumulation of organic carbon, particularly carbon stocks sequestration level in the soil will increase.

The full implementation of the mentioned technology will contribute to Social benefits like increase in employment in agriculture rural population incomes, which also implies decrease in migration and poverty reduction in rural communities as well. Concurrently, competitive and environmentally friendly agricultural products and processed foods will be exported to foreign countries.

The technology will contribute to the development of cattle breeding, which will consequently contribute to Economic benefits and development of other sectors and infrastructures based on the given subsector. At the same time, due to increased land utilization the Community budget incomes will increase.

Degraded Grassland radical improvement technology Environmental benefits should be: Positive impact on natural ecosystems and biodiversity, protection of a number of plants and animals, land protection and decertification risk reduction, reducing the risk of floods and landslides, positive impact on the circulation of water resources. All mentioned options are detailed in Annex I.

5.3 Criteria and process of technology prioritisation for Land use and Forestry sector

Like previous sectors criteria in the sector were based on current research that estimated potential effects of criteria on searching suitable technologies. As a result of intensive discussions with the stakeholders group, the

following 7 criteria were defined to prioritize technologies for Land use and Forestry sector. Criteria selection for Technologies Options in Land use and Forestry Sector is presented in **Table 18**.

Table 18 Criteria selection for Technologies Options in Land use and Forestry Sector

Criterion	Criteria category	Unit Chosen	Value Preferred
Affordability	Social and economic	Low to high	High
Investment cost	Economic	USD /ha	Low
Operating (current) cost	Economic	USD /ha	Low
Economic benefit	Economic	Low to high	High
GHG mitigation	Environment	Gg CO2-e/ year ha	High
Environmental benefit	Ecology	Low to high	High
Social benefit	Social	Low to high	High

Technologies were given scores and weighted for each criterion and arranged in priority order. Options evaluation in Land use and Forestry Sector is presented in the **Table 19** and Weighting of criteria in **Table 20**.

Table 19 Option evaluation in Land use and Forestry Sector

Option/Criterion	Affordability	Investment cost	Operating cost	Economic benefit	GHG mitigation	Environmental benefit	Social benefit
Units	**Low to high**	**USD/ha**	**USD/ha**	**Low to high**	**GgCO2-e/year ha**	**Low to high**	**Low to high**
Preferred value	**High**	**Low**	**Low**	**High**	**High**	**High**	**High**
Sustainable Forest management	3	1,800	115	5	1,498	5	3
New technology of cultivation of Perennial Plants	2	765	110	3	374	4	4
Degraded Grassland radical improvement	5	220	80	4	0.01	4	4
Grassland sustainable management	2	120	50	3	0.01	3	2
Use of non-cultivated land	1	160	90	4	4	2	4
Grassland surface improvement	4	90	40	2	0.01	3	2
Target use of cropland	3	450	85	4	2	1	4

However, all suggested technologies obtained rather close and roughly equal to each other total weighted scores. Meanwhile their scores in each criterion are with a big difference. Option 1 has very high Investment cost and at the same time the highest GHG mitigation. Option 2 gained medium scores in all 7 criteria. Option 3 is the most Affordable technology and has good score in Economic, Environmental and Social benefit criteria, justified by stimulation of growth and development of friendly agricultural products and food processing production. Positive impact on natural ecosystems, biodiversity, water resources, etc.

5.4 Results of technology prioritisation for Land use and Forestry sector

Most supporters of MCA use the method of "swing weighting" to elicit weights for the criteria. This is based, once again, on comparisons of differences: how does the swing from 0 to 100 on one preference scale compare to the 0 to 100 swing on another scale? To make these comparisons, assessors are encouraged to take into account both the difference between the least and most preferred options, and how much they care about that difference [**Ref 15**].

Table 20 Weighting of criteria in Land use and Forestry Sector	
Criterion	**Allocation of budget Weight, %**
Affordability	10%
Investment cost	16%
Operating (current) cost	12%
Economic benefit	16%
GHG mitigation	12%
Environmental benefit	18%
Social benefit	16%
Total allocated	**100%**

Taking into account the lack of exact and precise information about some actual costs and benefits, other data from introduced selected technologies, the criteria ranged and the productivity of technology was considered by categorized information in selecting technology, knowledge and views of experts. The results of scoring for each technology within each criterion under selected sector are provided in **Table 21**.

Table 21 Calculation of scores in Land use and Forestry Sector

Criteria Options	Affordability	Investment cost	Operating cost	Economic benefit	GHG mitigation	Environmental benefit	Social benefit	Weighted scores of each option
Units	**Low to high**	**$/ha**	**$/ha**	**Low to high**	**tCO2-e/year ha**	**Low to high**	**Low to high**	
Preferred value	**High**	**Low**	**Low**	**High**	**High**	**High**	**High**	
Weight	**10%**	**16%**	**12%**	**16%**	**12%**	**18%**	**16%**	
Sustainable Forest management	50.00	0.00	0.00	100.00	100.00	100.00	50.00	59.00
New technology of cultivation of Perennial plants	25.00	60.53	6.67	33.33	24.97	75.00	100.00	50.81
Degraded Grassland radical improvement	100.00	92.40	46.67	66.67	0.00	75.00	100.00	70.55
Grassland sustainable management	25.00	98.25	86.67	33.33	0.00	50.00	0.00	42.95
Use of non-cultivated land	0.00	95.91	33.33	66.67	0.27	25.00	100.00	50.54
Grassland surface improvement	75.00	100.00	100.00	0.00	0.00	50.00	0.00	44.50
Target use of cropland	50.00	78.95	40.00	66.67	0.13	0.00	100.00	49.11

As a result of the technology needs assessment process the one technology: Option 3, yielded the highest weighted score. The second is Option 1, and all remaining five technologies with weighted score very close to the second one and approximately equal to each other. The selected technologies are presented in **Table 22**. All TFSs are available in Annex I.

Table 22 Summary of results in Land use and Forestry Sector

Ranking of options

Rank	Option	Weighted Score
1	**Degraded Grassland radical improvement**	**70.6**
2	**Sustainable Forest management**	**59.0**
3	**New technology of cultivation of Perennial plants**	**50.8**
4	Use of non-cultivated land	50.5
5	Target use of cropland	49.1

6	Grassland surface improvement	44.5
7	Grassland sustainable management	43.0

Cumulative scores were given to sector technologies by stakeholders, which have later been endorsed by the project steering committee during a follow-up meeting in 24 December 2015 (Agenda of the meeting presented in Annex II).

Chapter 6 Technology prioritisation for Waste management Sector

6.1 GHG emissions and existing technologies of Waste management Sector. Decision context

"Waste" sector of National Inventory of GHG of Armenia includes the following subcategories: "Solid waste disposal", where methane emissions from solid waste is considered; "Incineration and open burning of solid waste", where carbon dioxide, methane, and nitrous oxide emissions from open burning is considered; "Wastewater treatment and discharge" where the following subcategories are considered: "Domestic wastewater treatment and discharge", "Industrial wastewater treatment and discharge".
In RA the SW is collected, transported and disposed of in 48 municipal landfills. The total area of solid waste disposal sites is 219 ha.
SWs include municipal, commercial, and other waste. For all sources, waste is piled without prior classification and sorting. The annual accumulated amount of SW is around 700 thousand tonnes, while the amount of collected and stored SW is about 510 thousand tonnes (241 kg per urban resident). Not all landfills (other than the largest one in Yerevan) are managed. The share of degradable organic carbon in SW is around 50-60%. The storage of large amounts of SW results in the anaerobic degradation of organic compounds and methane emissions [**Ref-25**].
Methane emissions from domestic and industrial wastewater and nitrous oxide emissions from domestic wastewater are considered in "Wastewater treatment and discharge" category.
Main sources for "Waste" sector include "Solid Waste Disposal" (methane emissions) accounting for 4.8% (in 2011) and 4.5% (in 2012), and "Wastewater treatment and discharge" (methane emissions) accounting for 2.08% (in 2011) and 1.02% (in 2012) [**Ref-25**].

Government policy on waste is directed on reduction of waste generation and minimization of waste danger through following measures:

- Use of contemporary scientific achievements to introduce no waste or low waste technologies;
- integrated utilization of material resources in order to reduce waste volumes;
- Direct, secondary or alternative consumption of waste bearing material value;
- Ensuring safe disposal of non-usable waste with appropriate waste neutralization technologies, developing environmentally safe methods and measures;
- Providing available information on waste utilization;
- Define mechanisms for economic motivation.

In order to adjust the economy to changing environment and to mitigate the impact of climate changes on water resources the following complex measures are suggested for implementation:

- Administrative and planning
  - consider the climate change factor during development of management plans for all major river drainage basins;

- optimization and renovation of the hydrologic observation decks network with contemporary equipment;
- granting water usage permissions taking into account the climate change risks;
- creating hydrologic reservations in all river basin areas of river flow formation;

• Informative and research.

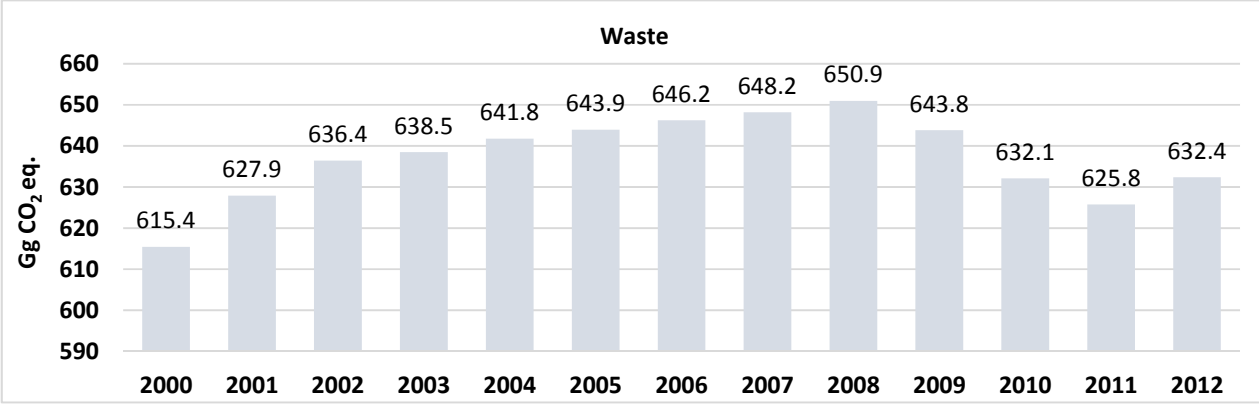
- assessment of climate changes on water resources of mountain lakes;
- assessment of the snow storage change for all major river drainage basins in Armenia, application of computer modeled climate change scenarios for all major river drainage basins;
- assessment of climate changes on underground waters;
- amendment of ecologic flow calculation method;

• Economic and technical.

- construction of new small reservoirs and renovation of out of-service ones;
- monitoring and controls over underground waters;
- reduction of flow losses in water supply and irrigation systems;
- develop economic mechanisms to promote application of advanced irrigation methods in agriculture.

Currently there are no projects for renovation and reconstruction of waste water treatment systems in Armenia. Consistent time series for years 2000-2012 for GHG emissions by Waste sector presented in **Figure 20**.

Figure 20 GHG emissions by Waste sector graphically, Gg CO_{2eq} (2000-2012)



Source: National Greenhouse Gas Inventory Report of the RA 2015 [**Ref-16**].

6.2 An overview of possible mitigation technology options in Waste management Sector and their mitigation potential and other co-benefits

Based on proposed TNA methodology, Waste management national expert have prepared a long list of possible technologies in Waste management sector. Previously, on 3 September 2015 the Mitigation TFS template supplementary to the clarification letter introducing TNA in Armenia was sent to long list of involved stakeholders. After consultations in the working groups Waste management national expert prepare 7 TFSs for presenting at "Workshop discussions with stakeholders" on 17 November, 2015 (Agenda of the meeting presented in Annex II) in Manugean Hall, American University of Armenia.

Criteria for prioritization of technologies have been clustered under Social, Social Economic, Economic, Environmental, Ecology, Technology groups. Based on current national strategy documents and expert judgments, the subsequent criteria were selected for prioritization of mitigation technologies in Waste management sector. Technologies Option selection in Waste Management Sector are presented in **Table 23**.

Table 23 Technologies Option selection in Waste management Sector	
N	**Option title**
Option 1	Utilization of methane form Yerevan city landfill for electricity and heat production
Option 2	Complex processing of Artik mining waste
Option 3	Surface water resource protection from pollution (Compact)
Option 4	Surface water protection from pollution (Natural)
Option 5	Utilization of biogas originated from chicken manure and heat (electric) energy cogeneration system (CHP) in "Aras Poultry Factory" CJSC
Option 6	Existing Lusakert biogas plant operation and reissuance organizational technology
Option 7	Chicken manure recycling and processing of granular organic fertilizer

Armenia is underdeveloped in its waste management and recycling activities. Currently, within the framework of the ARM–EU cooperation, the development of radioactive waste and spent fuel management strategy for Armenia is being carried out. It is planned to complete the development of the aforementioned strategy in 2016 [**Ref-9**]. Armenia has the potential for biogas-based power production at livestock farms, at the Nubarashen landfill (in the city of Yerevan) and at the Aeratsia waste water treatment plant (in the city of Yerevan). In 2001, a consortium of Japanese companies studied the potential for a landfill gas-to-energy plant at the Nubarashen landfill. Although eventually the consortium installed a methane gas flare plant instead of an energy project, more recent assessments have identified the potential for building up to a 2.5 MW landfill gas-to-energy plant at the facility [**Ref-9**].

The proposed technology of Utilization of methane form Yerevan city landfill for electricity and heat production (Option 1) will contribute to the Social and Economic benefits:

- the increase in employment
- the improving the atmosphere in Yerevan
- the reducing diseases
- surrounding land use
- other economic activities
- an additional source of fuel and energy

Environmental benefits of the technology should be the positive impact on natural ecosystems and biodiversity of the landfill area, protection of a number of plants and animals, land protection, positive impact on the circulation of water resources. Elimination of stench and irregular surface combustion products from areas adjacent to landfills will ensure a natural development of those areas that is very important for such a land-poor country as Armenia.

Armenia is the first country in the region that applies such an advanced technology to manage the process of SDW landfills and can pretend to become the centre of the region: the carrier of this culture and its promoter with all sequential benefits. The above-noted technology may be successfully applied (with involvement of certain grants) to reprocess biogas and produce electric energy out of it in SDW landfills of other RA rather large cities like Gyumri and Vanadzor.

Until now, in RA the area was discovered and explored more than 110 in tuff stone mines. The geological reserves are estimated at 2.5 trillion cubic meters. Research show that vast majority of extracted stones are thrown into the environment as waste. There are types of tuff stones 65-70% of which turn into waste.

[**Ref-** http://www.armworld.am/detail.php?paperid=4290&pageid=132334&lang=_arm]. The tuff stone of Artik is the most widely used one in the country. In 1928 machine extraction from Artik mining was started. So far more than 50 million cubic meters of tuff stone mass was manufactured, of which only 30-40% was used as construction material corresponding to the standard, the rest was mainly thrown into the environment as a

waste. These wastes and abandoned quarries occupy more than a thousand hectares of the fertile black soils. Overall, the area 7.0-7.5 thousand hectares of land is covered by stone waste. The waste being influenced by the winds constantly polluting the air basin of the settlements.

Artik mining waste complex processing, agricultural land degradation prevention and clean up technology (Option 2) suggested tuff waste utilization by combining different fractions of crushed stone with another problematic waste (plastic containers). In addition, organizing production of different construction products: thermal and sound insulation plates, as well as foam-concrete products, gravel ground tuff blocks, etc. Main benefits are Positive impact on natural ecosystems and biodiversity of the surrounding area, protection of plants, reduction of pollution, land protection, etc.

The household as well as industrial wastewater cleaning is not fully implemented in Armenia, resulting in wastewaters are flow into surface water without purification, irrigation ditches, polluting land areas, degrading ecosystems, damaging people's health.

At present, 5 treatment plants were built thanks to an investment loan, which carry only mechanical treatment (lack of finance does not allow for the construction of biological treatment facilities).

Two offered technologies in regards to Surface water resource protection from pollution and applying wastewater treatment alternative technologies (Option 3 and 4) applying natural, combined and/or compact stations will insure following Social, Economic and Environmental benefits:

- It is almost several times efficiency compared to mechanical systems and classic treatment plants
- Minimal operational expenses, particularly with regard to electricity
- Improving the sanitary conditions of the environment,
- Public health protection and food security.
- Opportunity to use treated wastewater at a lower cost as irrigation water and/or technical water use
- Protection of water and terrestrial ecosystems, landscapes from pollution and degrading
- Surface and underground water sources, agricultural land, aquatic and terrestrial ecosystems, landscapes protection from degradation and pollution
- Reduction in methane gas emission

Lusakert Biogas Plant was constructed at the Lusakert poultry farm for Methane Capture and Combustion from Poultry Manure Treatment. The proposed project aims to reduce Lusakert poultry farm animal waste generated GHG emissions through improvement of animal waste management system. The Plant was built in 2008 which was designed to reduce emissions and to produce electricity and organic fertilizer from poultry litter and animal waste. However, today this plant is not in operation.

Existing Lusakert biogas plant operation and reissuance organizational technology (Option 6) could insure following benefits:

- The creation of new jobs requiring professional qualifications
- Improving of the working conditions of factory staff
- Reduction of diseases
- Organic fertilizer production
- other economic activites
- additional sources of fuel and energy
- Prevention of environmental pollution.
- Elimination of stench
- Prevention of water and land resources from pollution

In 2010, the GEF/UNDP identified three livestock farms as potential candidates for biogas-to-energy projects, with a combined resource potential of 3.3 MW. These plants would be similar to the Lusakert biogas plant, which is Armenia’s only operated industrial-scale biogas-to-energy plant.

