Republic of Moldova

TECHNOLOGY NEEDS ASSESSMENT FOR CLIMATE CHANGE MITIGATION
REPORT I

TECHNOLOGY PRIORITIZATION

May, 2012

Supported by:

Preface

The Republic of Moldova has signed the United Nations Framework Convention on Climate Change (UNFCCC) on June 12, 1992, ratified it on March 16, 1995 and for our country the Convention entered into force on September 7, 1995. On January 28, 2011 the Republic of Moldova has associated with the Copenhagen Agreement of the United Nations Framework on Climate Change. Under this Agreement, our country has set a new target aimed at Greenhouse Gas (GHG) emissions reduction, specifying " reduction of total national levels of GHG emissions by not less than 25% by 2020 compared to the reference year (1990). Hereby, it is determined that this target shall be achieved by implementing global economic mechanisms focused on mitigating climate change in accordance with UNFCCC principles and decisions."

The recent and underway policies of the Republic of Moldova 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.

In conformity with the general objective of the Convention, which sets as a target the maximum global average temperature growth until 2100 by no more than 20C, the Republic of Moldova has decided to undertake a transition to a low GHG emissions development path. The first step in this direction was made in 2011 when development of the Low-Emission Development Strategy and Climate Change Adaptation Strategy started. Approval of these strategies is planned for 2013, which will allow access to the long-term financing mechanisms under the Convention to implement the so-called Nationally Appropriate Mitigation Actions (NAMA) and adaptation measures. Technology needs assessment in the context of climate change mitigation and adaptation is a crucial first step in achieving the objectives of these strategies. Methodological aspects of evaluation and identification of appropriate technologies in climate change mitigation and adaptation revealed during the TNA will serve as a starting point in promoting them nationwide. In the future the Republic of Moldova will address climate change issues so, that they can be included in all national and sector development policies and strategies of the country. This status will allow our country to get integrated in the global process of climate change mitigation and adaptation to this phenomenon at the national level.

Disclaimer

This document is an output of the Technology Needs Assessment project, funded by the Global Environment Facility (GEF) and implemented by the United Nations Environment Programme (UNEP) and the UNEP-Risoe Centre (URC) in collaboration with the Regional Centre Asian Institute of Technology, Bangkok for the benefit of the participating countries. The present report is the output of a fully country-led process and the views and information contained herein are a product of the National TNA team, led by the Climate Change Office (CCO) of the Ministry of Environment of the Republic of Moldova.

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FOREWORD

I am proud to provide a foreword to this report, which is one of the outputs of the 'Technology Needs Assessment' (TNA) conducted in the Republic of Moldova. The TNA process was coordinated by the Ministry of Environment through Climate Change Office (CCO), who, with the help of local experts, conducted a thorough stakeholder consultation and analysis of the technical and policy options for increasing the use of low-carbon and climate-resilient technologies in the Republic of Moldova.

Following methodological and technical assistance provided by the UNEP Risø Centre, the CCO facilitated a stakeholder-led Multi Criteria Analysis for the prioritisation of both mitigation and adaptation-side technologies. This was followed by stakeholder consultations regarding the most important barriers to the uptake of these technologies, and what can be done to overcome them.

The TNA process has finalised with Technology Action Plans (TAPs) that provide a clear and realistic road map to reforming market incentives and attracting investment in specific technologies. As such, these documents allow us to facilitate the transfer of key climate technologies that also serve to drive economic growth and development. Above all, the TAPs offer practical solutions for the sustainable development of the country's agricultural sector, upon which we depend heavily for our income and livelihoods.

Gheorghe Şalaru

Minister of Environment of the Republic of Moldova

March 2013

EXECUTIVE SUMMARY

Successive agreements made between Parties to the United Nations Framework Convention on Climate Change (UNFCCC) have highlighted the need to accelerate the transfer of environmentally-sound technologies to developing countries. The TNA Project provides a great opportunity for the Republic of Moldova to perform country-driven technology assessment to identify contemporary, environmentally sound technologies that might be implemented with a significant contribution in addressing climate change mitigation needs of the country.

Technology Needs Assessment Project is country driven and is done though a consultative process that engages relevant stakeholders.

The purpose of this TNA project is to assist participant developing country Parties identify and analyse priority technology needs, which can form the basis for a portfolio of environmentally sound technology projects and programmes to facilitate the transfer of, and access to, the ESTs and know-how in the implementation of Article 4.5 of the UNFCCC Convention.

The overall objective of this Project comprises technology needs assessment, activities associated with sector and technology prioritization, with high involvement of experts and stakeholders, which encourage the creation of enabling environment for the transfer of environmentally sound technologies. The Project also aims to identify barriers hindering the acquisition, deployment, and diffusion of prioritized technologies and to develop Technology Action Plans (TAP) specifying activities and enabling frameworks to overcome the barriers and facilitate the transfer, adoption, and diffusion of selected technologies.

The working group of Mitigation component has consulted a number of official documents (Republic of Moldova development strategies, sectoral strategies, sectoral plans, other relevant materials) and have clustered the national development priorities with relevance to climate change. These priorities, which reflect national circumstances, have been considered in each step of technological appraising.

The Institutional setup for TNA Project includes TNA Coordinator, National TNA Team, a National TNA Committee and National consultants/experts organized in workgroups. A National Steering Committee is envisaged as the top most decision making body of the TNA Project, comprising policy makers from relevant key ministries.

During inception workshop the TNA Team and stakeholders agreed upon activities to be implemented during Project lifetime and budget allocated. A detailed draft of Work Plan was elaborated and discussed with stakeholders, the final version was endorsed by the stakeholders and experts.

The TNA activities involved stakeholders from key institutions (Ministry of Environment, Ministry of Economy, Ministry of Agriculture and Food Industry of Moldova) in all stages of technology prioritization to ensure relevance of appraised technologies and to engage stakeholders that will be central to implementation of prioritized technologies. They have been involved in the clustering of national priorities with relevance to climate change, in sector and technology prioritization.

In the implementing TNA Project the methodological guidance was provided during TNA workshop in Bangkok (8-11 August, 2011) and the following methodological sources have been consulted: UNDP Handbook *Technology Needs Assessment for Climate Change*, Climate TechWiki website, *Multi-criteria analysis:* a *manual*, the TNA guide *Technologies for Climate Change Adaptation, Agriculture sector*, guidance provided by URC Country Coordinator, UNEP Risoe Centre website information, Asian Institute of Technology.

According to the TNA Project Work Plan, during the meetings of sectoral working groups, the representatives from Ministry of Environment, Ministry of Agriculture and Food Industry and Ministry of Health of the Republic of Moldova, experts, specialists from the main sectors of economy (Agriculture, Energy,) have applied Multi criteria Analysis to conduct sector's and technology's evaluations.

The selection of Climate Change Mitigation Technologies started from the determination of the (sub) sectors causing the highest country GHG emissions. Taking into consideration both GHG reduction potential and country priorities it was found two sector, Energy and Agriculture, and six subsectors for further consideration: Energy industries (Electricity and Heat supply), Transport, Other Sectors (Residential and Administrative buildings) and Agricultural Soils, which contribute by 69% to country total GHG emissions. The long list of technologies made up for the subsectors chosen encompassed 78 technologies from which two technologies were removed ("Charcoal production for cooking and heating" and "Second generation of bio-fuel production based on mobile rapid pyrolysis technology") because of too small benefit impact and not appropriateness to country conditions. The long list of technologies have been structured in four categories: small scale technologies available in the short term; small scale technologies available in the medium to long term; large scale technologies available in the short term; and large scale technologies available in the medium to long term. The further technologies selection, per each category, was done based on Multi-Criteria Decision Analysis (MCDA), being developed a respective tool (Excel Spreadsheet) based on one proposed at TNA workshop in Bangkok (8-11 August, 2011). At the experts meetings it was agreed the same benefits criteria be used for all subsectors, the cost criteria being limited to Investments and Prices as these parameters are very sensitive in the country decision making. The Republic of Moldova is still in the transition to market economy and the capacity to pay for goods and services is too low.

The crucial element in MCDAnalyses is the Technology Fact Sheet filled out for each of the technology, it serving as main source for creation of experts and stakeholders opinion on how to "vote" at the concrete criteria for the concrete technology. Along with TFS, the Performing Matrix for each technology was developed, it comprising the concrete data for specific investments, the country reserves for technology implementation, O&M costs, expected GHG emission reduction from the technology implementation, price. The Performing Matrix is integrated part of MCDA Excel Spreadsheet. The last contains a Guide how to fill out the tables' cells, make analyses, inclusive sensitive one. In this process the user has possibility to consult country priorities, they being enclosed in the same Excel Spreadsheet.