The other potential source of biogas energy in Armenia is the Aeratsia wastewater treatment plant. The plant is currently dilapidated and largely non-functioning, but if the plant were to undergo significant rehabilitation and anaerobic digesters were installed at the facility, it is expected that a 3 MW cogeneration plant could be constructed at the facility [**Ref-9**].

6.3 Criteria and process of technology prioritisation for Waste management sector

Like in previous sectors criteria in the sector were based on current research that estimated potential effects of criteria on searching suitable technologies. As a result of intensive discussions with the stakeholders group, the following 7 criteria were defined to prioritize technologies for Waste management sector. Criteria selection for Technologies Options in Waste Management Sector are presented in **Table 24**.

Table 24 Criteria selection for Technologies Options in Waste management Sector

Criterion	Criteria category	Unit Chosen	Value Preferred
Affordability	Social and Economic	Low to high	High
Investment cost	Economic	kUSD	Low
Economic benefit	Economic	Low to high	High
GHG mitigation	Environment	GgCO2-e/life time	High
Environmental benefit	Ecology	Low to high	High
Social benefit	Social	Low to high	High

Technologies were given score and weighted for each criterion and arranged in priority order. Option evaluation in Waste Management Sector is presented in the **Table 25** and Weighting of criteria in **Table 26**.

Table 25 Option evaluation in Waste management Sector

	Option/Criterion	Affordability	Investment cost	Economic benefit	GHG mitigation	Environmental benefit	Social benefit
	Units	**Low to high**	**k$**	**Low to high**	**GgCO2-e/life time**	**Low to high**	**Low to high**
	Preferred value	**High**	**Low**	**High**	**High**	**High**	**High**
1	Utilization of methane form Yerevan city landfill for electricity and heat production	2	51,000.0	5	212.0	5	5
2	Complex processing of Artik tufa mining waste and agricultural lands to prevent their further degradation	3	20.5	3	0.8	3	4
3	Surface water resource protection from pollution (wastewater treatment, alternative technologies, compact stations)	3	22.4	3	2.2	3	3
4	Surface water protection from pollution (Natural purification of domestic wastewater treatment, alternative technologies and associated technologies)	3	18.0	3	2.0	3	3
5	Utilization of biogas originated from chicken manure and heat (electric) energy cogeneration system (CHP) in "Aras Poultry Factory" CJSC	1	4,300.0	2	12.4	2	3

6	Existing Lusakert biogas plant operation and reissuance organizational technology	4	50.0	3	25.0	3	4
7	Chicken manure recycling and processing of granular organic fertilizer	5	20.0	2	3.0	2	2

Option 1 has significant role for environment and natural ecosystems, with its positive impact on biodiversity, water resources, plants, animals and land protection. Elimination of stench and rational development of areas is vital as well. Therefore, this option obtained best scores in Economic benefit, GHG mitigation, Environmental benefit and Social benefit criteria and the bad scores in Affordability and Investment cost ones. Option 6 also considered to have Helpful impact on ecosystems and surrounding area, along with reduction of pollution, land protection, etc. Rather high score gained Option 2 consequently due to its contribution to creation of new jobs, improving of the working conditions, decrease of diseases, prevention of environmental pollution, elimination of stench etc. The stakeholders due to their significant role in the Waste Management Sector consider Option 3, 4, 5 and 7 significant. The experts provided assessments for justification of the scores given for potential improvements and contribution to development priorities in each option.

6.4 Results of technology prioritisation for Waste management sector

According to the methodology [**Ref 15**], MCA can yield surprising results that need to be digested before decisions are taken. It may be necessary to establish a temporary decision system to deal with unexpected results and to consider the implications of new perspectives revealed by the MCA. This temporary system consists of a series of working meetings which eventually produce recommendations to the final decision making body. At the working meetings, participants were given the task of examining the MCA results, testing the findings for their validity, working though the possible impacts for the organization, and formulating proposals for the way forward.

Table 26 Weighting of criteria in Waste management Sector

Criterion	Allocation of budget Weight, %
Affordability	14%
Investment cost	20%
Economic benefit	20%
GHG mitigation	13%
Environmental benefit	15%
Social benefit	18%
Total allocated	**100%**

Like in previous sectors taking into account the lack of exact and precise information about some actual costs and benefits, other data from introduced selected technologies, the criteria ranged and the productivity of technology was considered by categorized information in selecting technology, knowledge and views of experts. The results of scoring for each technology within each criterion under selected sector are provided in **Table 27**.

Table 27 Calculation of scores in Waste management Sector

Criteria Options	Affordability	Investment cost	Economic benefit	GHG mitigation	Environmental benefit	Social benefit	Weighted scores of each option

Units	Low to high	kUSD	Low to high	GgCO2-e/life time	Low to high	Low to high	
Preferred value	**High**	**Low**	**High**	**High**	**High**	**High**	
Weight	**14%**	**20%**	**20%**	**13%**	**15%**	**18%**	
Utilization of methane form Yerevan city landfill for electricity and heat production	25.00	0.00	100.00	100.00	100.00	100.00	69.50
Complex processing of Artik mining waste	50.00	100.00	33.33	0.00	33.33	66.67	50.67
Surface water resource protection from pollution (Compact)	50.00	99.99	33.33	0.66	33.33	33.33	44.75
Surface water protection from pollution (Natural)	50.00	100.00	33.33	0.57	33.33	33.33	44.74
Utilization of biogas originated from chicken manure and heat (electric) energy cogeneration system (CHP) in "Aras Poultry Factory" CJSC	0.00	91.60	0.00	5.49	0.00	33.33	25.03
Existing Lusakert biogas plant operation and reissuance organizational technology	75.00	99.94	33.33	11.46	33.33	66.67	55.64
Chicken manure recycling and processing of granular organic fertilizer	100.00	100.00	0.00	1.04	0.00	0.00	34.13

As a result of the technology needs assessment process the one technology: Option 1, yielded the highest weighted score. The second and the third are respectively Option 6 and Option 2 all remaining four technologies seems not be prioritized due to low weighted score. The selected technologies are presented in **Table 28**. All TFSs are available in Annex I.

Table 28 Summary of results in Waste management Sector

Ranking of options

Rank	Option	Weighted Score
1	**Utilization of methane form Yerevan city landfill for electricity and heat production**	**69.5**
2	**Existing Lusakert biogas plant operation and reissuance organizational technology**	**55.6**
3	**Complex processing of Artik mining waste**	**50.7**
4	Surface water resource protection from pollution (Compact)	44.8
5	Surface water protection from pollution (Natural)	44.7
6	Chicken manure recycling and processing of granular organic fertilizer	34.1
7	Utilization of biogas originated from chicken manure and CHP in "Aras Poultry Factory"	25.0

Cumulative scores were given to sector technologies by stakeholders, which have later been endorsed by the project steering committee during a follow-up meeting in 24 December 2015 (Agenda of the meeting presented in Annex II).

Chapter 7 Summary and Conclusions

In the result of consultations, four sectors were chosen. These are Energy (including transport), Industry (including chemical industry), Land use (including forestry) and Waste management (including agriculture), Expert groups for each subsector held discussions with stakeholders in each segment.
Decision were based on the actual, calculated GHG emissions forecasts (mitigation scenarios) to the year 2030, consistent time series for years 2000-2012, as well as identified economic, social and environmental development priorities, based potential mitigating effect on climate change and compliance with country development priorities.
Based on proposed TNA methodology, national experts have prepared a long list of possible technologies and 28 TFS were developed.
Based on provided TNA methodology and MCA approach conducted, in accordance with the handbook the proposed 28 TFS has been scored (details of assessment are presented in chapters 3;4;5 and 6 presented above, as well as in Annex I).
As a result of the technology needs assessment process 14 technologies (5 for energy, 3 for Industry, 3 for Land use and 3 for Waste management) are presented for the approval. The selected technologies are presented in **Table 29** below.

Table 29 List of priority technologies for climate change mitigation in Armenia

	Technologies	Sector
1.	Cogeneration, Small Scale Combined Heat and Power production	Energy
2.	Improving energy efficiency in multi apartment buildings. Registry creation, development	Energy
3.	Mandatory realization of the Industrial Energy Audit as a mitigation component	Energy
4.	Reactive capacity (power) compensation in the RA electric energy system	Energy
5.	Correspondence of natural gas tariff structure to the methodology approved by decision of Public Services Regulatory Commission (PSRC)	Energy
6.	Production of synthetic rubbers from butadiene instead using natural gas (Chemical industry)	Industry
7.	Production and usage of photo luminescent materials with long-term lightening	Industry
8.	New type of Entirely Plastic solar water heater	Industry
9.	Degraded Grassland radical improvement	Land use
10.	Sustainable Forest management	Land use
11.	New technology of cultivation of Perennial plan	Land use
12.	Utilization of methane form Yerevan city landfill for electricity and heat production	Waste
13.	Existing Lusakert biogas plant operation and reissuance organizational technology	Waste
14.	Complex processing of Artik tufa mining waste and agricultural lands to prevent their further degradation	Waste

These technologies are related to a wide spectrum of economic, social, environmental and political factors. The barrier analysis and development of TAP for these selected technologies will reflect the need for technology actions in chosen sectors and subsectors. In general, there is a need to develop a comprehensive technology database for customer and policy maker decision making, as well as to support local technology and expertise development.

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Annex I: Technology Factsheets for selected technologies

Technology Factsheets for selected technologies in Energy Sector

Technology Factsheet 1 Energy

Technology name	**Cogeneration, Small Scale Combined Heat and Power production.**
Sphere	**Energy**
GHG emissions (CO_2 Equivalents, Gg)	**6,913 $GgCO_{2eq}$ (2012)**
Introduction	The combined generation of thermal and electric energy is known as cogeneration, which is the energy saving technology with a huge potential. Cogeneration stations may generate electric and thermal energy using modern gas turbine and gas –piston aggregates with the cumulative Efficiency Coefficient of 90-92 %: 42-44 % for electric energy, and 48-50% for thermal, accordingly. One of the unique properties of these technologies (both gas turbine and gas-piston) is the fact that they are produced at power starting from 40 kW up to a few MW, besides they are shipped with installed modules and may be located in the required heating energy and electricity destination, close to the energy consumers with all the subsequent advantages. These are the following: a). 0.4; 6 (10) kV output voltage, may be connected to the nearest transmission/distribution facilities or sub-stations excluding the necessity of high voltage electric energy transmission. b). the supply of thermal energy to the customers does not require building of long and expensive thermal pipelines. The more is the demand for the heat energy (especially in densely populated urban districts), the more obvious are the advantages of these technologies. The RA energy system's installed capacity at least twice exceeds the upmost requirement for the electricity load, besides; according to the annual energy balance, it is self – sufficient, and the thermal power stations will generate about 30% of electric energy in 2015.
Implementation opportunities	All the thermal power stations work on a condensation mode and have the following Efficiency Coefficients: Yerevan (CCGT 242 MW) Combined-Cycle Gas Turbine (gas and steam power plant) 47%, Hrazdan 5 unit (CCGT 445 MW) Thermal Power Plant 45-44%, Hrazdan TPP 33% (the 4x200 MW aggregates of the latter have been operated for over than 40 years). It is obvious that these latter capacities should be modernized. There is an erroneous perception among the society and some experts, that the replacement of the exhausted power must be restored with the help of stations working on the renewable energy resources. However, from the perspective of organic fuel economy, it has been found that cogeneration stations do not lose, but even outdo the well-known technologies working on the resources. Thus, 1kW power of a congregation station may annually generate at least 7,500 kWh electric energy and accordingly 8,200 kWh thermal energy. That is equal to about 8,000 kWh electric energy generated by the Hrazdan TTP (taking into account about 5% of loss), where 8,200

	kWh thermal energy is "produced in CHP" without additional fuel expenditures. Annual fuel saving will be about 1,100-1,300 m^3 of Natural Gas depending on the capacity of the Efficiency Coefficient (60-80%). Yet, stations with renewable energy resources have less working hours annually, small HPPs – 3,000 hours, solar stations – 1,800 hours. Estimates show that 1 kW power of a small Hydro Power Plant will save about 1,000 m^3 of natural gas (based on Hrazdan TTP Efficiency Coefficient) annually (on the condition it works 3,000 hours a year), whereas for Solar and Wind power stations the saving does not exceed 700 and 800 m^3 of Natural Gas, accordingly. In contrast to the stations using renewable energy, not a single legal act ensures obligatory purchase of the energy generated by the CHP units as well as there are no certain principles for tariff formation. The major impediment for the restoration of the centralized heating supply using cogeneration stations is the absence of the legal framework for the corresponding field.
Implementation barriers	According to the RA "Energy Law", electric and heat energy generation fields (except for small heat supply systems up to the power of 5.8 MW) are under the government regulation and are directed by the Public Services Regulatory Commission (PSRC) directives. In case of the absence of legal act ensuring obligatory purchase of the energy generated by the CHP and legal framework the private investments in CHP are impossible.
GHG emission reduction as a result of technology implementation (CO_2 Equivalents, Gg)	11,7 $GgCO_{2eq}$
Possible impacts, compatibility and benefits for the country development goals	
Social benefits	Restoration of civilized heating supply
Economic benefits	Decentralization of energy generation, particularly the bring closer to consumption and reduction of losses.
Environmental benefits	More efficient approach to the usage of organic fuels with all subsequent ecological and economic benefits
Other assumptions and benefits (market potential)	The potential of this technology is conditioned by the heat demand, which only for medium region of Yerevan is assumed as 40-45 Gcal/hour (46.52-52.33 MW), about 60% will be generated by the cogeneration stations. To meet this demand about 35 MW installed CHP power will be required.
Expenditures	
Capital cost	600-700 USD/kW for the equipment or 1,000 USD/kW for the implementation of the project
Operation and maintenance cost	0.8-1.0 USD cent/kWh:
Value of reduction of greenhouse gases emissions	119.6 USD/ $GgCO_{2eq}$
Life time	25 years
Other expenditures	Depending on circumstances

Technology Factsheet 2 Energy

Technology name	**CO_2 emissions reduction technology for emission of gas engines in Vehicles.**
Sphere	**Energy**
GHG emissions ($CO_{2\ Equivalents}$, Gg)	**6,913 $GgCO_2$ (2012)**
Introduction	Active control of gas-dynamic fuel fills in the combustion chamber of the internal combustion engine as well as provision of thermodynamic criteria for the combustion process in gas engines leads to the 5-7% increase of engine indicated power during the combustion stroke at the same time reducing fuel expenditures and CO_2 emissions.
Implementation opportunities	Operation regulations for commercial enterprises and sole proprietors' cars having petrol engines but working on Compressed Natural Gas (CNG) are the following: Increase of compression degree, Increase of firing spark angle, Active control of air-gas fuel mixture fill and improvement of homogenization, which increase the engine indicated power through the complete combustion of the fuel fill by 5-7% and save fuel expenditure by 4.5 - 5.5%. For this purpose, a device for air-gas mixture control and homogenization improvement is installed in the cars. These complex measures will reduce the amount of CO_2 in gas emissions of gas-based engines. For CNG based engines, it is 5-12%. K.H. Mosikyan, associate professor, Armenian National Agrarian University, chair of "Automobiles and tractors", has developed the above-mentioned technology.
Implementation barriers	Certification of devices for air-gas mixture control and homogenization improvement will be required.
GHG emission reduction as a result of technology implementation ($CO_{2\ Equivalents}$, Gg)	Overall amount of CO_2 emissions will be reduced by about 4.0 $GgCO_2$
Possible impacts, compatibility and benefits for the country development goals	
Social benefits	Reduction of transportation and freight charges for population
Economic benefits	Reduction of transportation net value
Environmental benefits	Reduction of CO_2 emissions
Other assumptions and benefits (market potential)	Increases the lifetime of a car engine and its motor potential. Implementation of this technology will save about 2.15 million m^3 natural gas annually for about 15,000 cars with gas engines.
Expenditures	
Capital cost	50.0 million AMD equivalent to 110,000 USD
Operation and maintenance cost	20,0 million AMD/ annually
Value of reduction of greenhouse gases emissions	5.5 USD/ $GgCO_{2eq}$
Life time	5 years
Other expenditures	N/A

Technology Factsheet 3 Energy

Technology name	**Natural gas combustion process regulation in water heating boilers.**
Sphere	**Energy**
GHG emissions (CO_2 Equivalents, Gg)	**6,913 $GgCO_2$ (2012)**
Introduction	One of the factors affecting the Efficiency of water heating boilers is the losses generated as a result of the fuel chemical incomplete combustion. It is well known that during a long-term (5 years and more) operation of water heating boilers the component of these losses increases considerably, thus reducing the Efficiency Coefficients of the boilers. The losses occurring owing to chemical incomplete combustion are a result of air insufficiency in the burner: carbon oxide (CO) is generated in combustion products. In case of low values of the Excess air ratio (α), this loss can be up to 5-7%. The application of modern mobile gas analysers significantly reduces the cost of the research (monitoring) of combustion process in the boiler and increases the overall regulation efficiency. Mobile gas analysers make possible to monitor the "α" coefficient during one working day and to evaluate the natural gas saving and measuring directly the decrease of carbon oxide contain in combustion products.
Implementation opportunities	According to the official data, about 3,500 water-heating boilers (boiler houses) with installed heat power of 100 – 500 kW are used in Armenia during the heating season, mainly in government-financed organizations, boiler houses of multi-apartment buildings, other public facilities, where about 50 million m^3 of natural gas is consumed during the heating season.
Implementation barriers	At present there are not any special technical regulations concerning the maintenance of the boilers' technical parameters. Testing and adjustment activities are carried out on a voluntary basis.
GHG emission reduction as a result of technology implementation (CO_2 Equivalents, Gg)	As a result of realization, the reduction of greenhouse gases emissions will be (equivalent to the saved gas) about 11,5 $GgCO_2$.
Possible impacts, compatibility and benefits for the country development goals	
Social benefits	The decrease of the consumed gas volume will contribute to the heating tariffs decrease.
Economic benefits	Gas-consuming organizations will pay for gas less.
Environmental benefits	Therefore, NO_X emissions will also be reduced
Other assumptions and benefits (market potential)	If this technology is applied as a mandatory preventive measure, it will enable to save at least 7-7.5 million m^3 of natural gas annually.
Expenditures	
Capital cost	10,000 USD
Operation and maintenance cost	20 000 USD /annually
Value of reduction of greenhouse gases emissions	0.09 USD/ $GgCO_{2eq}$
Life time	10 years
Other expenditures	N/A

Technology Factsheet 4 Energy

Technology name	**Correspondence of natural gas tariff structure to the methodology approved by decision of Public Services Regulatory Commission (PSRC).**
Sphere	**Energy**
GHG emissions (CO_2 Equivalents, Gg)	**6,913 $GgCO_{2eq}$ (2012)**
Introduction	On 8 August 1997, the PSRC decision #7 determined the natural gas tariffs with the following distribution: gas consumers up to 10,000 m^3 per month and 10,000 m^3 and more. Despite the fact that on 21 December 2004 the same Commission by decision #168A determined a methodology for calculation of natural gas tariffs based on the best international practice, it has not been applied yet, presumably because of some objective reasons. Gas tariffs were last reviewed in July 2013 and were determined, accordingly: 156 AMD / m^3 and 115.5 AMD / m^3 (calculations were made at the exchange rate 1 USD = 416.56 AMD). It is not difficult to guess that those who consumed 7,400 m^3 and those who consumed 10,000 m^3 will pay the same amount of money.
Implementation opportunities	Studies (Armenia Renewable Resources and Energy Efficiency Fund "Management of school boiler houses" Practical Guideline) show that in the heating season a number of boiler houses with low and average power (installed thermal power 200-450 kW) face a dilemma when it is possible to pay the same amount of money increasing the consumption by 2,000-2,500 m^3. It is obvious that the current tariffs structure does not contribute to the realization of energy saving measures by the Natural Gas consuming facilities. To persuade Armenian State Policy Authorities to reject the current tariffs structure and to base on the methodology adopted in 2004 (Decision #168A) by PSRC, determining consumer groups as is proposed by the methodology. According to data as of 2014, there are about 3,500 boiler houses in Armenia; the installed power of 60% of them is within the range of 200-450 kW. During the heating season, these consumers unintentionally squander/waste the gas.
Implementation barriers	Imperfection of the tariffs structure
GHG emission reduction as a result of technology implementation (CO_2 Equivalents, Gg)	During the heating season about 1.8 million m^3 of natural gas will be saved per year, therefore the annual emissions will be reduced up to 3.5 $GgCO_{2eq}$
Possible impacts, compatibility and benefits for the country development goals	
Social benefits	The tariffs will be more fair and justified.
Economic benefits	Gas consumers with monthly consumption of natural gas around 10,000 m^3 will pay for appropriate real natural gas amount.
Environmental benefits	Therefore, fugitive emissions from transmission, storage and distribution of natural gas will also be reduced
Other assumptions and benefits (market potential)	If this technology is applied as a mandatory preventive measure, it will enable to save at least 7-7.5 million m^3 of natural gas annually.
Expenditures	
Capital cost	5,000 USD
Operation and maintenance cost	N/A

Value of reduction of greenhouse gases emissions	0.29 USD/ $GgCO_{2eq}$
Life time	5 years
Other expenditures	N/A

Technology Factsheet 5 Energy

Technology name	**Mandatory realization of the Industrial Energy Audit as a mitigation component.**
Sphere	**Energy**
GHG emissions (CO_2 Equivalents, Gg)	**6,913 Gg CO_{2eq} (2012)**
Introduction	All administrative levers that enabled the state and the society to monitor the energy efficiency of industrial enterprises were liquidated after the collapse of the Soviet Union. Meanwhile, in the civilized world all large power-consuming enterprises not only publish information concerning the energy consumed per production unit, but also regularly undergo Industrial Energy Audit and take measures to increase energy efficiency. As part of this policy implementation (e.g. mandatory Energy Audit implementation) the enterprises are classified by their energy intensity, thermal energy and power consumption [e.g. in the Russian Federation – having annual expenses for energy of 10.0 million of Russian Rubbles or in Kazakhstan having annual consumption of energy equal or more 1,500 tons of equivalent fuel (reference fuel, standard fuel) are undergoing mandatory Energy Audits]. The enterprises classified as highly energy consuming undergo an Industrial Energy Audit carried out by certified companies. As a result, an economically sound project on measures for appropriation of energy efficiency potential is drawn and realized within a reasonable time. In 2009-2010 a mandatory expertise was adopted by law also in many former Soviet Union countries, such as the Russian Federation, Kazakhstan, Uzbekistan and others, depending on power consumption and property type. Kazakhstan has the leading position in the application of this technology: the GDP power consumption has reduced to 13% in the last two years thanks to the measures proposed as a result of the Energy Audits. In 2020, this index is foreseen to reach 25%. The energy efficiency potential in various large (energy consuming) industrial enterprises is estimated as 20-40%.
Implementation opportunities	The results of the "Resource efficiency and cleaner production program" (RECP) realized by the United Nations Industrial Development Organization (UNIDO) show that the consumption of energy resources by relatively big, medium and small power-consuming enterprises has never been seriously analysed. The experts revealed a significant increase of energy efficiency potential that can be appropriated either by organizational implementation (not requiring expenses) or by reasonable investment programs (ensuring 20 - 25% IRR).

	According to a conservative estimate, this potential will be about 20% of the total power consumption.
Implementation barriers	It is necessary to review the Law of the RA on Energy Saving and Renewable Energy. Particularly, it is essential to define a provision about mandatory Energy Audit, a classification of enterprises by energy consumption, a list of energy indices that are subject to compulsory publication.
GHG emission reduction as a result of technology implementation (CO_2 Equivalents, Gg)	According to official information, the industrial sector consumes 1.24 billion kWh of electric power. Only 25% of them can be classified as large (annual consumption 1.5 million kWh and more). Therefore, the reduction of greenhouse gases emission is estimated 76.6 Gg $CO_{2eq.}$ for 20 year life time period. So approximately 3.83 Gg $CO_{2eq.}$ annual reduction due to measures without essential expenses and investments.
Possible impacts, compatibility and benefits for the country development goals	
Social benefits	Formation of energy efficiency and energy saving culture.
Economic benefits	Decrease of expenses, increase of the production competitiveness.
Environmental benefits	Reduction of primary fuel expenses, consequently reduction of emissions.
Other assumptions and benefits (market potential)	Energy audit in Armenia can be implemented by certified entities. Certification, including that of physical persons, according to the procedure, can be performed by state accredited body (ies). Armenia has specialists in energy who received training/course participation certificates on energy audit of industrial facilities, residential and public buildings, and development of energy efficiency bankable projects
Expenditures	
Capital cost	Capital investments or increase of expenses on operation and maintenance should be economically justified. Apparently, 5,000 USD are assumed for calculations.
Operation and maintenance cost	N/A
Value of reduction of greenhouse gases emissions	0.26 USD/ GgCO2eq
Life time	Audits are implemented every 5 years
Other expenditures	N/A

Technology Factsheet 6 Energy

Technology name	**Reactive capacity (power) compensation in the RA electric energy system**
Sphere	**Energy**
GHG emissions (CO_2 Equivalents, Gg)	**6,913 $GgCO_{2eq}$ (2012)**
Introduction	While active power is the energy supplied to run a motor, heat a home, or illuminate an electric light bulb, reactive power provides the important function of regulating voltage. If voltage on the system is not high enough, active power cannot be supplied. Reactive power is used to provide the voltage levels necessary for active power to do useful work. Reactive power is essential to move active power through

	the transmission and distribution system to the customer. Reactive Power is a By-product of Alternating Current (AC) System. Reactive power is chiefly produced from the windings of the electrical generators in the power grid. Reactive power is also be produced as a side effect of unbalanced loads. The problem of compensating reactive power (inductive and capacitive) has arisen since the creation of energy systems. The consumers' inductive load causes the demand of inductive reactive power, and overall it is generated in the system generators, moves and distributes in respective networks and causes extra losses. The less the coefficient of the consumers of reactive power is, the much the demand of reactive power and respectively, the more the losses are. Inductive reactive power is compensated by substituting respective capacitor of voltage right at the energy consumer's or nearby. Modern compensators are capacitor batteries, which are automatically able to be smoothly modified depending on the current strength and to compensate it. It is well known that capacitive reactive power is generated in high-voltage lines of transmission network of energy system and can exceed inductive power in some modes. In this case, the launch of extra competences of energy consumers can cause problems in the energy system resulting in unacceptable voltage increase. It is worth mentioning that in cases of small values of power coefficient (cos φ) the losses of active energy in power transmission lines results in reactive power which can be both inductive and capacitive. The solution to this problem can be performed by complex measures: by reactors regulating compensation of capacitive reactive power, while the problem of energy consumers of inductive reactive power can be solved by placing auto regulating capacitor batteries.
Implementation opportunities	After the collapse of the USSR, the issue of compensating reactive power for energy consumers in the Armenian energy system is not regulated, meanwhile it has a significant potential for increasing energy efficiency (reducing active power losses). Reactive power is not registered in energy consumers and consequently there is no accurate information about power coefficient values. However, based on the measurements by "Energy Research Institute" CJSC and experience gained in USSR, the coefficient (excluding population) is within the range between 0.7-0.75. If cos φ = 0.9 is considered as a target value for energy system (including energy consumers), the potential of losses reduction can be approximately estimated. It is calculated about 80 million kWh.
Implementation barriers	The issue of reactive power compensation is partly out of the regulatory sphere. Available reactive currents in energy system are accounted during losses estimation, but no measures (technical, institutional) are taken to reduce the negative influence.
GHG emission reduction as a result of technology implementation (CO_2 Equivalents, Gg)	Taking into account the fact that about 30% of electricity is produced in thermal power plants, the potential to reduce greenhouse gases emissions will be 16.9 $GgCO_{2eq}$
Possible impacts, compatibility and benefits for the country development goals	
Social benefits	Considering the tariffs calculation on equitable basis, each consumer should reimburse his expenses. This principle is distracted as some

	consumers cause/create reactive energy losses and all consumers pay for it.
Economic benefits	Using compensating reactive power technologies in the chain from manufacturers to consumers will bring to: o reduction of active energy losses o increased efficiency of producing generators and transmission lines usage o increased conductivity of transmission lines and transformers o reduction of voltage falls
Environmental benefits	Reduction of greenhouse gases emission by 16.9 $GgCO_{2eq}$
Other assumptions and benefits (market potential)	If cos φ = 0.9 is considered as a target value for energy system (including energy consumers), the potential of losses reduction can be approximately estimated. It is calculated about 80 million kWh.
Expenditures	
Capital cost	About 200 million AMD equivalent to 425,500 thousand USD
Operation and maintenance cost	Practically not required
Value of reduction of greenhouse gases emissions	2.52 USD/ GgCO2eq
Life time	20 years
Other expenditures	N/A

Technology Factsheet 7 Energy

Technology name	**Technology on pilot programme on establishment of housing registry aimed at energy efficiency of buildings in RA**
Sphere	**Energy (housing subsector)**
GHG emissions (CO_2 Equivalents, Gg)	**6,913 $GgCO_{2eq}$ (2012)**
Introduction	There are more than 18,000 apartment buildings (27.0 million square m a total area of 435 thousand apartments) in Armenia. The residents own 97% of the apartments. Due to efficient use of energy resources, environmental protection and the need to reduce greenhouse gas emissions: energy saving and energy efficiency of the apartment buildings considered a priority policy for the government. Energy saving problems are more significant in the context of continuously increasing energy prices and are an essential element of energy security of the country. More than 35% of electrical energy generated and up to 25 % of Natural Gas imported to the Republic are consumed in the housing sector and more than 40% GHG emissions as well. The measurements to reduce greenhouse gas emissions in the buildings are significantly linked to availability of multi-structured and accurate data on technical specifications of buildings through the creation of housing register (hereinafter Register). The necessity of Registry establishment is defined in the Government Decree on 29 September 2011, resolution multi-protocol N38 on housing management, maintenance and operation of the five-year strategic improvement plan.

Implementation opportunities	The registry is aimed at using new technologies to create an integrated information system that will serve as an effective tool for identifying and selecting the priority buildings that have adequate organizational and technological capacity and the potential for reducing greenhouse gas emissions and energy efficiency measures. Taking into consideration that implementation of energy efficiency measures in the housing sector has great social importance and great potential for reducing emissions, and given that this sector requires a large-scale and long-term investments, which have realistic pay-back period due to high energy saving potential, thus to implement the program is getting possible by using revolving financial resources (e.g. under the financial mechanism of INDC). The possibility project implementation is motivated by the following: 1. Protocol N 41 from the RA Government meeting in 10 September, 2015; Extract 11. "Under the "UN - Climate change " Framework Convention as defined in the for the planned actions at national level under the Republic of Armenia / investment approval" Annex 4, point g) Climate change mitigation actions in the areas included in the urban sector (Buildings and constructions). 2. "Improving Energy Efficiency in Buildings" UNDP-GEF project experience 3. The fact of "Energy efficiency in public buildings and housing stock" (UNFCCC / NAMA registration in the International Registry. 4. The programing application to Green Climate Fond, which includes a component for increasing energy efficiency in the housing sector. The project is proposed to develop and implement a model demonstration (pilot) version of the computerized registry project for the 3 cities situated in different climate zones. The model will be based on four levels: first- apartment building or apartment building control authority, 2nd- local self-government bodies, 3rd- Regional governing body, 4th- the system under the Authorized sector (Ministry of Urban Development). It is assumed that in the Registry indicators' framework will be included indicators and data characterizing economic, technical and energy parameters of the buildings. The program must provide an opportunity to choose the "best and available technology". The information in the Registry should be transparent, accessible and affordable for the population.
Implementation barriers	The lack of selection methodology of the indicators including Registry Optimization Software which are important in terms of performance, particularly aimed at reducing greenhouse gases.
GHG emission reduction as a result of technology implementation (CO_2 Equivalents, Gg)	25.5 $GgCO_{2eq}$
Possible impacts, compatibility and benefits for the country development goals	
Social benefits	Iimplemented events to revealing the primary problems and their solution will contribute to reducing of payments for the consumed energy by the residents of apartment buildings and creation of comfortable living conditions (in the context of continued rise in energy prices).

Economic benefits	Taking into account possible volume of implementation, power consumption will substantially be reduced. Temperatures smoothing in the residential and non-residential areas of the buildings will have very positive impact on the constructions and infrastructures service life cycle.
Environmental benefits	The GHG emissions will be reduced, accordingly.
Other assumptions and benefits (market potential)	More than hundreds of energy audits were implemented in Armenia in the last five years, mainly of residential and public buildings, heating systems, street lighting and industrial sectors. Energy audits are mainly carried out in the frames of the following energy efficiency related projects financed/implemented by international organizations. Currently National Standard AST "Methodology for performing energy audit in residential and public buildings" is developed in the frames of "Improving Energy Efficiency in Buildings" UNDP-GEF/00059937 project based on EU standard EN 16247-2.
Expenditures	
Capital cost	Thanks to the creation of the registry, it will be possible to implement energy efficiency programs in all of 4,300 typical apartment buildings. Taking into account the above mentioned programs' experience the cost will be about $ 200 billion AMD or 417 million USD.
Operation and maintenance cost	100000 AMD or 210 USD annual for each building
Value of reduction of greenhouse gases emissions	81.76 USD/ $GgCO_{2eq}$
Life time	20 years
Other expenditures	

Technology Factsheets for selected technologies in Industry Sector

Technology Factsheet 1 Industry

Technology name	**Production of synthetic rubbers from butadiene instead using natural gas**
Sphere	**Industry**
GHG emissions (CO_2 Equivalents, Gg)	**620.1 $GgCO_{2eq}$ (2012)**
Introduction	Process for production of synthetic rubber named "Nairit" instead natural gas but from butadiene can be described as follows: The salt (N_aCL) obtained at the salt mine near Abovyan (city in Armenia, near to Yerevan) after mixed with water will be used for electrolysis. Obtained chlorine gas will be liquefied and then evaporated for the purpose of obtaining pure chlorine. The caustic soda and chlorine mixed in water will be forwarded to the special reactor where under the temperature 270 ^{0}C both components will react together with the butadiene vapour. The resulting mixture of vapour called dichlorbutenes (DCB) will be separated in order to extract the dichlorbutenec to be delivered into the isomerization reactor, where after using of catalyst and under the temperature, 115^{0}C cupric naphtenate 1.4-DCB-2 will be transformed into 3.4-DCB-1. The reaction mixture will be also separated by rectification and product named as 1.4-DCB-2 will be returned into the process while other product named as 3.4- DCB-1 will be for dehydrochlorination under the temperature 90 ^{0}C. This process of de-hydrochlorination will be conducted in the reactor together of caustic soda and water. The obtained product (mixture from reaction) will be sent to rectification and the 3.4-DCB-1 that did not participate in reaction will be returned into the process, water and sodium chloride will be separated, the obtained chloroprene will be cleaned, rectified and sent forward for polymerization. Polymerization of chloroprene takes place in closed system consisting of emulsifiers, polymerization initiator, regulators, stabilizers, etc. Result of polymerization is water-dispersed solution of polychloroprene, called as "latex" and which contains ≈40% of polymer to be extracted from latex by coagulation and freezing. End product is in form of granules and named as "Nairit".
Implementation opportunities	Company is producing currently synthetic rubber from natural gas. Natural gas containing 95% (by volume) of methane (CH_4), is delivered into the reactors of thermal oxidation pyrolysis. To these reactors also oxygen is delivered. Oxygen in its turn is obtained by deep cooling of air. In reactors, under the temperature 1,500 ^{0}C obtained pyro-gases are decomposed into acetylene and synthesis gas containing 60% (by volume) of hydrogen and 30% carbon monoxide. The synthesis gas is delivered for burning to the Yerevan TPP while acetylene is used for further production of synthetic rubber. Due to the temporary gas supply from Russian supplier and continues changes in setting natural gas prices from the supplier, production of synthetic rubbers using natural gas was despite to the available capacity

of the plant reduced during last year's up to 5,000 -10,000 tons/year. Long time ago established technology and equipment to use butadiene is not in operation already more than 10 years.