Before proceed to MCDAnalyzes an examination of present status of technologies used in each of subsector was done.

In Moldova power sector (Electricity supply) the technologies are totally depreciated, the efficiency not exceeding 30-38%, the last value corresponding to combined cycle units. Along CHPs are obsolete, they are operating at regime far from one corresponding to optimal cogeneration cycle, as heat demand has dropped significantly since 1991, when the country launched the transition to market economy. Around 20% of apartments and many administrative buildings have individual boiler houses on natural gas as heat supplier. During the last time a lot of energy efficiency projects have been promoted in the country, having big support from foreign donors (EBRD, WB, EU, etc). The wall of residential and administrative buildings are thermo isolated, the old windows are replaced by ones energy efficient, more and more heat pumps are used instead of conventional fuel boilers, biomass pellets and bales are produced broadly as a fuel, etc.

In Transport sector Diesel Oil accounts circa 55.6% of the total, Gasoline – 38.7%, jet fuel – 2.7%, LPG – 1.3%, LNG - 0.7%. Diesel oil and Gasoline is preponderantly used in road transport, to a less extent LPG and LNG; Diesel Oil is preponderantly used in railway and navigation transport, while air transport mostly uses jet fuel. 92% of the total energy consumption in the transport sector is used for road transportation; 5% - for railway transport; 2.4 percent - for air transportation. Present technologies applied in Transport sector correspond to ones known at the world level, those obsolete predominating. No electric transport is used at the moment. The share of road vehicles using compressed natural gas and liquefied petroleum gas as fuel is in increasing process. Bio-fuels (ethanol and biodiesel) utilization is on incipient stage. There is no vehicles production in the country. All the vehicles needed are from the import.

As to the agricultural soil, up to now around 312 million tons of CO_2 (from country tilled soils of 1.82 million hectares), have been emitted in atmosphere because of imbalanced humus concentration in the soil. Nowadays, 2.55 million tons of CO_2 pollute air annually. Only a balanced humus concentration in the soil can exclude further GHG emissions from it.

From the present status of technologies analyzes it was concluded that the country has significant reserves for GHG reduction if modern and new, more performant, technologies will replace the existing old ones. In order to find the best of them from those of 78 technologies included in the long list two approaches have been used: for the categories encompassing more than four technologies per category MCDA process was applied, otherwise manual prioritization within TNA assessment is done with justifications for the assessments made. In the MCDA the best two-three technologies per each category were identified based on Scoring procedure, then they were exposed to Cost-Benefits and Sensitive analysis. The following technologies have been selected per each category:

<u>Small scale/Short term</u>: 1. Combined heat and power plants based on internal combustion engines of at most 500 kW; 2. Heat boilers on solid fuel gasification; 3. Hybrid Electric Vehicles; 4. Energy Efficient lamps; 5. Energy Efficient lamps; 6. Classic tillage, no organic fertilizers.

<u>Small scale /Medium-Long term</u>: 1. Wind systems for water and space heating; 2. Heating system on hydrogen; 3. Electric vehicles; 4. High Efficient Heat, Ventilation and Air-conditioning System (HVAC); 5. High Efficient Heat, Ventilation and Air-conditioning System (HVAC); 6. Classic tillage with predominant straw cereals cultivation.

<u>Large scale /Short term</u>: 1. Natural gas combined cycle power plant; efficiency 50 %; 2. Big Heat Pumps; 3. Biodiesel; 4. Mini-Till tillage with mineral fertilizer application.

<u>Large scale /Medium-Long term</u>: 1. Natural gas combined cycle power plant; efficiency >60 %; 2. Gasification of Municipal Solid Waste for Electricity/Heat production; 3. Transport management systems; 6. No-Till tillage, with vetch application to fertilize soils.

All other selected technologies are presented in a separate Summarized table.

At the meeting devoted to open discussion on prioritised technologies the experts expressed the common opinion that the selected technologies cannot be considered as ones final for promotion. They should be further studied in the concrete implementation environment, taking into consideration their operation in a long term context. For example, the prioritized technologies for power sector could not be charged properly during the year and years because they are working in the system where load curve, electricity demand evolution, the existing PPs in operation, the characteristics of power units candidates are crucial parameters in the exercise of determining the cheapest and more friendly to environment and climate change electricity supply scenario. Moreover, the tools used for power sources scenarios development (WASP, MARKAL, etc) could not chose the technology selected based on MCDA. In such cases, additional analyzes are required to find the best electricity production technologies.

Finally, from 38 of technologies prioritized per subsectors of Energy and Agriculture Sectors six technologies were selected for further examination, namely:

For Energy Sector-three technologies:

1. Combined heat and power plants based on internal combustion engines of at most 500 kW (Electricity Supply subsector);
2. Gasification of Municipal Solid Waste for Electricity/Heat production (Heat Supply subsector);
3. Hybrid Electric Vehicles (Transport subsector).

For Agriculture Sector-three technologies:

1. The No-Till soil cultivation system with preliminary positive recovery of the post-arable layer and use of vetch as intermediary crop for green fertilizer (Agriculture soils subsector);
2. Mini-Till soil cultivation system with preliminary positive recovery of the post-arable layer and use of vetch as intermediary crop for green fertilizer (Agriculture soils subsector);
3. Classic tillage, including a vetch field (two yields per year –autumn and spring), as a „green fertilizer field" into a 5 fields crop rotation (two crops of vetch incorporated in soil as green fertilizer on each field once in 5 years) (Agriculture soils subsector).

CHAPTER 1. INTRODUCTION

1.1. About the TNA project

The promotion of the GHG reduction technologies is a long term priority of the Ministry of Environment of the Republic of Moldova, started 12 years ago.

In 2002 year, having the support of Global Environment Facility (GEF), the Republic of Moldova has undertaken the first technological needs assessment. The Report "Technology needs assessment and development priorities" was elaborated within the Project "Climate Change: Enabling Activity (Phase II)" and implemented by the Ministry of Ecology, Constructions and Territorial Development in cooperation with UNDP Moldova under GEF financial assistance and published in 2002 year. The document provides the information about current status of the national sectors with highest GHG emissions and the state-of –the–art world technologies that could replace depreciated at that time technologies from Moldova.

The second country driven technological needs assessment of the Republic of Moldova has been launched in 2011 year within TNA Project Republic of Moldova "Technology Needs assessment and technology action plans for climate change", having financial and guidance support of UNEP Risø (URC). The current assessment, presented in this report, aims to perform a country- specific evaluation of the current technological state in the most vulnerable to climate change sectors of the Republic of Moldova's economy for identifying and analyzing priority technology needs for climate change mitigation and adaptation. The output of the TNA Project is the portfolio projects using high efficiency, environmentally sustainable technologies, that would ensure Republic of Moldova sustainable development. The TNA activities involve stakeholders in all stages of technology prioritization to ensure the relevance of evaluated technologies and to engage stakeholders that are central to implementation of prioritized technologies. A number of professionals from relevant institutions from strategically important sectors of Moldova's economy, possessing knowledge and experience in the area, have been engaged as TNA experts. Most of them have participated in other climate change related projects, particularly in the First and Second National Communications. Both stakeholders and experts have performed the prioritization of technologies that further are subject to barrier analyses, technology plan implementation and, as a final step, submission of the projects ideas for effective implementation, having the investment support from international financing institutions.

Along with winners technologies developed into the projects ideas, other efficient technologies included in the TNA project will be considered as Nationally Appropriate Mitigation Actions (NAMAs) in currently under development Low Emission Development Strategies (LEDS) and Third National Communication (TNC) and treated as technological opportunities financed from domestic resources and/or involving foreign investors by creating a favorable investment environment.

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

Moldova development priorities are predetermined by country economic, political and social status inhered to it at the due stage. Since the date of independence declaration from 1991, the country is still in the process of transition to market economy, being declared the poorest country in the Europe (1630 US$ per capita) during the last decade. Because of Transnistria secessionism, starting with 1992 Moldova territory located at left bank of river Nistru is not controlled by country recognized authorities and that introduces a steady political instability in resolving its economic issues. Lack of own natural fossil fuel reserves is obliging the country to import more than 96% of energy resources needed. Being oriented to agricultural production in the former USSR, the share of industry in the GDP structure at present still remains at a quite low level (20%), that making the republic income vulnerable to climate conditions.

In order to overcome the accumulated problems in 2007 Moldova Parliament approved National Development Strategy 2008-2011 (NDS)

The key objective of the Strategy is to ensure a better quality of people's lives by strengthening the foundation for a robust, sustainable and inclusive economic growth. At country level, this implies a deep transformation and modernization of the country and an effective qualification for accession to the EU. The main operative focus of the strategy is to narrow the income gap against the European Union average and reduce the absolute poverty rate. The NDS also defines a vision including 15 objectives covering improvements in areas such as democratic processes, the judiciary system, poverty eradication, political security, European integration and economic development without endangering nature and the environment. The last broad declaration has not got further specific clarifications and development related to Climate Change improvement. Except First and Second National Communications no one other document specified GHG emission reduction targets. However, Greenhouse Gas (GHG) Sources and Sinks in the Republic of Moldova' (2009) reveals a decreasing trend of GHG emissions. Between 1990 and 2005, national GHG emissions fell by circa 72.3 percent: from 42.9 Mt CO2 equivalents in 1990 to 11.9 Mt CO2 equivalents in 2005 (Figure 1.2-1).

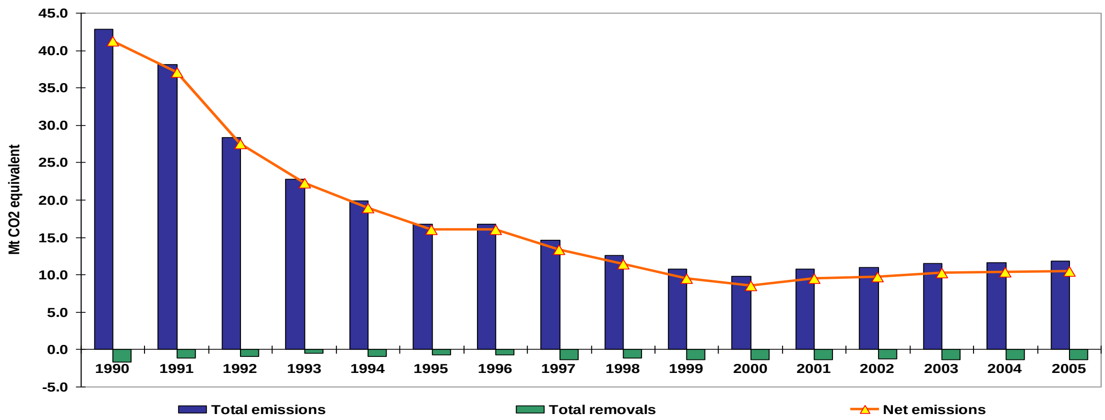

Figure 1.2-1. Moldova's GHG emission evolution

The significant reduction in national GHG emissions is a consequence, first of all, of the economic crisis following the break-up of the Soviet Union and characteristic for the transition (1991-2000) to a market economy in the Republic of Moldova. The years of transition also brought changes in the fuel mix of energy supply and consumption, with natural gas becoming the main fuel for the power stations and boiler houses.

The energy intensity of GDP at purchasing power parities for the Republic of Moldova is significantly higher than the EU average and the Central and Eastern Europe region average. This situation which significantly impacts GHG projections is attributable to low energy efficiency in supply and end use of energy due to ageing, obsolete and inefficient technologies, infrastructure and dwellings.

Being guided by the principles and provisions of the UNFCCC, the Republic of Moldova associated itself with the Copenhagen Accord and submitted an emission reduction target to be specified in its Appendix II, expressing the national willingness to undertake mitigation measures focused on reducing its total national GHG emissions by 2020 with no less than 25% of the base year (1990), through implementation of global economical mechanisms focused on the climate change mitigation, in accordance with the Convention's principles and provisions.

In 2000, the Republic of Moldova along with other 191 countries of the world committed to achieving the Millennium Development Goals (MDGs) by 2015. The achievement of these goals is promoted by the Government through the NDS. The MDG includes eight overarching development goals among which ensuring environmental sustainability is one goal which addresses issues such as degradation of natural resources, afforestation, preserving biological diversity, access to safe water sources, access to improved sewage and sanitation.

In order to fulfill the country commitments taken at the international level, including MDGs, the Government decided to elaborate Low Emission Development Strategy (LEDS) until 2020, as the Copenhagen Accord further envisages the developing countries prepare LEDS as blueprints for decoupling their economic development and emission growth. At the moment the draft of LEDS is in the process of public consultation and it is foreseen to be approved by the Government of the Republic of Moldova by the end of 2012 year.

The specific objectives of the Strategy are:

1) To propose mitigation solutions providing economic opportunities;
2) To highlight the barriers to the conversion to the low carbon emissions economy development;
3) To reinforce and build on existing projects/investments;
4) To prioritise the proposed NAMAs;
5) To propose besides domestically implemented NAMAs, such for international support.

In order to reach the goal of GHG emission redaction the accent will be given to the sectors with the main reserves in this respect, having in mind the objectives of the National Development Strategy 2008-2011. The most reserves for GHG reduction correspond to those with the higher GHG emissions, i.e. to Energy sector (65%), Agriculture (18%) and Waste (12%).

The Republic of Moldova's policies on GHG emissions reduction will be oriented mainly to increase energy efficiency in all abovementioned priority sectors, broad implementation of renewable sources, biofuels for transport sector, road improvement, optimization of crops in order to maintain carbon in soils, the reduction of fallow land, reclamation of degraded soils, introduction of sustainable fertilizer practices through application of manure and crop residues to soil, assist regeneration of forests, plant new forests and protection belts, apply best practices of waste management, etc.

1.2.1. Mitigation policy instruments

At present the main Moldovan climate change policy instruments are:

- Law on Renewable Energy.
- Law on Energy Efficiency.
- Energy Strategy of the Republic of Moldova until year 2020.
- UNFCCC Clean Development Mechanism.

All these instruments are applicable for priority sectors above mentioned to contribute the reaching the Republic of Moldova's mitigation target under the Copenhagen Accord (by 2020 with no less than twenty five percent of the 1990 level). More specifically:

Law on Renewable Energy.

The scope of the state policy in the field of renewable energy resources is to enhance the state energy security and independence and reduce the negative impact of the energy sector on the environment, through annual increase of the share of produced and consumed renewable energy and fuels. The main renewable energy objectives of state policy include:

a) Diversification of the local primary energetic basis;
b) Safeguarding in the year 2020 the production of energy from energy sources in the amount of about 20% from the quantum of energy originated from traditional sources.
c) In 2020, the volume of bioethanol mixed with gasoline and the volume of biodiesel mixed with diesel shall be 20%, accordingly, from the volume of commercialized gasoline and diesel;
d) Creation of the system of production, distribution, commercialization and rational consumption of renewable energy and fuels;

The organizational and economic measures developed by the state authorities with regard to stimulation of renewable energy production and use include, in particular, incentives in the fiscal and crediting fields.

In accordance with the Law, Energy Efficiency Fund was created which is an independent and financially autonomous legal entity.

In order to realize the Objectives the concrete bodies are identified and specific duties are established for them by the Law. In particular,

the Government shall:

a) Implement the objectives and determine the priority directions of the state policy in the field of renewable energy sources;
b) Establish the procedure of organization and administration of the activities in the field of renewable energy sources;
c) Approve the state programs for promotion of production and use of renewable energy sources and supervise the implementation thereof;
d) Apply mechanisms and stimulations for economic-financial support of the renewable energy activities.

ANRE:

a) approves tariffs for each type of renewable energy, calculated by the producers based on the methodologies approved by ANRE, which shall provide for return of investments, as the case might be, in construction, extension, modernization of installations, as well as in the lines for connection, transportation and distribution of energy and fuels, for a term up to 15 years, providing the prescribed profitability rate does not exceed more than two times the corresponding rate for the traditional energy;

When approving the tariffs, the prices for similar products on international markets shall be taken into consideration;

b) Develop, as the case might be, acts on regulating relationships between the participants of the renewable energy sources market.

The state authority in the field of renewable energy sources is the National Energy Efficiency Agency (NEEA)

Law on Energy Efficiency

The Law regulates activities destined to reduce energy intensity in the national economy, and diminish negative impact of the energy sector on environment, the purpose being to create prerequisites for improving energy efficiency, including the foundation and support of structures involved in the development and implementation of activities and programs, plans, energy services and other measures on increasing energy consumption efficiency.