After renovation of existing facilities including construction of new buildings for production of synthetic rubbers including other chemicals and replacing natural gas to butadiene, consumption of natural gas is expected to be reduced more than 7.97 thousand m^3/h; consumption of electricity will be reduced up to 68 % and consumption of heat energy up to 72 %. Additionally to the reduction of CO_2 and other gases emissions, renovated plant production cycle will be not dependent about only one supplier.

Butadiene is associated gas and product from oil refineries. Butadiene will be procured outside of Armenia. There are 5 companies providing butadiene in the area. Number of the potential suppliers will increase security and sustainability of the production instead using only one supplier in case of using natural gas from Russia. It is expected to procure product in the future from Romania.

Company is one of the 13 similar type of synthetic rubber manufactures in the world. Only few plants are using natural gas for production of synthetic rubbers. Most of the current competitors use butadiene and therefore can provide much larger range of the products than it could be offered by "Nairit plant" today. Introduction of the new technology will provide thereof new chemical products additionally to the synthetic rubber.

Implementation barriers Project implementation could be delayed due to the privatization process or due to the long lasting negotiations with Banks.

GHG emission reduction as a result of technology implementation (CO_2 Equivalents, Gg) 225.0 $GgCO_{2eq}$

Possible impacts, compatibility and benefits for the country development goals

Social benefits Huge positive impact on Chemical Industry and Republic Economy Development, Creation of new jobs.

Economic benefits Company is willing to re-establish production of chloroprene only from butadiene and produce up to 25,000 tons/year using raw material from Rumania. For that purpose, it is needed to renovate partially existing equipment and rebuilt buildings for production also chlorine and caustic soda. Additionally company plans to start production of monocarbonic acids, built plant for diclorobutadien and enlarge products of chloroprene rubbers.

Following outputs are expected to be achieved (tons per year):

Chloroprene rubbers and latexes	25,000
Acetic acid	38,000
Propionic acid	6,600
Formic acid	9,000
Liquid chlorine	25,000
Caustic soda	32,500
Hydrochloride acid	12,500
Sodium chloride	4,000
Dimetilvyniletinylcarbinol	50

Environmental benefits Presently the plant uses a technology for the production of synthetic rubber from natural gas. This technology is characterized by high-

Other assumptions and benefits (market potential)	energy consumption, environmental harmfulness and low productivity. The new technology for the production of synthetic rubber from butadiene and elimination of energy losses on the steam pipelines will reduce CO_2 and other gases emissions. Chemistry is of strategic importance to the country, that is why the importance to revive chemistry. This resuscitation attempted first to "Nairit". The market research shows that there is need for its production: rubbers from butadiene in the world market and the output will be sold out. In Armenia, there are good prospects for small-scale chemistry as well, for development of which a good scientific and research basis, specialists and an opportunity to train new personnel are available. However, the scientific and technical basis is already outdate and the upgrade requires large funds.
Expenditures	
Capital cost	57,000,000 USD
Operation and maintenance cost	2,000,000 USD /annually
Value of reduction of greenhouse gases emissions	12,700 USD/ $GgCO_{2eq}$
Life time	20 years
Other expenditures	

Technology Factsheet 2 Industry

Technology name	**New technology of processing copper sulphide concentrate**
Sphere	**Industry**
GHG emissions (CO_2 Equivalents, Gg)	**620.1 $GgCO_{2eq}$ (2012)**
Introduction	The technology has been developed in the Kapan laboratory of metallurgy and dressing of A.B. Nalbandyan Institute of Chemical Physics NAS RA. It has been developed in local mines using a special environment friendly copper sulphide concentrate mode (Know- How). This completely new technology guarantees a high level extraction of copper, iron, sulphur and precious metals, besides it is economically sound and corresponds to the modern ecological standards. To observe conditions of the electrochemical process has been used copper concentrate from Kajaran. Kajaran copper concentrate, expressed as a percent is the following: copper – 27,0 %, iron – 26,0 %, sulphur – 33,0 %, lead – 0,4 %, silicon dioxide – 7,0 %, molybdenum -0,09 %, arsenic – 0,025 %, aluminium oxide – 2,0 %, zinc – 0,35 %, calcium oxide – 1,1 %, carbon – 0,6 %, magnesium oxide – 0,46 %, gold – 4 grams / ton, silver – 65,5 grams / ton. The essence of the technology is that copper concentrate immediately undergoes electrochemical solution without being dried. In the outcome, copper gathers around the cathode as a copper powder, then, it gradually sits at the bottom of the electrolytic tank, while the metal passes to the solution (after it may be extracted through crystallization). A part of the sulphur is separated as elemental sulphur (as a result of chalcopyrite dissociation) and remains in the insoluble mass, while the other part passes to the solution as sulfuric acid. Gold and silver also

	remain in the insoluble mass. Elemental sulphur may be extracted through flotation. After the electrolysis, the solid sediments are filtered, washed, dried and undergo a chemical analysis. The chemical composition of the solution has been also discovered. The outcomes of solid sediments and calculations of dissolved element conversions have already been done. It has been chosen to replace hydro-electrochemical equipment with new machines to develop a new technology based copper sulphide concentrate in Kajaran copper-molybdenum mine. Construction of an experimental machine is planned for the first stage, which will enable processing of 100-150 kg concentrate. Conducting experiments on that machine will help to find out optimal modes to create technological regulations. Based on those, a huge factory processing 10 tons daily will be built.
Implementation opportunities	Lack of information and assurance among the interested parties as well as financial resources.
Implementation barriers	Organizations dealing with copper concentrate processing, pursuing their own interests, do not want to change old and environment contaminating technologies. Obtained black copper is sold as a product, which contains a large amount of precious metals. Proposed technology enables extracting those metals, thus increasing the product value.
GHG emission reduction as a result of technology implementation (CO_2 Equivalents, Gg)	This electro-hydrometallurgical technology is implemented without gas combustion and does not lead to the emission of harmful gases including greenhouse gases or noxious fluids. Most importantly, in contrast to the pyro metallurgy methods of sulphide minerals used in Armenia nowadays, it completely prevents the emission of a very dangerous SO_2 gas (acid rains, air pollution, and emissions). 3.48 $GgCO_{2eq}$ (emission reduction up to five times)
Possible impacts, compatibility and benefits for the country development goals	
Social benefits	New jobs will be provided.
Economic benefits	Natural gas savings. Besides, in contrast to the existing technology, this one will increase the extraction of precious metals.
Environmental benefits	The environment around the factory will be clean, as the emissions of SO_2 and other wastes are excluded as well.
Other assumptions and benefits (market potential)	The technology completely excludes natural gas combustion for production and may be applied in any country.
Expenditures	
Capital cost	To process 100-150 kg cooper concentrate daily, 150,000 USD is required to construct an experimental plant.
Operation and maintenance cost	3,000 USD monthly
Value of reduction of greenhouse gases emissions	2,155 USD/ $GgCO_{2eq}$
Life time	20 years
Other expenditures	500 USD monthly

Technology Factsheet 3 Industry

Technology name	**New technology of processing molybdenum sulphide concentrate**
Sphere	**Industry**
GHG emissions (CO_2 Equivalents, Gg)	**620.1 $GgCO_{2eq}$ (2012)**
Introduction	The technology has been developed in the Kapan laboratory of metallurgy and dressing of A.B. Nalbandyan Institute of Chemical Physics NAS RA. Brief introduction of the technology: the current technology is based on the unique process of roasting, guarantees processing of molybdenum, rhenium, sulphur, selenium, tellurium as well as high level of protection of the surrounding environment. A new complex measure of molybdenum concentrate processing is a no-waste technology. It is able to replace the molybdenum processing technologies in Armenia as well as abroad due to its high technical and economic indices and correspondence to the ecological standards. It produces molybdenum trioxide, ferromolybdenum, molybdenum metal, elemental sulphur, sodium sulphate, rhenium metal, selenium and tellurium. The above-mentioned technology has a huge commercial potential. The invention protected by copyrights and the Eurasian Patent. It was awarded a silver medal in the 31st Geneva 2003 international exhibition of inventions. A new advanced version has been developed together with Dr Shon, University of Utah, USA, which received the RA inventor patent. The technology has been developed and tested in a laboratory.
Implementation opportunities	Construction of an experimental machine is planned for the first stage, which will enable processing of 100-150 kg concentrate. Conducting experiments on that machine will help to find out optimal modes to create technological regulations. Based on those, a huge factory processing 10 tons daily will be built.
Implementation barriers	Lack of information and assurance among the interested parties as well as financial resources. Organizations dealing with molybdenum pursuing their own interests, do not want to change old and environment contaminating technologies.
GHG emission reduction as a result of technology implementation (CO_2 Equivalents, Gg)	First of all, this technology is using closed cycle and does not lead to the emissions of harmful gases including greenhouse gases or noxious fluids It is vital that in comparison with the pyro metallurgy methods of sulphide minerals used in Armenia nowadays, it completely prevents the emission of a very dangerous SO_2 gas (acid rains, air pollution, and emissions). 4.67 $GgCO_{2eq}$ (emission reduction up to five times)
Possible impacts, compatibility and benefits for the country development goals	
Social benefits	New workplaces will be provided
Economic benefits	Natural gas savings. Besides, in contrast to the existing technology, this one will increase the extraction of precious metals.
Environmental benefits	Decreasing pollution intensity. The emissions of SO_2 and other waste, wastewater and emissions are excluded as well.
Other assumptions and benefits (market potential)	The technology may be applied worldwide.

Expenditures	
Capital cost	To process 100-150 kg molybdenum concentrate daily, 150,000 USD is required to construct an experimental machine.
Operation and maintenance cost	3,000 USD monthly
Value of reduction of greenhouse gases emissions	1,606 USD/ $GgCO_{2eq}$
Life time	20 years
Other expenditures	500 USD monthly

Technology Factsheet 4 Industry

Technology name	**Production and usage of photo luminescent materials with long-term lightening**
Sphere	**Industry**
GHG emissions ($CO_{2\ Equivalents}$, Gg)	**620.1 $GgCO_{2eq}$ (2012)**
Introduction	Limitations on the usage of photo luminescent materials are mainly conditioned by a short-term lightening and harmful materials they contain. The specialists at the National Institute for Materials Science have many years of experience with the technology for production of glass ceramic and composite materials. They also have the necessary equipment for their industrial production. The realization of photo luminescent materials production and usage technology is foreseen to be implemented in the regional partnership with scientific and industrial enterprises in Georgia. The new extended content of the suggested photo luminescent materials (based on alkaline earth aluminates and silicates) and their production technology is not poisonous or explosive. They are fire resistant, do not melt or decompose at the temperature up to 1,500 ^{0}C, and do not contain radioactive elements, hard metals and other harmful components. They are environment-friendly and safe for the environment. The duration of the lightening of photo luminescent materials produced through the mentioned technology (8-12 hours up to the visibility threshold corresponding to the 0.32 mcd DIN 67510 standard) as well as their relatively low cost may contribute to its wide usage in various fields of economics. Dashboards from photo luminescent materials may be used in the fields of urban development (high-rise buildings, shops, hotels, to mark the emergency exits of other buildings of social importance), road construction (road signs and marking) and other design elements.
Implementation opportunities	Currently the market suggests LED (light emitting diodes) solutions for this problem. They are energy efficient and possess power of 0.25 W. However, taking into account the large demand and necessity to install energy transmission lines, the capital expenses significantly increase. Dashboards and marks made from photo luminescent materials do not use electric energy at all.
Implementation barriers	At this stage, it will be required to purchase and/or make some non-standard equipment, to acquire a quantity of commodity product samples, to carry out certification on compliance to the relevant standards, and to negotiate with the interested organizations and potential customers.

GHG emission reduction as a result of technology implementation (CO_2 Equivalents, Gg)	3.2 $GgCO_{2eq}$
Possible impacts, compatibility and benefits for the country development goals	
Social benefits	Marking the roads, boards, underground crossings and building entrance stairs with photo luminescent materials will increase the safety level for pedestrians and drivers.
Economic benefits	Taking into account the potential scale of the application, particularly for urban economy, it will significantly reduce energy consumption and capital costs.
Environmental benefits	Therefore, reduces greenhouse gases emissions.
Other assumptions and benefits (market potential)	Market potential is the highways, roads, underground crossings, building entrance stairs etc.
Expenditures	
Capital cost	200,000 USD
Operation and maintenance cost	1,000 USD/ annual
Value of reduction of greenhouse gases emissions	3,125 USD/ $GgCO_{2eq}$
Life time	10-20 years
Other expenditures	Depending on circumstances

Technology Factsheet 5 Industry

Technology name	**Cement production process optimization and energy-saving technologies in "Mika- Cement" CJSC**
Sphere	**Industry**
GHG emissions (CO_2 Equivalents, Gg)	**620.1 $GgCO_{2eq}$ (2012)**
Introduction	"Mika-Cement" CJSC is located in Hrazdan city and is a major regional producer of cement, 0.8 million tons per year of installed capacity. The manufactory occupies a monopolistic position in the region in the production of "Sulphate rack and Road" special cement types. The main components of raw materials for the production of cement plant has its own base and all necessary infrastructure. Raw materials completely are located in the territory of Armenia. The new technology is expected to • Drossy technology investment, replacing the clay component volcanic cinder. • Reconstruction of the heat exchangers in the kiln, • apply the rational fuel combustion system; a) installation the burners produced by UNTERN CEMCON and equipped by transfer and settlement MAC type systems b) Gas industry equipment installation with automatic management systems GKK and SMC c) Installation of automatic gas analyzers. 4. Reconstruction of raw materials mills (3,2x15 m), by the complete replacement of interior fixtures, QDK22N separators installation.

Implementation opportunities	As a result of the technology implementation is expected; - Reduce oven temperature up to 32% material provided, which would lead to a reduction in gas flow rate of 20.4 m3 1 t of clinker, - 12% increase in furnace efficiency, which will reduce the energy consumption of 4.2 kWh per 1 t of clinker, - to provide a complete combustion of fuel, clinker roasting process optimization, reducing fuel consumption, - To increase up to 30% of hydraulic supplements contribution due to high activity of clinker. This will lead to clinker cost reduction and as a result, to the reduction in use of natural resources and emissions which gathered through the lime de carbonation and combustion of natural gas during the clinker roasting process. - To increase the cement mill capacity from 48.5 to 80 t / h and as a result reduce electricity consumption by 16 kW * h / t respectively.
Implementation barriers	
GHG emission reduction as a result of technology implementation ($CO_{2\ Equivalents}$, Gg)	80.5 Gg $CO_{2eq.}$
Possible impacts, compatibility and benefits for the country development goals	
Social benefits	The growth of the company's profit would increase the average wage of staff by 20%.
Economic benefits	- Gas consumption cost will be reduced by 1 t of clinker 34.2 m3 / tonnes, - Electricity-share cost of 1 ton of cement will be reduced by 8 kW * h / tonnes, - The content of clinker in cement (for the same qualitative indicators) will be reduced by 11.5 percent,
Environmental benefits	In addition to carbon dioxide the following emissions will be reduced as well: - cement and clinker inorganic dust emissions by 8.6%, - sulphur dioxide emissions by 10%, - carbon monoxide emissions by 18%, - Nitrogen oxide emissions by 17%.
Other assumptions and benefits (market potential)	The implementation of the technology will contribute to cement cost reduction and cement market expansion.
Expenditures	
Capital cost	3.523 million Euro
Operation and maintenance cost	
Value of reduction of greenhouse gases emissions	10,500 USD/ $GgCO_{2eq}$
Life time	20 year
Other expenditures	Depending on circumstances

Technology Factsheet 6 Industry

Technology name	**Thermal insulation materials production**
Sphere	**Industry**
GHG emissions (CO_2 Equivalents, Gg)	**620.1 $GgCO_{2eq}$ (2012)**

Introduction

Proper heat insulation has always been the most efficient method of ensuring energy saving and reducing energy costs in buildings.

Since ancient times, Armenian builders were using traditional "midis" block-work as a wall constructive solution: two layers (each 50 cm thick) of tuff with interlayer of minor tuff spalls (break-stone), natural and artificial (industrial burning waste) slag, pumice stone etc. The stone block-work was affixed with lime-concrete mixture. Although tuff is a porous rock of volcanic sedimentary origin with proven exquisite insulation performance, nevertheless, walls performed with 'midis' technique do not meet modern requirements of thermal protection.