Economic agents, which implement measures and projects on improving energy efficiency may use loans or investment guarantees from the Energy Efficiency Fund's resources, in accordance with the Law on Renewable Energy No.1060 from July 12, 2007 and Regulation on Energy Efficiency Fund that is approved by the Government in 2012.

In order to implement important energy efficiency programs and projects financial sources can be allocated from the state budget.

Energy efficiency improvement measures can be financed by third parties based on a written agreement in compliance with the Law on Public-Private Partnership No. 179-XVI from July 10, 2008 and ESCO.

Energy companies and third parties involved in financing energy efficiency projects are eligible for tax incentives in accordance with provisions from the Tax Code.

Two main bodies are established to manage energy efficiency: The Government and National Energy Efficiency Agency (NEEA).

The Government establishes main directions for energy efficiency national policy; approve national energy efficiency programs and action plans; elaborate and apply energy efficiency mechanisms and financial instruments for energy saving; establish organizational order, structure and activity procedures for the state energy efficiency authority.

The Agency shall:

– implement state policy in energy efficiency and renewable energy sources;

participate in drafting normative acts including technical regulations and standards in energy efficiency and renewable energy sources; elaborate minimum energy efficiency requirements for the devices and equipment produced or imported in the Republic of Moldova and present them for approval to the central branch authority in charge of the energy sector; draft energy efficiency and renewable energy innovative projects; provide assistance, consulting, expertise, coordination, etc. in energy efficiency and renewable energy sources;

- authorize natural and legal entities with the right to perform energy audits; create a database on energy efficiency and renewable energy sources and present the information to the interested parties;
- disseminate the information, etc. on energy efficiency, including energy efficiency mechanisms, financial and legal frameworks adopted in order to meet the national indicative target, and on the use of renewable energy;

In order to identify and quantify costs for effective energy savings opportunities, and report the findings a system of Energy certificates should be implemented. Conditions for correspondence or not correspondence of legal and natural entities with the quality of an Energy Auditor shall be determined by the Certification Commission created by the NEEA.

Every year NEEA jointly with institutions and organizations from the field shall present proposals with the topics for researches and experimental activities in energy efficiency.

National and local Programs and Action Plans are planned to be implemented to improve energy efficiency.

<u>Energy Strategy of the Republic of Moldova until year 2020</u>.

In accordance with energy policy objectives, the general environment objective specific to energy policy is the reduction of the impact of energy generation and use on the environment. This will be sought mainly by:

- promoting activities towards increasing energy efficiency in all sectors; and
- increasing the amount of energy produced from renewable sources.

An essential factor for the implementation of the Strategy is its financial component, i.e. its capital investment needs. These investments are required to upgrade all energy system components (i.e. generation-transmission-distribution-consumption) whilst taking into consideration the rules and policies of the Energy Community and the EU integral energy market.

An Indicative Action Plan for implementation of the Energy strategy until the year of 2020 is developed, in which the name of the sector and the concrete actions, Time frame, Responsible institution, Estimated investments and Sources of funds are identified. It comprises the following sectors and domains: Electricity sector: International interconnections, Internal transmission network, Electricity generation, Electricity distribution; Heating Sector; Natural Gas Sector; Liquid Fuel Sector; Renewable Energy Sources; Energy Efficiency; Institutional, legal and regulatory framework; Education, Training, Research and Development; International Cooperation and Attracting Investment.

<u>UNFCCC Clean Development Mechanism</u>

In the context of climate change, Moldova has set up a Designated National Authority (DNA) within the Ministry of Ecology and Natural Resources to promote Clean Development Mechanism (CDM) projects. It is governed by Government Decree no 1574 from 26.12/2003 (Monitorul Oficial No. 6-12 from 01.01.04, http://lex.justice.md/)

Two institution are involved to promote CDM Projects:

- The Climate Change Office under the Ministry of Environment which is the knowledge center on policy analysis and assessment of national GHG emissions, and
- The Financing Carbon Office under the Ministry of Environment, which currently oversees implementation of the CDM projects in Moldova.

1.2.2. Development priorities cluster

In order to facilitate the prioritization processes for sectors and technologies (described in the following chapters), the Moldova development priorities identified in the chapter 1.2 (reflected in the National Development Strategy 2008-2011) and analyzed in light of a changing climate in the same chapter are clustered in categories in the Table 1.2.2-1.

Table 1.2.2-1. Cluster of Moldova development priorities for short and medium/long term

Environmental Development Priorities	
Reduced soil degradation	Soil is continuing to degraded due to unsustainable harvesting
Extended forest area	The eco-protective function of forests is manifested more strongly only if the degree of the country afforestation exceeds 15% of a country's territory. For this reason, the forested area of the Republic of Moldova should be extended by around 150 000 hectares
Improved management of the water supply and sewerage sector	The current management of the water supply and sewerage sector is not adequate to today requirements
Economic Development Priorities	
Reduced the absolute poverty rate	26.3% of population is below poverty line (2009).
Increased energy security	Lack of own natural fossil fuel reserves is obliging the country to import more than 96% of energy resources needed. 70% of electricity demand is covered by import. All natural gas is coming from GAZPROM
Improved urban and rural roads	According to World Economic Forum the quality of the Republic of Moldova roads accumulate 1,6 point from a maximum of 7.
Establishment of an integrated and stable agricultural system	The vegetable crop production and animal breeding is not one integrated by each agricultural soil/climate zone
Improved employment	This holds for both quantity of jobs and human capital transfer
Social Development Priorities	
Access of rural child to well-equipped school	During the last 10-15 years in the many of the villages the number of child has decreased significantly and that has leaded to both lack of tutors and necessary equipment for qualitative teaching
Political Priority	
Re-integrate the country	Because of Transnistria secessionism, starting with 1992 Moldova territory located at left bank of river Nistru is not controlled by country recognized authorities

CHAPTER 2. INSTITUTIONAL ARRANGEMENT FOR THE TNA AND THE STAKEHOLDERS' INVOLVEMENT

2.1. TNA team, national project coordinator, consultants, etc.

The National TNA team includes a TNA Coordinator, a wide range of stakeholders to constitute the National TNA Committee and National Consultants/experts organized in workgroups. A National Steering Committee is envisaged as the top most decision making body of the TNA Project, comprising policy makers from relevant key ministries. As presented in Figure 2.1-1, as well as in the detailed description provided next, each element of the in-country institutional structure is designed to play an important role.

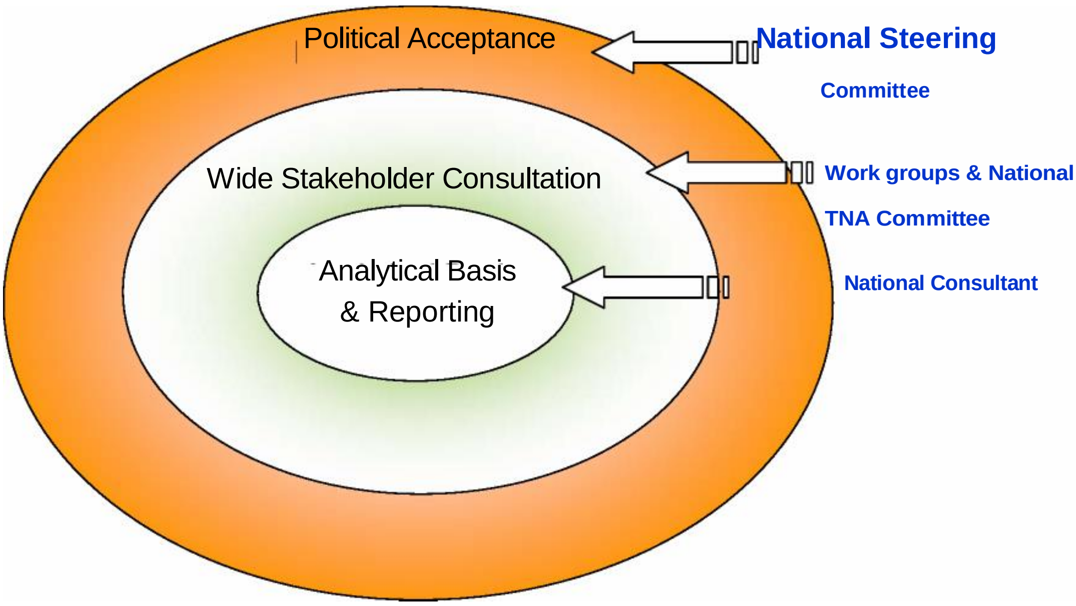

Figure 2.1-1. Role of Institutional Elements for the TNA Project in the Republic of Moldova

National Steering Committee

National Steering Committee is envisaged as the top most decision making body of the project. The National Steering Committee is comprised of members responsible for policy making from relevant ministries as well as key stakeholders from the academia sector and civil society. The National Steering Committee provides political acceptance to the TNA process and is also responsible for appointment the National TNA Committee, as well as for the political acceptance for the Technology Action Plan (TAP).