Currently, relatively new generation of construction insulation materials are getting to be widely used in Armenia; these are of a considerable capacity of improving buildings' energy efficiency significantly.

In Armenian market, perlite, mineral and basalt micro-fibre, foam polystyrene, foam polyurethane, cellulose system and flax fibre made heat insulation materials are available as well as heat reflector materials envisaged for radiation heat transfer protection.

The group of heat insulation materials of rock wool includes those made of rock microfiber (basalt, diabase) and glass microfiber. Heat insulation materials of this group come in the form of mats, wool and smooth slabs. Their density depends on material type and falls in the range of 10 to 150 kg/m3. Glass wool and mineral wool production uses cohesive materials, except assortment of extra-fine basalt microfiber mats. Heat insulation materials produced of rock wool are known for high heat insulation performance and for high resistance to chemical substances' impact.

Implementation opportunities

Swelled perlite is used in production of insulation materials. Swelled perlite (density: 50 to 150 kg/m3) is produced of raw perlite (density: 1,100 kg/m3) through heat processing at 850 to 900°C with volume increase of 7 to 15 times. Technical properties of heat insulation materials produced of swelled perlite are presented in the Table below.

№	Product	Density, kg/m^3	Heat transfer coefficient, W/m·°C
1.	Swelled perlite sand	50-150	0.038-0.058
2.	Foam glass grains	150-200	0.058-0.076
3.	Perlite silicate slabs and segments	200-270	0.06-0.07
4.	Flexible perlite heat insulation mat	80-120	0.04-0.045
5.	Perlite cement slabs	400-500	0.06-0.14
6.	Perlite gypsum slabs	270-330	0.165
7.	Foam glass grain slabs	225-325	0.059-0.065

Implementation barriers

At this stage, it will be required to purchase and/or make some non-standard equipment, to acquire a quantity of commodity product samples, to carry out certification on compliance to the relevant standards, and to hold negotiations with the interested organizations and potential customers.

GHG emission reduction as a result of technology implementation (CO_2 Equivalents, Gg)	106.4 $GgCO_{2eq}$
Possible impacts, compatibility and benefits for the country development goals	
Social benefits	Poverty reduction, Reduction of unemployment, Creation of work places, Increase of income.
Economic benefits	Development of Thermal insulation materials production based on Local raw materials: perlite and basalt.
Environmental benefits	GHG reduction from the one of key sectors i.e. public, commercial and residential buildings.
Other assumptions and benefits (market potential)	Raw perlite is produced by "Levadan" LLC և "Aragats-Perlite" OJSC. Swelled perlite and heat insulation material of that are produced by "Kanazit GAF" LLC, "Ecoperlite" LLC, "Thermo-mineral" Co Ltd., "Vani" LLC, "Sci-Ind TNASHEN" LLC, "Stone and Silicates" CJSC. Extra-fine and fine basalt microfiber mats are produced by "Arjermek" LLC. Rock wool is imported by "Unipool" LLC, "Knauf Armenia" LLC, "Geesa" LLC, "Legion Parisp" LLC, "Aquatus" LLC և "Sarme Group" LLC, "Fil" LLC. Heat insulation materials of glass microfiber are imported by "Arantsk" LLC, "Arevik" LLC, "Norik Hakobjanyan" PE, "Comfort R & V" LLC, "Kasco" LLC, "Semur & Co" LLC. Flax fiber made insulating materials is producing "Payte Tun" LLC
Expenditures	
Capital cost	17,500,000 USD
Operation and maintenance cost	60,000 USD/ annual
Value of reduction of greenhouse gases emissions	8.200 USD/ $GgCO_{2eq}$
Life time	20 years
Other expenditures	Depending on circumstances

Technology Factsheet 7 Industry

Technology name	**New type of Entirely Plastic solar water heater**
Sphere	**Industry**
GHG emissions (CO_2 Equivalents, Gg)	**620.1 $GgCO_{2eq}$ (2012)**
Introduction	AREVIK company creates and offers the mentioned technology of solar water heaters. This company has many years of experience in fabrication, testing and installation of solar systems. In contrast to available metallic solar water heaters, which are enough expensive (about 500 USD for 1.5 square meter), the price of proposed plastic collectors of same surface area is about 100 USD and the weight is about 5 kg. All components of theses collectors, pipes, the transparent glazing, etc. are made from plastic materials. These water heater are able to produce hourly 60 litters of hot water at 70 ^{0}C. Their efficiency is not suffer significantly the same of standard collectors but they have other advantages. Besides, due to their low weight the assembly and mounting of large systems is very easy. The prototype of such collector is fabricated and can be demonstrated and tested.

Implementation opportunities	Conditions for solar power widely usage is very favourable in Armenia, as well as in the entire region. In particular, various regions of Armenia sun radiation is 1400-1740 kW/m ^{2}. Market studies indicate that the use of solar panels is mainly due to the relative high cost of traditional solar water heaters, or purchasing capacity low level. The proposed technology is available about 3.5 times in and much easier in terms of installation. The market research and available advantages create the confidence to found production of the mentioned product. It is possible to organize large-scale production (1,000 units daily) of such collectors.
Implementation barriers	The project (factory construction) seems to be profitable (IRR up to 16-18%) circumstanced that 100 thousand and more panels should be produced and sold with appropriate prices during a year. However, it is considered realistic that in the initial period, demand should be rather small, something near to 25 thousand units per year. Therefore, it is necessary to attract low-interest loans or grants, as well as undertake continuous measures to raise the awareness of potential clients.
GHG emission reduction as a result of technology implementation (CO_2 Equivalents, Gg)	0.78-3.9 Gg CO2eq. (25,000-100,000 panel units conditions for sale)
Possible impacts, compatibility and benefits for the country development goals	
Social benefits	Proposed plastic solar water heaters will allow the low-income people to buy and use these systems and to obtain hot water in summer time for washing and for everyday use. This is especially important because the cost of gas and electricity hikes. Besides, it will create new jobs for population.
Economic benefits	The price of commercial solar water heaters in Armenian market is rather high and consequently the sales are small. The price of entirely plastic solar water collectors is much cheaper and will be incomparably available to a wider population. Besides, the market analysis shows that there is a great demand in such systems for food processing facilities, restaurants, hotels, schools, chemical enterprises as well.
Environmental benefits	As it is wellknown, solar water heaters are considered as environmentally clean because no fossil fuel is required for their operation.
Other assumptions and benefits (market potential)	Entirely plastic Solar water heaters may be exported and sold in the regional and other countries.
Expenditures	
Capital cost	For creation of plant for daily production of 1,000 units of plastic solar water, heaters it is required about 160,000 USD.
Operation and maintenance cost	130,000 USD monthly
Value of reduction of greenhouse gases emissions	2,050 USD/ GgCO2eq
Life time	About 20 years
Other expenditures	About 10,000 USD monthly

Technology Factsheets for selected technologies in Land Use and Forestry Sector

Technology Factsheet 1 Land Use and Forestry

Technology name	**Sustainable Forest management**
Sphere	**Land Use and Forestry**
GHG emissions (CO_2 Equivalents, Gg)	**-531.4 (2012)**
Introduction	As a result of economic and energetic crisis in the beginning of 1990s over exploitation of forest was registered, due to which a notable decrease in forestry surface was followed (according to expert estimations value of forest cutting in that period was around 800,000 to 1,000,000 m^3). According to the positive scenario developed within the UN Millennium Development programmer, forest volume in 2015 (as a result of forest recovery activities in the RA) should have been made 12% of the size of the Republic whereas as of 2014 it was made only 11.2% or around 350 thousand ha. **Risks expected from climate change;** • Changes in forests' borders and species composition, • Increase in probability of fires, • Upper movement of the lower zone of forests by 200-400 m in 2100, • Changes in forest regrowth and recovery potential, • An increase in diseases and pests, • Economic losses, declining biodiversity and soil erosion caused by degradation of forests. **Suggested technologies**; Forest sustainable management ensures the complex implementation of the technologies and activities described below. Forest inventory and continuous monitoring are considered as the first precondition of forest sustainable management. **Main components of the technology are;** 1. Forest maintenance, protection and management 2. Forest recovery and re-generation. 3. Rehabilitation of degraded forests and forest building, 4. Creating buffer zones of specially protected areas, 5. Optimal forest building, expansion of forest areas, 6. Implementation of forest preservation measures, including the fight against pests and fires. **Main activities of the sustainable management are;** o enlargement of main surface of forest under the management o assistance to forest natural regeneration and rebuilding o implementation of appropriate trees species' growing o new forests planting and care o provision of water supply and control over the landslides o forest protection from illegal cuttings o forest protection from grazing, farming activities, etc.
Implementation opportunities	For the implementation of the technology a favourable environment is available, particularly, a Government decree was adopted on the verification of establishment of proposed activities at national level under the "Climate

	change" convention. For applying this technology a relevant activities were undertaken by the UNDP country office as well, which launched a project on "Sustainable management of pastures and forest in Armenia to demonstrate climate change mitigation and adaptation benefits and dividends for local communities". GIZ implements another project on Biodiversity sustainable management. As a result of the technology application the forest surface will enlarge and restore. This will affect total amount of emissions, atmosphere in the air, the climate and various ecosystems interconnected with forest. Climate change mitigation will hamper the forest and grassland systems movements and prevent big changes inside of different ecosystems.
Implementation barriers	Barriers to the complete and effective implementation of the technology could be insufficient financial resources, population living standard and living conditions, illegal cuttings and big volumes of wood usage by the population, absence of one coordination centre to coordinate similar projects implemented by different donor organizations etc.
GHG emission reduction as a result of technology implementation (CO_2 Equivalents, Gg)	As a result of the technology implication firstly forest biomass growth will increase the volume of takeovers, while decrease in illegal cuttings and volumes of firewood will lead to the reduction in CO_2 emissions. -1,498 t CO_{2eq}./year, ha
Possible impacts, compatibility and benefits for the country development goals	
Social benefits	The full implementation of technology will contribute to the increase in relevant areas of jobs, but also have a negative impact on the social situation of many households. According to various research results, 31-34% of households in Armenia use wood fuel for heating and other purposes as the main source of energy. Reduction in the volume of illegally cut firewood will force households to use more expensive energy sources, which will become a significant burden on their budgets.
Economic benefits	Technology will ensure additional stocks/reserves of construction materials and firewood, which will have positive impact on other sectors of economy and from the other side, it will ensure less expensive energy source for households.
Environmental benefits	Positive impact on forest and other ecosystems and biodiversity, climate improvement, decrease of dust content in atmosphere, land protection and decertification risk reduction, reducing the risk of floods and landslides.
Other assumptions and benefits (market potential)	N/A
Expenditures	
Capital cost	1,800 USD/ha
Operation and maintenance cost	115 USD/ha
Value of reduction of greenhouse gases emissions	-1.2 USD /t CO_{2eq} (year, ha)
Life time	20 year
Other expenditures	N/A

Technology Factsheet 2 Land Use and Forestry

Technology name	**New technology of cultivation of Perennial Plants**
Sphere	**Land Use and Forestry**

GHG emissions (CO_2 Equivalents, Gg)	**-1.4 (2012)**
Introduction	Since the beginning of 90s agriculture, as a result of privatization processes in agriculture sector some transformations were registered which have negative impact on this sector future development. Particularly: • Agricultural lands desecrated (over 1.2 million plots), which resulted a decrease in the cultivation efficiency. • Most areas of perennial plants turned into grain crop areas. Only in recent years has seen a growth area of orchards. • notably reduced consumption volumes of inorganic and organic fertilizers. In comparison with the pre-economic reform period now consumption of inorganic fertilaizers was reduced almost 7-8 times, consumption of organic fertilizers and means of plant protection18 times. • use of advanced technology remained out of practice. • irrigation system became deteriorating, costs and volume of uncultivated land had increased, etc. From the other side, economic declaine, highe level of poverty and decrease of population incomes became the reasons which lead to the engagement of rural population in crop cultivation having higher potential consumer "liquidity" in the market. That is why perennial, technical and other liquid crop fields were gradually expanded. Agricultural lands in Armenia (according to 2013 official data) make up 2051.0 thousand hectares, of which arable land- 448.2 thousand hectares, perennial plantations- 33.3 thousand hectares, grass fields- 121.8 thousand hectares, pastures -1055.3 thousand hectares, other lands- 392.4 thousand hectares. Agricultural crops lower boundary is starting from 400 m above sea level, while the upper limit is reached at 2,300 meters above sea level. Around 40% of the republic territory is not usefull for agricultural purposes. Currently there is a 1.4 hectares (in average) of agricultural land per farm, including 1.1 hectares of arable land, which does not allow to carry out intensive use of technologies and conduct effective management, as well as use of agricultural technology with less time and resources costs. In addition, as a result of various factors, 29% or 130 thousand hectares of arable land are not used for target purposes, so implementation of land use effectiveness program is a strategic priority. **Risks expected from climate change;** • The expected shortage of irrigation water and increase in demand • Increased risk of drought, 10-30% decrease in soil moisture, water deficit increase 25-30%. • Predicted increase in frequency and intensity of extreme meteorological phenomena • The expected increase in number and prevalence of pests. **Suggested technologies:** **<u>Technology 2:</u> New technology of cultivation of perennial grass** Main activities are: o To expand field baskets of local and selective varieties of fruit and grape by expantion of collector orchards, by purchaising of samples of armenian origin from other countries genetic samples banks, and through the enrichment of orchards

	o Focus of grape selection works to frost-resistant, high-quality, transportable, universal directions and creation of new varieties, o Apply of new technology for fruit (especially apricot) orchards establishment by using smaller spaces between the tree lines, with thickness of 5 m x 5 m or plantations. For example, in Armenian case in 1 hectare of the old (public) orchards was planted 156 tree (this management system is still preserved), now the new method of cultivation of 1 hectare of trees implies planting of up to 1000 trees. The biomass, which is 8 x 8.8 x 6, or 7 x 4 meters of density of 100 trees is the same as in dense plantings of 1000 trees, but on which the biomass generated not in 20 years, but within 5 years. o Reinstatement of field protecting forest areas and planting of new ones.
Implementation opportunities	There is a favorable environment for the implementation of the technology, in particular the Government of RA has developed and adopted several strategies that refer to the balanced regional development, rural and agricultural development and so on, which provide sufficient ground for political goals set for the introduction of this technology. As an effective opportunity for introduction of this technology can be the development of multiple forms of agricultural cooperatives on a voluntary basis and multifunctional approaches due to which per household land plots will expand and thus growth of labor and capital production will be reached. Effective introduction of the technology will notably increase agricultural production volume. However, under formed agriculture market, low level of consuming, small domestic demand and lack of relevant infrastructure could fail the process effective implementation.
Implementation barriers	The next serious challenge is low access to financial resources, which is grounded by high credit rates and duration of agricultural loans. Other challenges could be as follows; • Insufficiency of risk mitigation measures and lack of an insurance system. • Resistance from farmers toward the innovations, new technologies, knowledge understanding and its introduction , • Underdeveloped infrastructure, like roads, weak irrigation systems, etc.
GHG emission reduction as a result of technology implementation (CO_2 Equivalents, Gg)	Vineyards and fruit cultivation as a result of the introduction of new technology in this category of land use will increase carbon absorption due to the rapid growth in biomass. In case of annual and perennial crops and uncultivated land technology, no significant change in emission/removals will be registered (due to change in biomass), however, will increase the stock of organic carbon in soil and improve soil quality. 374 t $CO_{2eq.}$/year, ha
Possible impacts, compatibility and benefits for the country development goals	
Social benefits	Full implementation of technologies will contribute to the employment and income growth in agriculture, which implies the reduction of rural poverty and migration. Community budget incomes will increase. Role of civil society in community administration and management process will increase as well. Sufficient resources will be available to solve community's social issues.
Economic benefits	o Growth of agricultural production, development of food processing production. o Competitive and environmentally friendly agricultural products and processed food will be exported to other countries. o Additional financial flows for community development.

Environmental benefits	o Positive impact on natural ecosystems and biodiversity, o Reduction of land erosion and desertion risks, floods and landslides o Positive impact on water resources circulation.
Other assumptions and benefits (market potential)	N/A
Expenditures	
Capital cost	765 USD/ha
Operation and maintenance cost	110 USD/ha
Value of reduction of greenhouse gases emissions	2.04 USD /t CO_{2eq}. (year, ha)
Life time	5 year
Other expenditures	N/A

Technology Factsheet 3 Land Use and Forestry

Technology name	**Degraded Grassland radical improvement**
Sphere	**Land Use and Forestry**
GHG emissions (CO_2 Equivalents, Gg)	**17.22 (2012) "Grassland" sector**
Introduction	Because of privatization process implementing in the beginning of 1990s agriculture management practice, format and content was totally changed, which directly affected different types of land and ecosystem situation. De-enlargement of cattle farms, livestock reduction, economic decline and poverty increases, inflation and emigration have negatively affected the development of the livestock sector, which led to a chain of under usage or over usage processes of natural pastures, and as a result they became degraded and classified as under the erosion and desertification risk. According to the balance of the land, the total area of agricultural land is 2049.4 thousand hectares, including 121.7 thousand hectares of grassland, and 1054.2 thousand hectares of pastureland. According to a number of researches, a wide range of natural pastures- around 60% is under the desertification and erosion risk. Important to mention, that degradation of natural pastures is mostly have two reasons; Remote pastures lost their qualitative specifications and thus became degraded due to absence of management and not usage, and the livestock overgrazing in areas close to the community are exposed due to erosion and desertification risk. Therefore, as the main reason for the degradation of natural pastures cannot considered the bad weather conditions, but it is mostly due to irregular and wasteful use of land, as well as almost total absence of relevant measures of improvement, maintenance and care. In addition to the economic and social consequences, such a situation leads to the destruction of natural pastures as carbon sinks and stores. Along with the anthropogenic influence, due to climate changes (increase in temperature and decrease in precipitation), vertically movement of natural ecosystems' borders have been forecasted. It was grounded that in foreseeable future alpine and sub-alpine ecosystems will be in particular vulnerable situation (up to 3000 meters above sea level), where many species of plants and animals can be completely pushed out. **Risks expected from climate change:**

- Increased risk of drought, 10-30% decrease in soil moisture, water deficit increase 25-30%.
- predicted increase in frequency and intensity of extreme meteorological phenomena
- the expected increase in number and prevalence of pests
- Reduction of grazing lands , decrease in their productivity by 4-10%, including 19-22% decrease in productivity in the sub-alpine zone,
- Hay lands productivity decrease by 7-10 percent.

Suggested technologies;

Sustainable management of natural pastures implies not only rehabilitation of natural ecosystems but also implication of such formats of management and implementation of measures which will significantly contribute to the restoration of quality properties and protection of those ecosystems and effective use of these systems for economic purposes.

As a primary precondition for sustainable management it is necessary to

1. Conduct an inventory of natural pastures and classification of pasturelands and grasslands by degradation type (erosion and desertification), degree and reasons/factors,
2. Selection of relevant improvement method for each particular area (deeper/in general),
3. Development and implementation of complex activities of sustainable management for each area.

Technology 1;

Grassland radical improvement

Main activities are:

- Radical improvement of degraded wetlands nearby to communities (destruction of natural vegetation and new grass seeding on the creation of new vegetation) and the effective management,
- Targeted combination and apply of ways in either freely and irregular, or "by turn" or "grazing area distribution" ways of animals grazing,
- Introduction of grazing periodicity method in pasture utilization practice.

Implementation opportunities

For the implementtion of the technology a favorable environment is available, particularly, a Governmnet decree was adopted on the verification of establishment of proposed activities at national level under the «Climate change» convention. For applying this technology a relevant activities were undertaken by the UNDP country office as well, which launched a project on "Sustainable management of pastures and forest in Armenia to demonstrate climate change mitigation and adaptation benefits and dividends for local communities". GIZ implements another project on Biodiversity sustainable management.

As a result of the technology application it will be possible not only to save and protect natural ecosystems, but also to contribute to the social and economic development of rural communities.

Implementation barriers

Limitations to the complete and effective implementation of the technology could be

- Insufficient financial resources,
- Population living standard and living conditions,
- Limited opportunities to livestock products consumption and low process,

	o Low operational efficiency and profitability of remote pastures utilization, o The lack of relevant infrastructure and long distance of markets, o Low level of agricultural commodity productivity and low competitiveness in import; o Procurement organizations monopolistic behavior etc.
GHG emission reduction as a result of technology implementation (CO_2 Equivalents, Gg)	Because of the technology implication natural growth of biomass and effective management of natural pastures will contribute to the effective management of storage resources, accumulation of organic carbon, particularly carbon stocks sequestration level in the soil will increase. 0.01 t $CO_{2eq.}$/year, ha
Possible impacts, compatibility and benefits for the country development goals	
Social benefits	The full implementation of technology will contribute to the increase in employment in agriculture rural population incomes, which also implies decrease in migration and poverty reduction in rural communities. From the other side competitive and environmentally friendly agricultural products and processed foods will be exported to other countries.
Economic benefits	The technology will contribute to the development of cattle breeding, which will consequently contribute to the development of other sectors and infrastructures based on the given subsector. At the same time, due to increased land utilization the Community budget incomes will increase.
Environmental benefits	Positive impact on natural ecosystems and biodiversity, protection of a number of plants and animals, land protection and decertification risk reduction, reducing the risk of floods and landslides, positive impact on the circulation of water resources.
Other assumptions and benefits (market potential)	N/A
Expenditures	
Capital cost	220 USD/ha
Operation and maintenance cost	80 USD/ha
Value of reduction of greenhouse gases emissions	22 USD /t $CO_{2eq.}$ (year, ha)
Life time	3 year
Other expenditures	N/A

Technology Factsheet 4 Land Use and Forestry

Technology name	**Grassland sustainable management**
Sphere	**Land Use and Forestry**
GHG emissions (CO_2 Equivalents, Gg)	**17.22 (2012) "Grassland" sector**
Introduction	As a result of privatization process implementing in the beginning of 1990s agriculture management practice, format and content was totally changed, which directly impacted on different types of land and ecosystem situation. De-enlargement of cattle farms, livestock reduction, economic decline and poverty increases, inflation and emigration have negatively affected the development of the livestock sector, which led to a chain of under usage or over usage processes of natural pastures, and as a result they became degraded and classified as under the erosion and desertification risk.

According to the balance of the land, the total area of agricultural land is 2049.4 thousand hectares, including 121.7 thousand hectares of grassland, and 1054.2 thousand hectares of pastureland. According to a number of researches, a wide range of natural pastures- around 60% is under the desertification and erosion risk. Important to mention, that degradation of natural pastures is mostly have two reasons; Remote pastures lost their qualitative specifications and thus became degraded due to absence of management and not usage, and the livestock overgrazing in areas close to the community are exposed due to erosion and desertification risk. Therefore, as the main reason for the degradation of natural pastures cannot considered the bad weather conditions, but it is mostly due to irregular and wasteful use of land, as well as almost total absence of relevant measures of improvement, maintenance and care. In addition to the economic and social consequences, such a situation leads to the destruction of natural pastures as carbon sinks and stores. Along with the anthropogenic influence, due to climate changes (increase in temperature and decrease in precipitation), vertically movement of natural ecosystems' borders have been forecasted. It was grounded that in foreseeable future alpine and sub-alpine ecosystems will be in particular vulnerable situation (up to 3000 meters above sea level), where many species of plants and animals can be completely pushed out.

Risks expected from climate change:

- Increased risk of drought, 10-30% decrease in soil moisture, water deficit increase 25-30%.
- predicted increase in frequency and intensity of extreme meteorological phenomena
- the expected increase in number and prevalence of pests
- Reduction of grazing lands , decrease in their productivity by 4-10%, including 19-22% decrease in productivity in the sub-alpine zone,
- Hay lands productivity decrease by 7-10 percent.

Suggested technologies;

Sustainable management of natural pastures implies not only rehabilitation of natural ecosystems but also implication of such formats of management and implementation of measures which will significantly contribute to the restoration of quality properties and protection of those ecosystems and effective use of these systems for economic purposes.

As a primary precondition for sustainable management it is necessary to

1. Conduct an inventory of natural pastures and classification of pasturelands and grasslands by degradation type (erosion and desertification), degree and reasons/factors,
2. Selection of relevant improvement method for each particular area (deeper/in general),
3. Development and implementation of complex activities of sustainable management for each area.

Technology 3;

Grassland sustainable management

Main activities are;

- Watering of areas and construction of irrigation places,
- Soil fertilization (organic and inorganic fertilizers)
- Fight against weeds,
- Effective usage of pastures taking into account main standards of grazing;

Implementation opportunities	1. Time and periods, cattle grazing will start in case of sufficient availability of vegetation grow 2. Area and grazing land (plants) height 3. Load of area or livestock number: a) keep livestock / surface area ratio b) use pastures by applying rotation mode of grazing For the implementtion of the technology a favorable environment is available, particularly, a Governmnet decree was adopted on the verification of establishment of proposed activities at national level under the "Climate change" convention. For applying this technology a relevant activities were undertaken by the UNDP country office as well, which launched a project on "Sustainable management of pastures and forest in Armenia to demonstrate climate change mitigation and adaptation benefits and dividends for local communities". GIZ implements another project on Biodiversity sustainable management. As a result of the technology application it will be possible not only to save and protect natural ecosystems, but also to contribute to the social and economic development of rural communities.
Implementation barriers	Limitations to the complete and effective implementation of the technology could be o insufficient financial resources, o population living standard and living conditions, o limited opportunities to livestock products consumption and low process, o low operational efficiency and profitability of remote pastures utilization, o the lack of relevant infrastructure and long distance of markets, o Low level of agricultural commodity productivity and low competitiveness in import; o Procurement organizations monopolistic behavior etc.
GHG emission reduction as a result of technology implementation (CO_2 Equivalents, Gg)	As a result of the technology implication natural growth of biomass and effective management of natural pastures will contribute to the effective management of storage resources, accumulation of organic carbon, particularly carbon stocks sequestration level in the soil will increase. 0.01 t $CO_{2eq.}$/year, ha
Possible impacts, compatibility and benefits for the country development goals	
Social benefits	The full implementation of technology will contribute to the increase in employment in agriculture rural population incomes, which also implies decrease in migration and poverty reduction in rural communities. From the other side competitive and environmentally friendly agricultural products and processed foods will be exported to other countries.
Economic benefits	The technology will contribute to the development of cattle breeding, which will consequently contribute to the development of other sectors and infrastructures based on the given subsector. At the same time, due to increased land utilization incomes of the Community budget will increase.
Environmental benefits	Positive impact on natural ecosystems and biodiversity, protection of a number of plants and animals, land protection and decertification risk reduction, reducing the risk of floods and landslides, positive impact on the circulation of water resources.
Other assumptions and benefits (market potential)	N/A

Expenditures	
Capital cost	120 USD/ha
Operation and maintenance cost	50 USD/ha
Value of reduction of greenhouse gases emissions	12 USD /t CO_{2eq}. (year, ha)
Life time	3 year
Other expenditures	N/A

Technology Factsheet 5 Land Use and Forestry

Technology name	**Use of non-cultivated land**
Sphere	**Land Use and Forestry**
GHG emissions (CO_2 Equivalents, Gg)	**-1.4 (2012) "Cropland" sector**
Introduction	Since the beginning of 90s agriculture, in particular horticulture is the most important sector of the economy. In this sector right after the declaration of independence was implemented a privatization policy covering land and other means of agriculture production, servce infrastructure, agricultural food consumption and processing companies. Inaction or annihilation of agricultural infrastructures and pumping stations, high prices of energy, fertilizers , other resources and many other reasons significantly affected the agriculture, namely; o use of advanced technology remained out of practice, o irrigation system became deteriorating, costs and volume of uncultivated land had increased, o practice of land target use was disrupted, etc. Agricultural development vision for the future in case of inertial scenario leads to rather poor results. According to World Bank assessments, Armenia being the most sensitive geographical area in terms of climate change, in case of the absence of appropriate measures and technologies will be under the risk of desertification. The rise in temperature and reduction in precipitation will lead to the expansion of desert, semi-desert and arid areas of open forest with the vertical movement of upper limits. These changes in economic, social and environmental situation will have direct impact on land use and crop development, in terms of land degradation, deforestation and the expansion of cultivated areas. The picture is getting even worst when considering the fact that from 232.9 thousand ha arable land only around 154.2 thousand ha is actually irrigated, while a huge volume of land areas are not cultivated due to water absence, being not profitable and etc. Apart from frequent drought other extreme phenomenas also became more frequent, such as frost, hail, torrential rains, which are also have significant damage to agriculture and land resources. Around 40% of the republic territory is not usefull for agricultural purposes. In addition, because of various factors, 29% or 130 thousand hectares of arable land are not used for target purposes, so implementation of land use effectiveness program is a strategic priority. **Risks expected from climate change:** • The expected shortage of irrigation water and increase in demand • Increased risk of drought, 10-30% decrease in soil moisture, water deficit increase 25-30%.

	• Predicted increase in frequency and intensity of extreme meteorological phenomena • The expected increase in number and prevalence of pests.
Implementation opportunities	**Suggested technologies**: **<u>Technology 3:</u> Use of non-cultivated land** Main activities are: ✓ Processing of uncultivated land through resistent grain crops, melons crops or fodder crops planting. ✓ The irrigation system expansion, focusing on manual and / or automatic (self-flow) mode. Promotion of process of applying modern irrigation techniques (drip, sprinklers, semi-surface) There is a favorable environment for the implementation of the technology, in particular the Government of RA has developed and adopted several strategies that refer to the balanced regional development, rural and agricultural development and so on, which provide sufficient ground for political goals set for the introduction of this technology. As an effective opportunity for introduction of this technology can be the development of multiple forms of agricultural cooperatives on a voluntary basis and multifunctional approaches due to which per household land plots will expand and thus growth of labor and capital production will be reached. Effective introduction of the technology will notably increase agricultural production volume. However, under formed agriculture market, low level of consuming, small domestic demand and lack of relevant infrastructure could fail the process effective implementation.
Implementation barriers	The next serious challenge is low access to financial resources, which is grounded by high credit rates and duration of agricultural loans. Other challenges could be as follows; o Insufficiency of risk mitigation measures and lack of an insurance system. o Resistance from farmers toward the innovations, new technologies, knowledge understanding and its introduction , o Underdeveloped infrastructure, like roads, weak irrigation systems, etc.
GHG emission reduction as a result of technology implementation (CO_2 Equivalents, Gg)	Use of non-cultivated land will increase the stock of organic carbon in soil and improve soil quality. 4 t $CO_{2eq.}$/year, ha
Possible impacts, compatibility and benefits for the country development goals	
Social benefits	Full implementation of technologies will contribute to the employment and income growth in agriculture, which implies the reduction of rural poverty and migration. Community budget incomes will increase. Role of civil society in community administration and management process will increase as well. Sufficient resources will be available tosolve community's social issues.
Economic benefits	Growth of agricultural production. The use of uncultivated land will improve agricultural output and incomes growth of the population and communities.
Environmental benefits	o Positive impact on natural ecosystems and biodiversity, o Reduction of land erosion and desertion risks, floods and landslides , o Positive impact on water resources circulation.

Other assumptions and benefits (market potential)	N/A
Expenditures	
Capital cost	160 USD/ha
Operation and maintenance cost	90 USD/ha
Value of reduction of greenhouse gases emissions	40 USD /t CO_{2eq} (year, ha)
Life time	1-5 year
Other expenditures	N/A

Technology Factsheet 6 Land Use and Forestry

Technology name	**Grassland surface improvement**
Sphere	**Land Use and Forestry**
GHG emissions (CO_2 Equivalents, Gg)	**17.22 (2012) "Grassland" sector**
Introduction	As a result of privatization process implementing in the beginning of 1990s agriculture management practice, format and content was totally changed, which directly impacted on different types of land and ecosystem situation. De-enlargement of cattle farms, livestock reduction, economic decline and poverty increases, inflation and emigration have negatively affected the development of the livestock sector, which led to a chain of under usage or over usage processes of natural pastures, and as a result they became degraded and classified as under the erosion and desertification risk. According to the balance of the land, the total area of agricultural land is 2049.4 thousand hectares, including 121.7 thousand hectares of grassland, and 1054.2 thousand hectares of pastureland. According to a number of researches, a wide range of natural pastures- around 60% is under the desertification and erosion risk. Important to mention, that degradation of natural pastures is mostly have two reasons; Remote pastures lost their qualitative specifications and thus became degraded due to absence of management and not usage, and the livestock overgrazing in areas close to the community are exposed due to erosion and desertification risk. Therefore, as the main reason for the degradation of natural pastures cannot considered the bad weather conditions, but it is mostly due to irregular and wasteful use of land, as well as almost total absence of relevant measures of improvement, maintenance and care. In addition to the economic and social consequences, such a situation leads to the destruction of natural pastures as carbon sinks and stores. Along with the anthropogenic influence, due to climate changes (increase in temperature and decrease in precipitation), vertically movement of natural ecosystems' borders have been forecasted. It was grounded that in foreseeable future alpine and sub-alpine ecosystems will be in particular vulnerable situation (up to 3000 meters above sea level), where many species of plants and animals can be completely pushed out. **Risks expected from climate change:** • Increased risk of drought, 10-30% decrease in soil moisture, water deficit increase 25-30%.

- predicted increase in frequency and intensity of extreme meteorological phenomena
- the expected increase in number and prevalence of pests
- Reduction of grazing lands , decrease in their productivity by 4-10%, including 19-22% decrease in productivity in the sub-alpine zone,
- Hay lands productivity decrease by 7-10 percent.

Suggested technologies;

Sustainable management of natural pastures implies not only rehabilitation of natural ecosystems but also implication of such formats of management and implementation of measures which will significantly contribute to the restoration of quality properties and protection of those ecosystems and effective use of these systems for economic purposes.

As a primary precondition for sustainable management it is necessary to

1. Conduct an inventory of natural pastures and classification of pasturelands and grasslands by degradation type (erosion and desertification), degree and reasons/factors,
2. Selection of relevant improvement method for each particular area (deeper/in general),
3. Development and implementation of complex activities of sustainable management for each area.

Technology 2:

Grassland surface improvement

Main activities are;

- surface improvement of less degraded pastures nearby to the communities and remote pastures:

✓ stones and garbage removal, grass sowing and territory expansion,
✓ Not useful plant removal or control over their growth and increase of quality of pasture vegetation
✓ Seeding in vegetation free areas

- Targeted combination and apply of ways in either freely and irregular, or "by turn" or "grazing area distribution" ways of animals grazing,
- Introduction of grazing periodicity method in pasture utilization practice.

For the implementtion of the technology a favorable environment is available, particularly, a Governmnet decree was adopted on the verification of establishment of proposed activities at national level under the «Climate change» convention. For applying this technology a relevant activities were undertaken by the UNDP country office as well, which launched a project on "Sustainable management of pastures and forest in Armenia to demonstrate climate change mitigation and adaptation benefits and dividends for local communities". GIZ implements another project on Biodiversity sustainable management.

Implementation opportunities

As a result of the technology application it will be possible not only to save and protect natural ecosystems, but also to contribute to the social and economic development of rural communities.