Republic of Moldova National Steering Committee

1. **TNA Coordinator:**

   PhD Vasile SCORPAN

2. **Members of National Steering Committee:**

   1) H.E. Gheorghe SALARU, Minister, Ministry of Environment; UNFCCC and GEF Focal Point, Head of National Steering Committee;

2) Mrs. Maria NAGORNII, Head of Direction, Direction Analysis, Monitoring and Policies Evaluation, Ministry of Environment, Steering Committee Member.
3) Mr. Pintilie PIRVAN, Head of Direction, Food Industry Direction, Ministry of Agriculture and Food Industry, Steering Committee Member.
4) PhD Vladimir BERZAN, Director, Institute of Power Engineering, Academy of Sciences of Moldova, Steering Committee Member.
5) Prof., PhD Petru TODOS, first vice-rector, vice-president of the Council of Administration of the Technical University of Moldova; Technical University of Moldova, Steering Committee Member.
6) Mr. Stefan LOZINSCHII, Director, Association of Environment Radio Journalists "ECOTERA" (NGO), Steering Committee Member.

3. Members of National TNA Committee:

1) Mrs. Galina PARSIAN, Deputy Head of Direction, Thermo Power Direction; Ministry of Economy,
2) Mrs. Tamara ROZNERITA, Deputy Head, Direction Ecological Agriculture, Renewable Energy and Irrigation, Ministry of Agriculture and Food Industry,
3) Mr. Sergiu BRUMA, Head of Direction, Direction of Technology Transfer, Agency of Innovation and Technology Transfer, Academy of Sciences of Moldova;
4) PhD Mihai TIRSU, Deputy-Director, Institute of Power Engineering, Academy of Sciences of Moldova;
5) Acad., PhD Ion HABASESCU, Director, Institute of Agriculture Technics "MECAGRO" of the Academy of Sciences of Moldova;
6) Prof., PhD Dumitru UNGUREANU, vice-rector for practical instruction, social issues and relationships with technical colleges, Technical University of Moldova;
7) Prof., PhD Grigore MARIAN, State Agrarian University of Moldova, Faculty of Agricultural Engineering and Auto Transportation, Department of Machines Maintenance and Materials Engineering;
8) PhD. Andrei CHICIUC, Vice-director "Energie Plus" University Centre, Technical University of Moldova.
9) Prof., PhD Aurel GUTU, Technical University of Moldova
10) Prof., Grigore FRIPTULEAC, the State University of Medicine and Pharmaceuticals of Moldova "Nicolae Testimiteanu".

4. Institutions Overview

1) Ministry of Environment;
2) Ministry of Economy;
3) Ministry of Agriculture and Food Industry;
4) Agency of Innovation and Technology Transfer of the Academy of Sciences of Moldova;
5) Institute of Power Engineering of the Academy of Sciences of Moldova;
6) Institute of Ecology and Geography of the Academy of Sciences of Moldova;
7) Institute of Agriculture Technics "MECAGRO" of the Academy of Sciences of Moldova;
8) Practical Scientific Institute of Plant Growing of the Academy of Sciences of Moldova;
9) Technical State University;
10) State Agrarian University of Moldova;
11) RED Union Fenosa S.A.;

12) MOLDAGROTEHNICA S.A.;
13) Ministry of Health;
14) Agency of Innovation and Technology Transfer;
15) State Hydrometeorological Service.

National TNA Team

The National TNA Team is the main decision making body for the project with the TNA Coordinator acting as a focal point. The National TNA team is comprised of a small core group as the National TNA Committee, and a broader group of stakeholders and experts, that are aid the core group. This broader group includes national consultants and sectoral / technological workgroups. The TNA coordinator will play a key role and coordinate amongst the different groups to ensure that they work together as a team.

TNA Coordinator

The appointment of the TNA Coordinator was done by the Ministry of Environment of the Republic of Moldova (the representing of MoEN performs the functions of UNFCCC Focal Point, as well as of GEF Political and Operational Focal Points). The TNA Coordinator is the focal point for the effort and manager of the overall TNA process. This involves providing vision and leadership for the overall effort, facilitating the tasks of communication with the National TNA Committee members, National Consultants and stakeholder groups, formation of networks, information acquisition, and coordination and communication of all work products.

The leadership of the TNA coordinator is critical for the success of the TNA, therefore it was ensured that the skill set of the TNA Coordinator include facilitation skills, project management, and some scientific background, as these are likely to be advantageous in terms of familiarity with technology specifications and performance requirements.

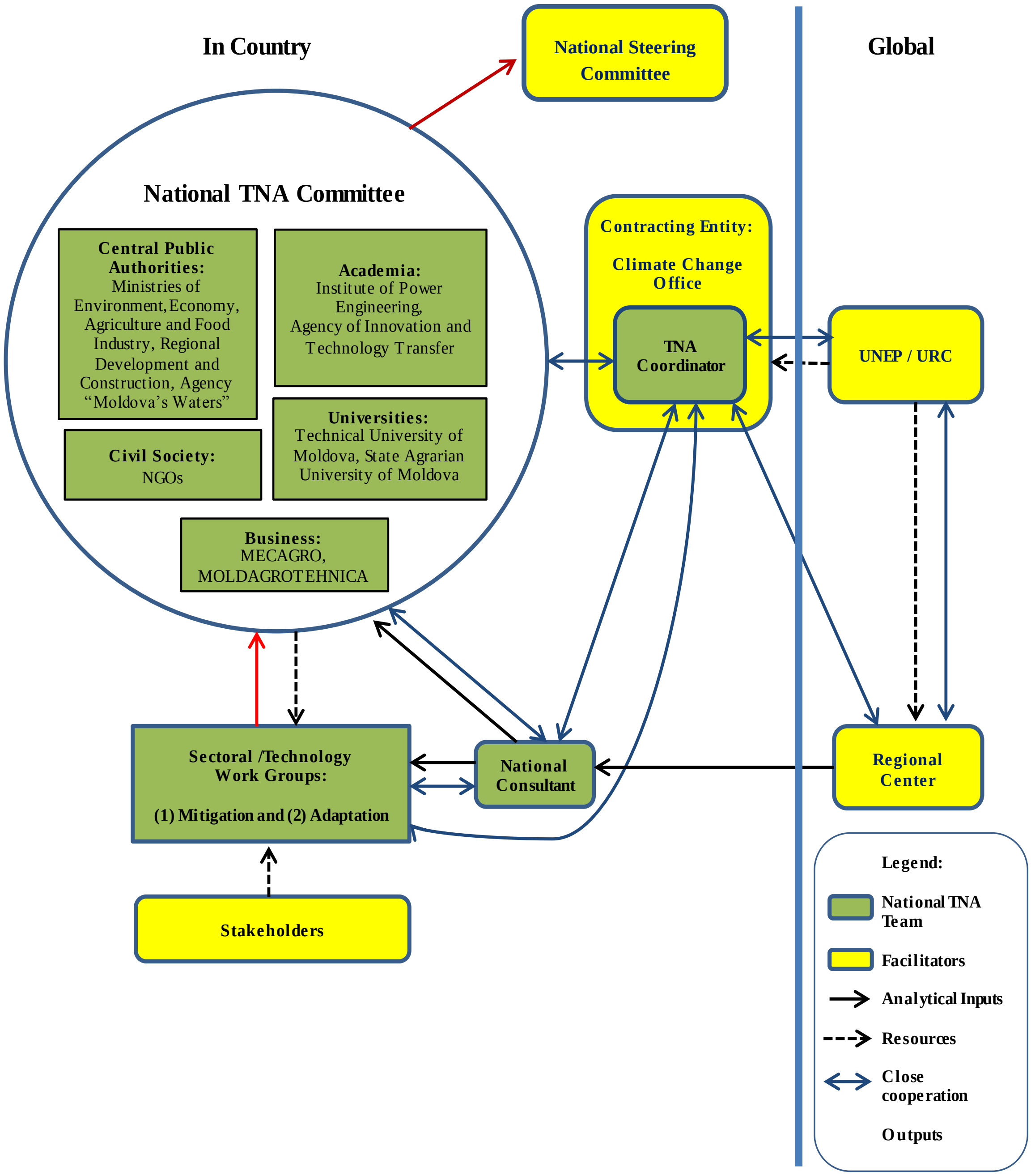

Figure 2.1-2. Institutional Structure for the TNA project in the Republic of Moldova

National TNA Committee

The National TNA Committee is the core group of decision makers and includes representatives responsible for implementing policies from concerned ministries, members familiar with national development objectives, sector policies, climate change science, potential climate change impacts for the country, and adaptation needs.