Implementation barriers

Limitations to the complete and effective implementation of the technology could be

- Insufficient financial resources,
- Population living standard and living conditions,

	o Limited opportunities to livestock products consumption and low process, o Low operational efficiency and profitability of remote pastures utilization, o The lack of relevant infrastructure and long distance of markets, o Low level of agricultural commodity productivity and low competitiveness in import; o Procurement organizations monopolistic behavior etc.
GHG emission reduction as a result of technology implementation (CO_2 Equivalents, Gg)	As a result of the technology implication natural growth of biomass and effective management of natural pastures will contribute to the effective management of storage resources, accumulation of organic carbon, particularly carbon stocks sequestration level in the soil will increase. 0.01 t CO_{2eq}/year, ha
Possible impacts, compatibility and benefits for the country development goals	
Social benefits	The full implementation of technology will contribute to the increase in employment in agriculture rural population incomes, which also implies decrease in migration and poverty reduction in rural communities. From the other side competitive and environmentally friendly agricultural products and processed foods will be exported to other countries.
Economic benefits	The technology will contribute to the development of cattle breeding, which will consequently contribute to the development of other sectors and infrastructures based on the given subsector. At the same time, due to increased land utilization incomes of the Community budget will increase
Environmental benefits	Positive impact on natural ecosystems and biodiversity, protection of a number of plants and animals, land protection and decertification risk reduction, reducing the risk of floods and landslides, positive impact on the circulation of water resources.
Other assumptions and benefits (market potential)	N/A
Expenditures	
Capital cost	90 USD/ha
Operation and maintenance cost	40 USD/ha
Value of reduction of greenhouse gases emissions	9 USD /t CO_{2eq} (year, ha)
Life time	1-5 year
Other expenditures	N/A

Technology Factsheet 7 Land Use and Forestry

Technology name	**Target use of cropland (annual and perennial)**
Sphere	**Land Use and Forestry**
GHG emissions (CO_2 Equivalents, Gg)	**-1.4 (2012) "Cropland" sector**
Introduction	Agriculture sector right after the declaration of independence was implemented a privatization policy covering land and other means of agriculture production, servce infrastructure, agricultural food consumption and processing companies. In parallel to the positive effect privatization had also negative results, such as;

- Agricultural lands desecrated (over 1.2 million plots), which resulted a decrease in the cultivation efficiency.
- Most areas of perennial plants turned into grain crop areas. Only in recent years has seen a growth area of orchards.
- Use of advanced technology remained out of practice,
- Practice of land target use was disrupted, etc.

The picture is getting even worst when considering the fact that from 232.9 thousand ha arable land only around 154.2 thousand ha is actually irrigated, while a huge volume of land areas are not cultivated due to water absence, being not profitable and etc. Agricultural lands in Armenia (according to 2013 official data) make up 2051.0 thousand hectares, of which arable land- 448.2 thousand hectares, perennial plantations- 33.3 thousand hectares, grass fields- 121.8 thousand hectares, pastures -1055.3 thousand hectares, other lands- 392.4 thousand hectares. Agricultural crops lower boundary is starting from 400 m above sea level, while the upper limit is reached at 2,300 meters above sea level. Around 40% of the republic territory is not usefull for agricultural purposes. Currently there is a 1.4 hectares (in average) of agricultural land per farm, including 1.1 hectares of arable land, which does not allow to carry out intensive use of technologies and conduct effective management, as well as use of agricultural technology with less time and resources costs. In addition, as a result of various factors, 29% or 130 thousand hectares of arable land are not used for target purposes, so implementation of land use effectiveness program is a strategic priority.

The picture of target land use was changed due to poor social-economic conditions, high level of poverty and low-income level of rural population. For example, in Ararat valley grain crops, technical crops etc., are still occupy a large areas, which significantly reduces the efficiency of land use.

Risks expected from climate change:

- The expected shortage of irrigation water and increase in demand
- Increased risk of drought, 10-30% decrease in soil moisture, water deficit increase 25-30%.
- Predicted increase in frequency and intensity of extreme meteorological phenomena
- The expected increase in number and prevalence of pests.

Suggested technologies;

Technology 1: Target land use technology. Main activities are;

- ✓ Climate change caused movement of climatic zones (perpendicular to the border zone), allows to grow new plants, which were not typical for that climatic zone in the past.
- ✓ Sustainable use of land, which means thoroughly, grounded zonal specialization and rational distribution of production. This technology could be implemented in a long-term period due to market factors, which, however, need to accelerate the state's policies on Regional Development within the framework of direct and indirect policy instruments. From the management aspect zonal specialization (distribution) and production distribution are necessary to design and implement not only by climatic zones but also by regions. For example,

1. **Aragatsotn region(marz)** is usefull for– perennial grass, grapes, crops, potatoes, fodder crops.
2. **Ararat and Armavir regions (marzes)** – perennial grass, grapes, crops, vegetables, early potatoes:

	3. **Gegharkunik region(marz)** – cereal crops, industrial crops, potatoes, fodder crops. 4. **Lori region(marz**) – perennial, cereals, fodder crops, radish, technical crops, potatoes, tropical fruit growing. 5. **Kotayk region(marz**) – perennial grain crops, vegetables, fodder crops. 6. **Shirak region(marz**) - cereal crops, industrial crops, potatoes, fodder crops, radish, vegetables. 7. **Syunik region(marz) -** Grain and leguminous crops, potatoes, vegetables, fodder crops, perennial, tropical fruit growing. 8. **Vayots Dzor and Tavush regions(marzes)** – perennial grass, grapes, grain crops, industrial crops, fodder crops, tropical fruit growing.
Implementation opportunities	There is a favorable environment for the implementation of the technology, in particular the Government of RA has developed and adopted several strategies that refer to the balanced regional development, rural and agricultural development and so on, which provide sufficient ground for political goals set for the introduction of this technology. As an effective opportunity for introduction of this technology can be the development of multiple forms of agricultural cooperatives on a voluntary basis and multifunctional approaches due to which per household land plots will expand and thus growth of labor and capital production will be reached. Effective introduction of the technology will notably increase agricultural production volume. However, under formed agriculture market, low level of consuming, small domestic demand and lack of relevant infrastructure could fail the process effective implementation.
Implementation barriers	The next serious challenge is low access to financial resources, which is grounded by high credit rates and duration of agricultural loans. Other challenges could be as follows; o Insufficiency of risk mitigation measures and lack of an insurance system. o Resistance from farmers toward the innovations, new technologies, knowledge understanding and its introduction , o Underdeveloped infrastructure, like roads, weak irrigation systems, etc.
GHG emission reduction as a result of technology implementation (CO_2 Equivalents, Gg)	Vineyards and fruit cultivation as a result of the introduction of new technology in this category of land use will increase carbon absorption due to the rapid growth in biomass. In case of annual and perennial crops and uncultivated land technology, no significant change in emissions/removals will be registered (due to change in biomass), however, will increase the stock of organic carbon in soil and improve soil quality. -2 to -374 t $CO_{2eq.}$/year, ha
Possible impacts, compatibility and benefits for the country development goals	
Social benefits	Full implementation of technologies will contribute to the employment and income growth in agriculture, which implies the reduction of rural poverty and migration. Community budget incomes will increase.
Economic benefits	o Growth of agricultural production, development of food processing production. o Competitive and environmentally friendly agricultural products and processed food will be exported to other countries. o Additional financial flows for community development.
Environmental benefits	o Positive impact on natural ecosystems and biodiversity, o Reduction of land erosion and desertion risks, floods and landslides , o Positive impact on water resources circulation.

Other assumptions and benefits (market potential)	N/A
Expenditures	
Capital cost	450 USD/ha
Operation and maintenance cost	85 USD/ha
Value of reduction of greenhouse gases emissions	-225 to -1.2 USD /t $CO_{2eq.}$ (year, ha)
Life time	1-5 year
Other expenditures	N/A

Technology Factsheets for selected technologies in Waste Management Sector

Technology Factsheet 1 Waste Management

Technology name	**Utilization of methane form Yerevan city landfill for electricity and heat production**
Sphere	**Waste Management**
GHG emissions (CO_2 Equivalents, Gg)	**632 $GgCO_{2eq}$ (2012)**
Introduction	In order to mitigate the effect of greenhouse gases generating from Solid Domestic Waste (SDW) and affecting the climate change, a technology of reprocessed gas recovery and its further burning in SDW landfills or electric energy production in gas engine power stations is being successfully applied in developed countries. This technology can be presented as vertical wells, horizontal gas channels, a gas-gathering pipeline that are isolated by an air-proof insulating film. Gas Golders, a compressor system and corresponding measuring equipment (gas meters, gas analysers) are also installed. In the soil, in wet medium, the gas reprocessing is done by means of vacuum. This technology makes possible to reprocess 60% and more of biogas. Gas engine generator can be presented as a gas piston-like engine that can operate at low-density biogas (less than 27% of Methane content), an electric generator, remote controls, equipment connected to an electric system and transmission lines. The Efficiency Coefficient of these engines is about 39-42%. This technology is widely used in Japan and other developed countries. In the last few years, this technology has been successfully applied also in Belarus in four different SDW landfills by means of gas engine stations processing power of 0.6 – 3.0 MW. The projects is developed by Shimizu Corporation (Japan) based on instruction form NEDO. 102-110 thousand t of solid domestic waste is accumulated annually in Yerevan city landfill, which is disposed of without preliminary processing and sorting. The landfill is a source of methane emissions and environmental pollution. The projects proposes to use the waste and accompanying methane as fuel for combined electricity and heat generation. The project envisages equipment for collecting waste, their separation and preparation for burning, a system for methane collection, incinerators, boiler, energy block (steam turbine, generator), boiler-utilizer for obtaining hot water, cleaning system for discharged gases. The annual electricity production will be 89.3 GWh, heat energy 59.5 GWh. The annual saving of fossil fuel is 15.4 thousand tons of equivalent fuel (reference fuel, standard fuel). For the implementation of the technology can be useful the experience from the pilot project, which is being implemented at Nubarashen landfill.
Implementation opportunities	In order to mitigate the effect of greenhouse gases generating from SDW and affecting the climate change, a number of projects aimed at the improvement of SDW monitoring system and construction of new regional landfills are being carried out in Armenia in collaboration with international organizations. It creates preconditions for continuous application of the suggested technology and biogas reprocessing. On the 13 October 2009 the first stage of the project on biogas, reprocessing from SDW was launched in the landfill 7 ha of Nubarashen district in Yerevan. As a result of its implementation, the biogas (methane content 41%) generated from SDW was burnt: transformed into CO_2. The project was being carried out

	jointly by a Japanese company "Shimizu" and Yerevan municipality. The second stage of the project: installation of a gas engine system, which is foreseen to be done after obtaining more accurate information about the real expense of biogas. However, it has not been carried out yet because of the digression from the initial scope of the project (for the implementation of the project only the landfill 7 ha was let by Yerevan municipality instead of the foreseen SDW landfill 20 ha). The continuity of biogas reprocessing can be ensured in case of the above-mentioned technology application also in the landfill 20 ha, as was foreseen, by installing a gas engine unit (power 250 kW). With the help of international sponsors, it can be applied in SDW landfills of Gyumri and Vanadzor, as well as in 5 new regional landfills, foreseen in the project of Asian development bank.
Implementation barriers	Lack of appropriate requirements in the law about garbage disposal. Barriers to the complete and effective implementation of the technology could be insufficient financial resources.
GHG emission reduction as a result of technology implementation (CO_2 Equivalents, Gg)	As a result of an incomplete application of this technology, within the period of 6 years 7.8 million m^3 of Methane or 22.3 m^3 of biogas was reprocessed and burnt that led to the reduction of greenhouse gases emissions up to 120.1 Gg $CO_{2eq.}$ (during 6 years). Average 212 thousand t CO_2 equivalent During project functioning 6.36 Mt Per unit cost of emission reduction 8.0 USD/t CO2 equivalent
Possible impacts, compatibility and benefits for the country development goals	
Social benefits	Creation of new jobs for the management of the advanced technology process and operation of the units. Formation of a new culture of SDW landfills management. The project aims at substituting the imported fuel, reducing GHG emissions, improving sanitary and energy situation. Technology will contribute to; o the increase in employment, o the improving the atmosphere in Yerevan o the reducing diseases, etc.
Economic benefits	Simple calculations can show that incomplete application of this technology can result in loss of benefits annually up to 4.8 million kWh of electric energy (in case it is produced in a gas engine station possessing a Efficiency Coefficient equal to 40%, with biogas having 35% of Methane content). In the last 6 years, the benefits would have been about 29 million kWh or, in money terms, 1.35 billion AMD. It is not difficult to guess that in case of biogas reprocessing in the whole area of Nubarashen SDW disposal project, as was planned, these benefits would have trebled. The positive economic impact of technology; o surrounding land use o Other economic activities o An additional source of fuel and energy.
Environmental benefits	Positive impact on natural ecosystems and biodiversity of the landfill area, protection of a number of plants and animals, land protection, positive impact on the circulation of water resources.
Other assumptions and benefits (market potential)	Elimination of stench and irregular surface combustion products from areas adjacent to landfills will ensure a natural development of those areas that is very important for such a land-poor country as Armenia. Armenia is the first country in the region that applies such an advanced technology to manage the process of SDW landfills and can pretend to become

	the centre of the region: the carrier of this culture and its promoter with all sequential benefits. The above-noted technology can be successfully applied (with involvement of certain grants) not only to reprocess biogas and produce electric energy out of it in SDW landfills of Gyumri and Vanadzor, but also to increase the maintenance efficiency of the new landfills foreseen for SDW collection within the framework of the mentioned projects in the republic in order to reduce the emissions even more.
Expenditures	
Capital cost	The needed investment 51.0 million USD
Operation and maintenance cost	60,000 USD /annually
Value of reduction of greenhouse gases emissions	240,000 USD/GgCO_{2eq}
Life time	Construction duration 3 years Duration of project functioning 30 years
Other expenditures	N/A

Technology Factsheet 2 Waste Management

Technology name	**Artik mining waste complex processing, agricultural land degradation prevention and clean up**
Sphere	**Waste Management**
GHG emissions (CO_2 Equivalents, Gg)	**632 GgCO_{2eq} (2012)**
Introduction	Armenia area is covered with volcanic, sedimentary, metamorphic stones layers. Stone is used as a construction material so far. Each type of stone material is also considered as complex raw material, which can be used for production of various products. Research show that vast majority of extracted stones are thrown into the environment as waste. There are types of stones 65-70% of which turn into waste. There are many different types and colours of tuff stones. All of which are of architectural interest. Until now, the area was discovered and explored more than 110 in tuff stone mines. The geological reserves are estimated at 2.5 trillion cubic meters. The tuff stone of Artik is the most widely used one in the country. In 1928 machine extraction from Artik mining was started. So far more than 50 million cubic meters of tuff stone mass was manufactured, of which only 30-40% was used as construction material corresponding to the standard, the rest was mainly thrown into the environment as a waste. These wastes and abandoned quarries occupy more than a thousand hectares of the fertile black soils. Overall, the area 7.0-7.5 thousand hectares of land is covered by stone waste. The waste being influenced by the winds constantly polluting the air basin of the settlements. If the mass of the extracted raw materials used in full, the cost of materials

will be reduced at least 1.5-2.0 times, so extraction of the stone mass will be correspondingly reduced as well, and the air spaces will not be polluted.

Suggested technology

As a solution of this issue, it is recommended to use complex, phased and diversified approach implying organization of innovative production.

Accumulations of such a tuff-stone waste are conditioned by its technical characteristics. Because of the relatively low strength and high porosity rates the tuff stones waste is not attractive for construction and thus previously could not be used in construction like the other more solid stones waste, such as basalt, granite, marble and other mining wastes.

Possible areas of tuff waste utilization should be considered from their fractions aspect, considering minimal investment, operating costs and non-waste production conditions. This approach implies the following;

- In case of < 5 mm fraction foam-blocks, thermal and sound insulation plates, as well as production of foam-concrete products (Phase I);
- In case of 5 to 20 mm fractions gravel ground tuff blocks production (conventional and polymer) (Phase II);
- In case of 5 to 50 mm, fractions by combining with another problematic waste (plastic containers) and tuff-plastic crushed stone and on this basis organize a production of different products (Phase III) and so on.

Productions of the last two types conditioned by dramatically increase in utilization of waste volumes will allow parallel use of tuff waste big volumes (like in road construction).

If the program's objectives for the implementation of phases I and II are known both the technologies and composition and value of the machinery, the same can not be said for the Phase III program objectives. Here we should start from zero level. No demand for gravel in the form of tuff waste, in addition to a relatively smooth (max. M 190) is due to its porosity high rate (40 to 70%), which strongly reduces its seasonal recurrence indicator (F50 - F600).

Vertical constructions, such as walls, the porosity is a positive indicator, in case of horizontal constructions (like in road construction) the constant presence of moisture/humidity due to seasonal freeze-thaw leads to its rapid depletion.

Plastic coverage of tuff remnants: 1. Gives them extra strength; 2. Excludes the undesirable phenomenon (moisture penetration into the gravel); 3. Ensures a minimum of 2 times increase in it’s seasonally recurrence indicator.