The role of the National TNA Committee is to provide leadership to the project in association with the TNA coordinator. Specific responsibilities will include also:

1. Identifying national development priorities, and priority sectors from thereon;
2. Deciding on the constitution of sectoral / technological workgroups;
3. Approving technologies and strategies for mitigation and adaptation which are recommended by sectoral workgroups;

4. Approving the Sectoral Technology Action Plan (a roadmap of policies that will be required for removing barriers and creating the enabling environment) and developing a cross cutting National Technology Action Plan for mitigation and adaptation.

National Consultants

The National TNA Committee has engaged a number of professionals and relevant institutions from strategically important sectors of Moldova's economy, possessing deep knowledge and extended experience in the area, high scientific degrees (PhD and habilitate) and holding administrative institutional positions. Most of the experts have participated in other climate change Projects, particularly National Communications, which is of great benefit for TNA assessment. Involvement in the TNA assess of high level professionals from different sectors, assured a multidisciplinary team, led by the National Coordinator, who has a rich administrative and technical background and extended experience in climate change. The role of the national consultants is to lead and undertake activities such as research, analysis and synthesis in support of the TNA exercise.

The national consultants/experts worked in close collaboration with the National TNA Committee and sectoral work groups, and are directly responsible to the TNA Coordinator.

The national consultants'/experts overall task is to support the entire TNA process. The national experts are an important component of the TNA Project and participated in the capacity building workshops organized by UNEP Risoe Centre in Chisinau.

The national consultants/experts assisted the TNA coordinator in applying a participatory approach to the TNA process by facilitating the tasks of communication within the national TNA team, outreach to stakeholders, formation of networks, and coordination and communication of work products.

The national consultants have undertaken the following tasks:

- Provided support to the identification and categorization of the country's priority sectors, and identification and prioritization of technologies for mitigation and adaptation through a participatory process with a broad involvement of relevant stakeholders;
- Facilitated the process of analyzing with the work groups how the prioritized technologies can be implemented in the country

Sectoral / Technological Workgroups

The stakeholders are central to the TNA process. Therefore, to give an active role to the stakeholders in the TNA process, constitution of workgroups is proposed.

The workgroups are constituted by the National TNA Committee. The workgroups are on sectoral basis and they decide on the technologies appropriate for a sector, undertake market / barrier analysis and recommend an enabling framework for the sector.

During inception workshop the TNA Team and stakeholders agreed upon activities to be implemented during Project lifetime and budget allocated. A detailed draft of Work Plan was elaborated and discussed with stakeholders, and the final version was endorsed by the stakeholders and experts.

The **leading national Agency for implementing TNA assessment Project is the Climate Change Office**, Ministry of Environment, Republic of Moldova. In the implementing TNA Project the methodological guidance was provided during TNA workshop in Bangkok (8-11 August, 2011) and the following methodological sources have been used: UNDP Handbook *Technology Needs*

Assessment for Climate Change, Climate TechWiki website, *Multi-criteria analysis:* a *manual*, the TNA guide *Technologies for Climate Change Adaptation, Agriculture sector*, guidance provided by URC Country Coordinator, UNEP Risoe Centre website information, and the Asian Institute of Technology**.** The activities were implemented according to the Working Plan time schedule approved during the inception workshop.

These methodologies have been adjusted to the country specific circumstances, collecting relevant data for performing TNA assess.

2.2. Stakeholder Engagement Process followed in TNA – Overall assessment

The TNA activities involved stakeholders in all stages of technology prioritization to ensure relevance of appraised technologies and to engage stakeholders that will be central to implementation of prioritized technologies.

Meetings with selected stakeholders

During the assessment of adaptation technologies TNA core team tried to have a strong engagement of stakeholders in order to have their commitment in the implementation of further actions, bring knowledge skills, their experience in the area, new ideas. The TNA Team identified stakeholders involved in the mitigation expertise. Firstly, the identification of those who are directly impacted by the climate change in the area of interest: Ministry of Environment, Ministry of Agriculture and Food Industry, Ministry of Economy, Academy of Sciences of Moldova, Institute of Ecology and Geography of the AS of Moldova, State Hydrometeorological Service, Agency of Innovation and Technology Transfer, other institutions. This initial group of stakeholders was requested to suggest other stakeholders who have interest in promoting technology transfer and are concerned of future climate change impact. An iterative method was applied in identifying other stakeholders, especially those in local and national institutions who have the power to support the technology transfer process. The audiences that are specifically targeted in this wise are planners and decision makers, sectoral planners and key stakeholders at the local and national levels. They are representatives of ministries, persons with strong political background, business representatives, sectoral experts, academic and research communities' representatives, members of NGOs with climate change status, private sectors (Table 2.1-3). The stakeholders group included men and women, youth and senior persons.

Ministry of Environment, Ministry of Agriculture and Food Industry and National Agency of Energy Efficiency, and key national institutions are identified as potential leading institutions in technological transfer and included in the National Steering Committee of TNA Project.

Approaches used for better engagement of stakeholders in the TNA Project

A number of approaches were applied to have stakeholders' engagement in the current Project. These are formal and informal events: appreciative inquiries, informal meetings, workshops, including TNA inception national workshop, focus group meetings, sector group meetings policy dialogues, participatory events. Interactive participation involving experts and stakeholders in terms of joint analysis and joint action planning to build a strong sense of shared ownership and long term implementation activities was used during TNA assess.

During the inception workshop selected stakeholders have been introduced to the TNA objectives, were proposed and agreed the Working Plan and Project time table during the inception workshop.

Table 2.2-1. Stakeholders involvement in the activities of TNA project

Stakeholders	TNA Activities	
	Workshops	Group meetings
Ministries: of Environment; of Economy; of Agriculture and Food Industry; of Health.	• Inception workshop, • Sector's prioritisation workshop.	• Identification of national priorities, • Clustering of national priorities, • Prioritisation of the sectors, • Providing information and participation in the discussions of current state of technology in particular sector • Technology prioritisation applying MCDA.
Academic and research institutions: State University of Medicine and Pharmaceuticals of Moldova "Nicolae Testimiteanu". Technical State University; Institute of Power Engineering of the Academy of Sciences of Moldova; Institute of Ecology and Geography of the Academy of Sciences of Moldova; State Agrarian University of Moldova; State University of Medicine and Pharmaceuticals of Moldova "Nicolae Testimiteanu Research Institute in Forestry and Silviculture planning	• Inception workshop, • Sector's prioritisation workshop.	• Identification of national priorities, • Prioritisation of the sectors using MCDA; • Providing information and participation in the discussions of current state of technology in particular sector; • Technology prioritisation applying MCDA
Agencies National Agency for Energy Regulation; National Agency for Energy Efficiency;	• Inception workshop • Sector's prioritisation workshop	• Identification of national priorities, • Prioritisation of the sectors using MCDA; • Providing information and participation in the discussions of current state of technology in particular sector; • Technology prioritisation applying MCDA
Business representatives RED Union Fenosa S.A.;	• Inception workshop • Sector's prioritisation workshop.	
State Hydrometeorological Service	• Inception workshop • Sector's prioritisation workshop.	
NGO NGO "Ecospectr" NGO "Energie Plus"	• Inception workshop • Sector's prioritisation workshop.	

Stakeholders' involvement in the clustering of national priorities

The identification of national priorities has been done commonly by the TNA Project experts and interested stakeholders, members of working group. The team leader has informed working group members about the need to consult country's documents where national medium and long term priorities are articulated. In the activities related to national priorities clustering, especially valuable were opinions and experience of Ministry level stakeholders: Ministry of Environment, Ministry of Economy, Ministry of Agriculture and Food Industry. These stakeholders participated in the collection of the documents where national priorities specified and showed good knowledge and constructive approach during all the activities with national priorities involvement.

Stakeholders' involvement in sector and technology prioritizations

The consultation with stakeholders was an on-going process during all phases of the Project done so far, of particular importance were their consultations and opinions in providing technological details about current situation in the sectors. Ministry of Economy has provided details about current situation of technologies used in the power production and what the technologies are projected for the future, accent being made on the necessity to diversify the fuels used.

The stakeholders have an important contribution in developing the final set of criteria and indicators used for technology options prioritization. Broad discussions were developed when considering different options of technologies in electricity production, and also important arguments were brought up during the exercise of giving weight to criteria, as working group members judgment depending on their knowledge, interests, other considerations. During these discussions stakeholders' opinions and arguments were highly considered being decisive in setting short list of adaptation technologies.

Stakeholders from energy sector had high involvement in sectors prioritization, providing data from electricity and heat supply systems.

Organizations that could benefit from the TNA assessment include those specifically responsible for environmental sectors (Ministry of Environment), and those responsible for development sectors such as Ministry of Economy and Ministry of Transport and Road Administration. These organizations have extended experience in implementing national and international projects, and it will mainly be interested in the development and implementation of new technologies. All stakeholders are keen to see that the implementation of the Project would bring high benefits to Moldova, as it would lead to an increased degree of competitiveness in the climate change adaptive capacity and resilience.

CHAPTER 3. (SUB) SECTORS PRIORITIZATION FOR CLIMATE CHANGE MITIGATION

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

According to the 'National Inventory Report: 1990-2005, Greenhouse Gas Sources and Sinks in the Republic of Moldova the following GHG emissions structure were identified by sectors for 2000 and 2005 years (Table 3.1-1).

Table 3.1-1. Republic of Moldova's GHG Emission by Sector in 2000 and 2005 years

Greenhouse Gas Categories	2000, Gg CO_2 eq	2005, Gg CO_2 eq	% increase in emissions from 2000 to 2005	Share of GHG per sectors, %
National Total (excluding LULUCF)	9839.95	11883.46	**20.8**	
National Total (including LULUCF)	8486.8	10502.4	**23.7**	**100**
1. Energy	5437.82	7724.81	**42**	**74**
A. Fuel Combustion Activities	4934.43	7070.91	43	67
1. Energy Industries	2653.71	2989.77	13	28
2. Manufacturing Industries and Construct.	258.17	396.99	54	4
3. Transport	848.27	1654.52	95	16
4. Other Sectors	1122.76	1911.11	70	18
5. Other (other works and needs in energy)	51.51	118.52	**130**	1
B. Fugitive Emissions from Fuels	503.4	653.9	30	6
1. Solid Fuels	NO	NO		
2. Oil and Natural Gas	503.4	653.9	30	6
2. Industrial Processes	325.6	581.9	**79**	**6**
A. Mineral Products	217.93	416.84	91	4
B. Chemical Industry	NO, NE	NO, NE		
C. Metal Production	91.22	105.29	15	1
D. Other Production	12.25	40.77	233	0
E. Production of Halocarbons and SF6	NO	NO		
F. Consumption of Halocarbons and SF6	4.21	19	351	0
3. Solvents and Other Products Use	33.06	49	**48**	**0.5**
A. Paint Application	6.74	17.98	167	0
B. Degreasing and Dry Cleaning	0.34	1.24	265	0
C. Chemical Products, Manufacture and Processing	0.1	0.29	190	0
D. Other	25.89	29.49	14	0
4. Agriculture	2312.19	2127.79	**-8**	**20**
A. Enteric Fermentation	903.06	792.86	-12	8
B. Manure Management	762.67	635.68	-17	6
C. Rice Cultivation	NO	NO		

Greenhouse Gas Categories	2000, Gg CO_2 eq	2005, Gg CO_2 eq	% increase in emissions from 2000 to 2005	Share of GHG per sectors, %
D. Agricultural Soils	646.46	699.25	8	7
E. Prescribed Burning of Savannas	NO	NO		
F. Field Burning of Agricultural Residues	IE	IE		
5. LULUCF	-1353.15	-1381.06	**2**	**-13**
A. Forest Land	-2140.32	-2246.2	5	-21
B. Cropland	1612.69	1684.6	4	16
C. Grassland	-825.53	-819.46	-1	-8
D. Wetlands	NE	NE		
E. Settlements	IE	IE		
6. Waste	1731.28	1399.96	**-19**	**13**
A. Solid Waste Disposal on Land	1536.42	1186.21	-23	11
B. Wastewater Handling	194.86	213.75	10	2
C. Waste Incineration	NO, NE	NO, NE		
7. Other	NO, NE	NO, NE		
International Bunkers	66.95	64.64		
CO2 emissions from biomass	367.86	295.04		

Abbreviations: IE – Included Elsewhere; NE – Not Estimated; NO– Not Occurring

Comparing 2000-2005 GHG emission trends it can be observed the highest increase of CO_2eq is marked for Energy (42%), Industry process (79%) and Solvents and Other Products Use (48%) whereas the biggest share in the total country GHG emissions is recorded for Energy (74%) and Agriculture (20%), the other two sectors mentioned above, i.e. Industry process and Solvents and Other Products Use being distinguished by a much lower share in the total country GHG emissions: 6% and 0,5% respectively. No GHG share emissions increasing for these two sectors are foreseen in the following years. So that there is no reason to examine these two sectors, as well as the sector Other, in the following analyses devoted to GHG emission reduction sectors prioritization.

3.2. Short list of prioritized (sub)sectors

Taking into consideration the conclusion made in the p. 3.1, the following sectors are of high GHG relevance and hence is considered for the list of prioritized sectors: Energy, Agriculture, LULUCF and Waste. From these sectors should be chosen those sectors that cumulatively encompass more than 75% of the total country GHG emissions. Analyzing the evolution of GHG emissions by sectors up to 2030 shown in the Table 3.2-1, we can conclude that the increasing of CO_2 emissions in all three scenarios, i.e. Base Line Scenario (BLS), High Alternative Scenario (HAS) and Intermediary Alternative Scenario (IAS), during 2005-2030 has the following values, for:

1. LULUCF sector varies between: (-4) – (+1) %;
2. Agriculture sector varies between: 14 – 15 %;
3. Waste sector varies between: 6 – 11%.

Table 3.2-1. Projections of Greenhouse Gas Emissions and Sinks in the RM by sector under the Scenarios Considered for the 2005-2030 time series, Gg CO_2eq

Scenarios and Sectors	2005	2010	2015	2020	2025	2030	Share of emissions increase (in %) (2030/2005), compared with the difference between the total national GHG emissions (with LULUCF) in 2030 and 2005
Baseline Scenario (BLS)							
Energy	7,725	10,272	12,335	14,443	16,420	19,582	65
Industrial Processes	582	758	984	1,286	1,736	2,431	10
Agriculture	2,128	2,654	3,158	3,728	4,337	4,841	15
LULUCF	-1,381	-1,416	-1,451	-1,488	-1,525	-1,563	-1
Waste	1,400	1,540	1,837	2,245	2,771	3,402	11
Total (With LULUCF)	10,453	13,808	16,862	20,214	23,739	28,693	
Total (Without LULUCF)	11,835	15,224	18,314	21,702	25,264	30,256	
High Alternative Scenario (HAS)							
Energy	7,725	9,426	11,050	12,992	14,785	17,866	72
Industrial Processes	582	727	909	1,177	1,555	2,060	11
Agriculture	2,128	2,604	2,996	3,405	3,872	4,187	15
LULUCF	-1,381	-1,558	-1,669	-1,785	-1,830	-1,876	-4
Waste	1,400	1,281	1,495	1,673	1,962	2,282	6
Total (With LULUCF)	10,453	12,480	14,781	17,461	20,343	24,519	
Total (Without LULUCF)	11,835	14,037	16,450	19,246	22,173	26,395	
Intermediary Alternative Scenario (IAS)							
Energy	7,725	9,876	11,787	14,147	16,114	18,947	68
Industrial Processes	582	743	938	1,215	1,612	2,232	10
Agriculture	2,128	2,636	3,077	3,594	4,083	4,458	14
LULUCF	-1,381	-1,274	-1,234	-1,190	-1,220	-1,250	1
Waste	1,400	1,423	1,638	1,867	2,189	2,614	7
Total (With LULUCF)	10,453	13,403	16,206	19,633	22,778	27,001	
Total (Without LULUCF)	11,835	14,677	17,439	20,823	23,998	28,252	

As it is seen, Agriculture sector has the most GHG emission growth during 2005-2030, it being distinguished by the highest share of emissions amongst these four sectors in 2005 year (20% versus 13% for Waste sector), being kept at approximately the same level for the following years as well.