In construction is currently used by ripped tuff-blocks or concrete blocks, which consist of (as an inert ingredient) ground basalt, granite or sand. The mentioned types of construction materials are heavy and are out of comparison with foam blocks and tuff grave blocks by their technical

	characteristics. Thus, there is a paradoxical situation; having such obvious advantages, tuff waste continuous to remain in the "shadows".
Implementation opportunities	For the implementation of the technology can be useful the foreign experience and the scientific research results from the soviet period.
Implementation barriers	Barriers to the complete and effective implementation of the technology could be insufficient financial resources.
GHG emission reduction as a result of technology implementation ($CO_{2\ Equivalents}$, Gg)	Proposed new material will be used in building construction as insulation material and will contribute to energy savings and GHG emotion reduction as well. Average assumed 0.8 GgCO2-e/life time.
Possible impacts, compatibility and benefits for the country development goals	
Social benefits	Technology will contribute to; o the increase in employment, o the improving the atmosphere, o the reducing diseases, etc.
Economic benefits	The positive economic impact of technology; o surrounding land use o positive impacts on other economic branches and activities o development of infrastructure
Environmental benefits	Positive impact on natural ecosystems and biodiversity of the surrounding area, protection of plants, reduction of pollution, land protection.
Other assumptions and benefits (market potential)	N/A
Expenditures	
Capital cost	The needed investment 20,500 USD
Operation and maintenance cost	5,000-10,000 USD
Value of reduction of greenhouse gases emissions	25,600 USD/Gg CO_{2eq}
Life time	30 years
Other expenditures	N/A

Technology Factsheet 3 Waste Management

Technology name	**Surface water resource protection from pollution (applying alternative wastewater treatment technologies – instalment of compact stations)**
Sphere	**Development of Water treatment technologies to mitigate against the effects of global climate change.**
GHG emissions ($CO_{2\ Equivalents}$, Gg)	**632 $GgCO_{2eq}$ (2012)**
Introduction	The household as well as industrial wastewater cleaning is not fully implemented in Armenia, resulting in wastewaters are flow into surface water without purification, irrigation ditches, polluting land areas, degrading ecosystems, damaging people's health. Tourism, leisure, catering facilities outside of communities, which are located in the upper stream of the river, as a result of wastewater treatment process water ecosystems are getting polluted. Such territories close to internal stream of the river are mostly used as unorganized rest areas, where vacationers have direct contact with polluted river.

Technology description	Factory, production wastewater treatment technology based on compact classical station, assembled in one place (block, modular, unit-type). Provides biological wastewater deep cleaning for filling in the river or intended for target use. Treated waste water can be stored along with a rain water in underground special structure storage, with the aim of the irrigation, watering of green spaces (Grass, play gardens, sports fields), excluding the irrigation system.
Implementation opportunities	o This is worldwide-recognized method. It has a wide application o Compact cleaning stations have been installed and are operating in Teghut mine, the Agarak city's hospital, Sotq territory (for domestic wastewater treatment).
Implementation barriers	o lack of financial resources o low fines and penalties for untreated wastewater
GHG emission reduction as a result of technology implementation (CO_2 Equivalents, Gg)	Instalments of local compact cleaning stations in such facilities will not only exclude pollution of water ecosystems, but allow also the use of treated wastewater for irrigation or technical needs: biological treatment resulting sludge as a fertilizer, in order to obtain methane for combustion. Average assumed 2.2 $GgCO_{2\text{-}e}$/life time.
Possible impacts, compatibility and benefits for the country development goals	
Social benefits	o It is almost 2 to 5 times effective compared to mechanical system to keep green areas wet o Minimal operational expenses, particularly with regard to electricity. o Improving the sanitary conditions of the environment, o Public health protection and food security.
Economic benefits	o Possibility to use treated wastewater for irrigation or technical water use.
Environmental benefits	o Protection of water and terrestrial ecosystems, landscapes from pollution and degrading, o Reduction in methane gas emission.
Other assumptions and benefits (market potential)	N/A
Expenditures	
Capital cost	Average assumed 22,400 USD The prices are depending on waste water volume as follows; 5 persons 2 000 Euro 50 person 15 000 Euro 100 person 22 000 Euro Annual maintenance expenses could be varied within 300-1,200 euro range depending on the station power.
Operation and maintenance cost	
Value of reduction of greenhouse gases emissions	10,182 USD /Gg CO_{2eq}
Life time	Long-term
Other expenditures	N/A

Technology Factsheet 4 Waste Management

Technology name	**Surface water protection from pollution (applying alternative technologies of household wastewater treatment – applying natural and combined treatment technologies)**
Sphere	**Development of Water treatment technologies to mitigate against the effects of global climate change**
GHG emissions (CO_2 Equivalents, Gg)	**632 $GgCO_{2eq}$ (2012)**
Introduction	At present, 5 treatment plants were built thanks to an investment loan, which carry only mechanical treatment (lack of finance does not allow for the construction of biological treatment facilities). However, a complete purification of waste water also hampered by other conditions, which were analysed within the framework of "Support to development of National Strategy of wastewater removal and treatment" program held in 2014. As a result of the program the following suggestions on sector improvement were presented; ✓ Passing from the group wastewater treatment systems to the local one, which allows the settlement water resources basin (considering the treated waste water as a water resource) to leave in the area / pool area and use for their own needs, ✓ Applying new, modern, cheaper treatment technologies, ✓ Applying natural treatment systems.
Technology description	Development of wastewater full treatment (mechanical and biological) process will enable not only to re-use/recycling treated wastewater, but also to use the sludge resulted from biological treatment as a fertilizer or in order to obtain methane gas. Depending on weather conditions, size of available free area, quantity and quality of wastewater, degree of purification some elements of natural and classical wastewater treatment systems are combined.
Implementation opportunities	Treatment station with combined technology is operating in Parakar community of Armavir marz, which has a power of 11.7 litre /min, (the technology was designed and developed by "GING" LTD). There are similar projects for other communities as well. Natural treatment technology (constructed wetlands) is intended to establish in Tandzut community of the same marz within the framework of WASTnet regional programme (Black sea Partnership program). International experience is quite rich, a method widely spread in the Central and Eastern European countries, USA, Canada, and Turkey.
Implementation barriers	o lack of financial resources o Lack of legislative and regulatory mechanisms, in particular the absence of legislative regulation on wastewater treatment and removal, lack of wastewater treatment standards, lack of irrigation water quality standards and so on.
GHG emission reduction as a result of technology implementation (CO_2 Equivalents, Gg)	2.0 $GgCO_{2-e}$/life time
Possible impacts, compatibility and benefits for the country development goals	

Social benefits	Combined treatment plant construction costs are 4-5 times lower compared to the classic treatment plants, while operating expenses are lower dozens of times.
Economic benefits	o Improving the sanitary conditions of the environment, o Public health protection and food security. o Opportunity to use treated wastewater at a lower cost as irrigation water and/or processed sludge - as fertilizer use.
Environmental benefits	o surface and underground water sources, agricultural land, aquatic and terrestrial ecosystems, landscapes protection from degradation and pollution, o reducing methane emissions
Other assumptions and benefits (market potential)	N/A
Expenditures	
Capital cost	N/A
Operation and maintenance cost	The price depends on the quantity of purified wastewater. 1 m3 of wastewater cleaning by combined method will cost US $ 250-400. System maintenance costs are very low and amounted to 0.08 US dollars for 1 m3 of wastewater treatment.
Value of reduction of greenhouse gases emissions	9,000 USD /Gg CO_{2eq}
Life time	Long-term
Other expenditures	N/A

Technology Factsheet 5 Waste Management

Technology name	**"Araks Poultry Factory" CJSC Biogas bird droppings and heat (electric) power generation project**
Sphere	**Reducing CH_4 emissions from waste utilization**
GHG emissions (CO_2 Equivalents, Gg)	**632 GgCO_{2eq} (2012)**
Introduction	The project aims to reduce greenhouse gas emissions caused by bird droppings, improving "Araks Poultry Factory" CJSC currently used system and using animal waste (burn) biogas cogeneration system project resulting in the production of electricity and heat. The project further aims to "Araks poultry factory" CJSC from organic waste (litter), treatment, neutralization and fertilizer production.
Technology description	
Implementation opportunities	Lusakert "Biogas Plant" CJSC experience could be replicated.
Implementation barriers	Financial resources can be an obstacle to the full and effective implementation of technology.
GHG emission reduction as a result of technology implementation (CO_2 Equivalents, Gg)	12.4 Gg CO_2 eq.
Possible impacts, compatibility and benefits for the country development goals	
Social benefits	- The creation of new jobs requiring professional qualifications, - Improving of the working conditions of factory staff,

	- Reduction of diseases, etc.
Economic benefits	Economic benefits of technology implementation - Organic fertilizer production - other economic activates, - additional sources of fuel and energy
Environmental benefits	- Prevention of environmental pollution. - Elimination of stench - Prevention of water and land resources from pollution
Other assumptions and benefits (market potential)	Not available
Expenditures	
Capital cost	4.0 million Euro or 4.3 million USD
Operation and maintenance cost	Not available
Value of reduction of greenhouse gases emissions	346,800USD /Gg $CO_{2eq.}$
Life time	Construction duration 10 year Construction start 2010
Other expenditures	Not available

Technology Factsheet 6 Waste Management

Technology name	Existing Lusakert biogas plant operation and reissuance organizational technology
Sphere	CH_4 emissions reduction by using wastes
GHG emissions (CO_2 Equivalents, Gg)	**632 GgCO_{2eq} (2012)**
Introduction	The proposed project aims to reduce Lusakert poultry farm animal waste generated greenhouse gas emissions through improvement of animal waste management system. In 2008 in Lusakert was built biogas production plant, which was designed to reduce emissions and to produce electricity and organic fertilizer from poultry litter and animal waste. However, today this plant is not working due to lack of litter. As before, the factory as a litter processing system used in traditional open stabilization ponds, which are necessary for the processing of liquid waste from poultry operations. Anaerobic ponds generate methane (CH4) and nitrous oxide (N2O) emissions on the environment as a direct result of fermentation basins in the anaerobes. It is suggested to increase the volume of litter through the import from other poultry plants.
Technology description	
Implementation opportunities	The technology has been applied to Lusakert poultry factory.
Implementation barriers	Lack of financial resources and Lusakert Biogas Plant CJSC disagreement can be obstacle for full and effective implementation of the technology.

GHG emission reduction as a result of technology implementation (CO_2 Equivalents, Gg)	Annual 25,000 tons of CO_2 equivalent. For the period of 7 year 175,000 t CO_{2eq}.
Possible impacts, compatibility and benefits for the country development goals	
Social benefits	o The creation of new jobs requiring professional qualifications, o Improving of the working conditions of factory staff, o Reduction of diseases, etc.
Economic benefits	Economic benefits of technology implementation o Organic fertilizer production o other economic activites, o additional sources of fuel and energy
Environmental benefits	o Prevention of environmental pollution. o Elimination of stench o Prevention of water and land resources from pollution
Other assumptions and benefits (market potential)	N/A
Expenditures	
Capital cost	50,000 USD
Operation and maintenance cost	Not available
Value of reduction of greenhouse gases emissions	2,000 USD /Gg $CO_{2eq.}$
Life time	Duration of construction 3 years Construction start 2016
Other expenditures	Not available

Technology Factsheet 7 Waste Management

Technology name	**Chicken manure recycling and production of granular organic fertilizer**
Sphere	CH_4 emissions reduction by using wastes
GHG emissions (CO_2 Equivalents, Gg)	**632 GgCO_{2eq} (2012)**
Introduction	In Armenia around 250,000 tons of crude litter is gathered a year, which is accumulated in large quantities in open areas and reservoirs as a source of greenhouse gas emissions. The project proposes to process a litter through the heat treatment by granulation and get granular and enriched with chemical elements organic fertilizer. The humidity in the granules is 15-20%.
Implementation opportunities	The organic fertilizer can be used to fertilize haylands, which is carried out through a special machine. This technology was used in Soviet times in "Friendship" OJSC of the Gavar region and the equipment are still available.
Implementation barriers	Lack of financial resources can be obstacle for full and effective implementation of the technology.

GHG emission reduction as a result of technology implementation ($CO_{2\ Equivalents}$, Gg)	3,000 tons of $CO_{2eq.}$
Possible impacts, compatibility and benefits for the country development goals	
Social benefits	o The creation of new jobs requiring professional qualifications, o Improvment of social situation of population o Increase of soil fertility o Reduction of diseases, etc.
Economic benefits	o Organic fertilizer production o Increase of agriculture production up to 50% o Increase of agriculture profit by 32%
Environmental benefits	o Prevention of environmental pollution. o Elimination of stench o Prevention of water and land resources from pollution
Other assumptions and benefits (market potential)	NA
Expenditures	
Capital cost	5,000 USD granule equipment 15,000 USD fertilizer distribution machine, Total 20,000 USD
Operation and maintenance cost	3,000-5,000 USD
Value of reduction of greenhouse gases emissions	6,667 USD/Gg CO_{2eq}
Life time	Duration of construction 6-7 months Construction start 2016.
Other expenditures	Not available

Annex II: List of stakeholders involved and their contacts

Institutions involved in stakeholder consultation process

Institution	Representative	Contacts
Public Administration Bodies		
Environmental Project Implementation Unit State Institution www.mnp.am/?p=291; www.epiu.am/	Rubik Shahazizyan Edik Voskanyan	+374 94 251709 rshahazizyan@yahoo.com +374 94 384151
Public Services Regulatory Commission of the RA www.psrc.am	Mesrop Kharibyan	+374 94 902242 gabrielyan@psrc.am
Armenian Settlement Center CJSC Ministry of Energy and Natural Resources	Svetlana Tavakalyan	+374 91 421799 info@setcenter.am stavakalyan@rambler.ru
"Electro power system operator" CJSC Ministry of Energy and Natural Resources www.energyoperator.am	Armen Hovhannisyan	+374 99 971193 office@energyoperator.am
Yerevan Djur CJSC www.veoliadjur.am	Sahakyan Aram	+374 77 522555 com@yerevandjur.am
"Hayantar" SNCO of the Ministry of Agriculture www.hayantar.am	Armen Nalbandyan	+374 93189333 arm_forest@yahoo.com
Armenian Water and Sewerage CJSC www.armwater.am	Lilit Hovhannisyan	+055 552040 info@armwater.am hovhannisyan@gmail.com
Ministry of Healthcare www.moh.am	Olga Margaryan Ekaterina Melkumyan	+374 91 412480 omargaryan@moh.am +374 93 523018 ekaterina.melkumyan@mail.ru
NGOs		
Green Lane www.greenlane.am	Zabel Hayruni	zabel@greenlane.am
Technology Transfer Association www.itguide.eif.am	Mikael Abovyan	+374 95 404665 tta@netsys.am
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Technological Needs Assessment (TNA) Project implemented by "Environmental project implementation unit" State Institution UN Environment Programme, RA Ministry of Nature Protection

The Project interim results / Workshop discussions with stakeholders

A G E N D A

Manugean Hall, American University of Armenia
Yerevan, Baghramyan 40
November 17, 2015.

9:00 – 09:30	**Registration of participants**
09:30 – 09.40	**Opening of the meeting**
09:40 – 10:00	**Armenia's position on the UN Framework Convention on Climate Change (UNFCCC). Intended Nationally Determined Contributions (INDC)** *Aram Gabrielyan, TNA National Project Coordinator, UNFCCC National Focal Point*
10:00 – 10:20	*Tigran Sekoyan, TNA Mitigation Component Team Leader*
10:20 – 10:40	*Mkrtich Jalalyan, Energy and Industry Sectors Expert*
10:40 – 11:00	*Arevik Hovsepyan, Waste Sector Expert*
11:00 – 11:20	*Anastas Aghazaryan, an expert in land use and forestry sector*
11:20 – 11:40	**Discussion**
11:40 – 12:00	*Vardan Melikyan, TNA Adaptation Component Team Leader*
12:00 – 12:20	*Samvel Avetisyan, an expert in agriculture sector*
12:20 – 12:40	*Arevik Hovsepyan, an expert in water resources sector.*
12:40 – 13:00	**Discussion**
13:00-13:20	**Summary** *Tigran Sekoyan, Vardan Melikyan*
13:20	***Tea / Coffee / Lunch***

Technological Needs Assessment (TNA) Project implemented by
"Environmental project implementation unit" State Institution
UN Environment Programme, RA Ministry of Nature Protection

The Project technologies prioritization final results / Workshop discussions with stakeholders

A G E N D A

Erebuni Plaza Business Center, "Argishti" hall
c. Yerevan, 26/1 Vazgen Sargsyan
December 24, 2015

9:30 – 10:00	Registration of participants
10:00 – 10.05	Opening of the meeting
10:05 – 10:35	***UN "Framework Convention on Climate Change" (UNFCCC) COP 21 forum results*** *Aram Gabrielyan, TNA National Project Coordinator, UNFCCC National Focal Point*
10:35 – 10:50	***Climate Change Mitigation TNA technologies prioritization final results*** *Tigran Sekoyan, TNA Mitigation Component Team Leader*
10:50 – 11:10	***Energy and industrial sector priority technologies*** *Mkrtich Jalalyan, Energy and Industry Sectors Expert*
11:10 – 11:30	***Waste management sector priority technologies*** *Arevik Hovsepyan, Waste Sector Expert*
11:30 – 11:50	***Land use and forestry sector priority technologies*** *Anastas Aghazaryan, an expert in land use and forestry sector*
11:50 – 11:55	Discussion
11:55 – 12:10	***Climate Change Adaptation TNA technologies prioritization final results*** *Vardan Melikyan, TNA Adaptation Component Team Leader*
12:10 – 12:30	***Land use and forestry sector priority technologies*** *Samvel Avetisyan, an expert in agriculture sector*
12:30 – 12:50	***Land use and forestry sector priority technologies*** *Arevik Hovsepyan, an expert in water resources sector*
12:50 – 12:55	Discussion
12:55 – 13:00	Summary
13:00 -	Tea / Coffee / Lunch