Finally we can assume that Energy and Agriculture sectors can be considered in the short list of sectors, chosen for new technologies implementation. They encompass 94% of total country GHG emissions in 2005. In order to make more aimed and determined new GHG emission reduction technologies for their future implementation the two sectors chosen need to be divided by subsectors. They are presented in the Table 3.2-2.

Table 3.2-2. Energy and Agriculture subsectors GHG emissions in 2005

Sectors	Subsectors	GHG emissions	
		Gg CO_2eq	% from total
1. Energy	1. Energy Industries	2990	30
	2. Manufacturing Industries and Construction.	397	4
	3. Transport	1655	17
	4. Other Sectors	1911	19
	5. Other (other works and needs in energy)	119	1
	6. Oil and Natural Gas (Fugitive Emissions from Fuels)	654	7
2. Agriculture	A. Enteric Fermentation	793	8
	B. Manure Management	636	6
	D. Agricultural Soils	699	7
TOTAL		**9853**	**100**

Three subsectors from the Table 3.2-2 are excluded from the list:

a) 2 “Manufacturing Industries and Construct” and 5“Other (other works and needs in energy)”, for the reason their share of GHG emission is too small, 4% and 1% respectively.

b) 6. “Oil and Natural Gas (Fugitive Emissions from Fuels)”, because in the Natural Gas sector a CDM Project is launched in Moldova recently, leading to significant Fugitive Emissions reduction and making the CO_2 emission share of this subsector too small for further examination Table 3.2-3 gives more detailed GHG emission reduction subsectors short list looks as follows:

Table 3.2-3. GHG emission reduction (sub) sectors short list, 2005 year

Sectors	Subsectors	GHG emissions	
		Gg CO_2eq	% from total national GHG emissions (with LULUCF)
1. Energy	Energy industries	2990	**83**
	Transport	1655	
	Other Sectors	1911	
2. Agriculture	Enteric Fermentation	793	
	Manure Management	636	
	Agricultural Soils	699	
TOTAL		**8684**	

GHG emissions of (sub) sectors chosen in the short list presented in the Table 3.2-3 comprise 83% of country CO_2eq emissions.

3.3. Identification of prioritized (sub) sectors for climate change mitigation

Below the (sub)sectors are identified where improvements (e.g., in terms of low emission technologies or coping strategies) would make a strong contribution to meeting the development priorities specified in the chapter 1.1 above and to reducing GHG emissions or vulnerability to climate change.

Improvements are defined in terms of contribution to the clusters of criteria defined in chapter 1.1.2 (Table 1.1.2-1, economic, social and environmental development contribution) in comparison to the present situation in (sub) sectors and future trends.

The identification of prioritized (sub)sectors was done based on Stakeholders contribution through Multi Criteria analysis process in TNA assessment. Before proceed to Multi Criteria analysis process The Stakeholders were familiarized with: a) the existing technologies used in the (sub)sectors, described below; National Inventory Report: 1990-2005 and others sources; b) the impacts of the (sub)sectors on the country's sustainable development and where could the largest improvements be achieved, as they are described in the Second National Communication of the Republic of Moldova, the draft Low Emissions Development Strategy of the Republic of Moldova to the year 2020 and other sources.

The following rating scheme was used:

0 — no benefit

1 — faintly desirable

2 — fairly desirable

3 — moderately desirable

4 — very desirable

5 — extremely desirable

In the Table 3.3-1 performance matrix for prioritizing subsectors is shown, were the scores correspond to average Stakeholders' scores for each cell. Criteria contribution to the total benefit of each subsector is seen from the Fig. 3.3-1.

Table 3.3-1. Performance matrix for prioritizing subsectors

Subsector	Economic priorities	Social priorities	Environmental priorities	GHG reduction potential	Total benefit
Energy industries	4.875	3.875	4.5	4.875	18.125
Transport	4.25	3.875	4	4.375	16.5
Other Sectors	4	3.25	3.375	4.25	14.875
Enteric Fermentation	1	1.125	1.25	2.375	5.75
Manure Management	2.375	3.125	2.5	3.75	11.75
Agricultural Soils	4.125	3.125	2.5	3.875	13.625

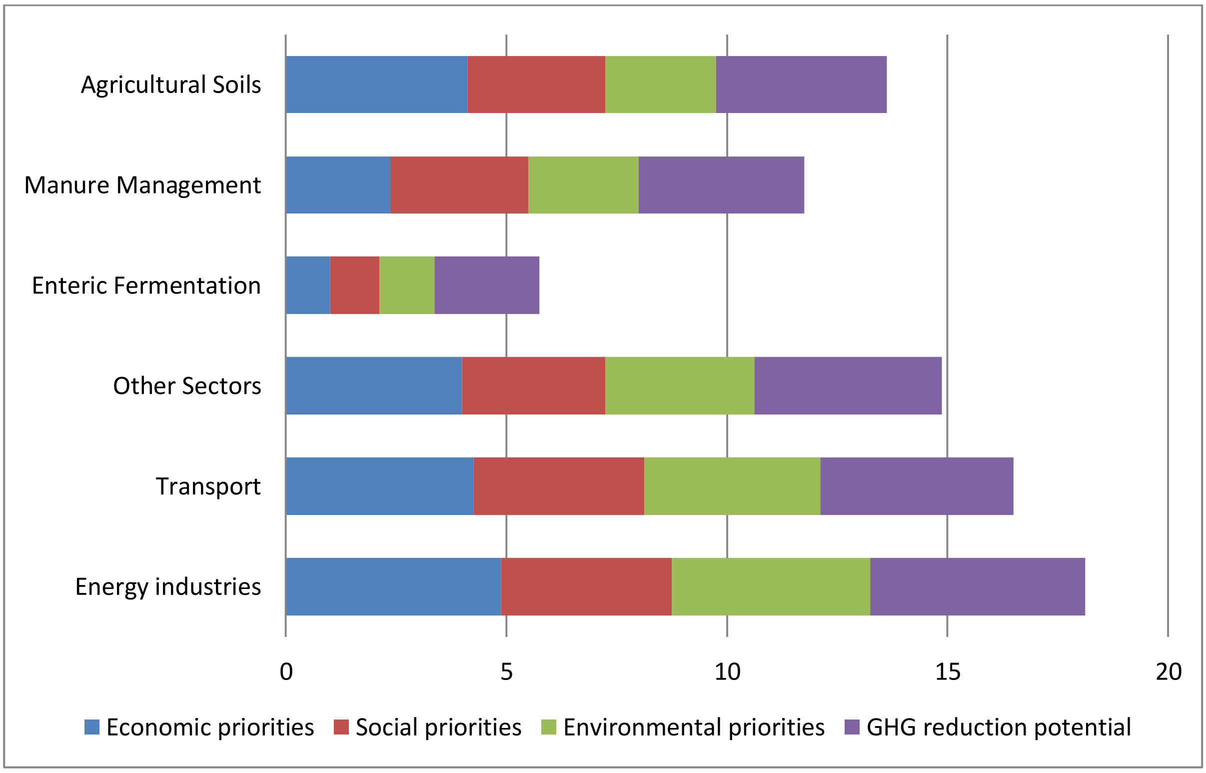

Figure 3.3-1. Criteria Contribution Graph

As we can see from the Table 3.3-1 and the Fig. 3.3-1 all the subsectors are distinguished by approximately the same, quite high level of GHG reduction potential, except Enteric Fermentation for which it is much lower. From the economic point of view two subsectors, Enteric Fermentation and Manure Management have a score much lower than other four subsectors. So that taking into consideration both GHG reduction potential and economic priority we can assume that the following four subsectors are most preferable for further consideration: Energy industries, Transport, Other Sectors and Agricultural Soils, which contribute by 69% to country total GHG emissions.

CHAPTER 4. COMMON ASPECT ON TECHNOLOGIES IDENTIFICATION AND CATEGORIZATION

Before Stakeholders be involved in the process of Energy and Agriculture technologies categorization 11 experts (In the Table 4.1 experts' expertise area is presented) identified the long list of technologies per each subsector. The experts classified the technologies in four categories: small scale technologies available in the short term; small scale technologies available in the medium to long term; large scale technologies available in the short term; and large scale technologies available in the medium to long term.

Small scale technologies are those that are applied at the household and/or community level, which could be scaled up into a program. Technologies applied on a scale larger than household or community level are considered large scale technologies. Short term technologies have been applied commercially with proven reliability in a comparable market context. Medium term would be pre-commercial in that given market context (5 years to full marketing) and a long term technology would still be in an RD&D phase or a prototype.

The technologies were selected from all available sources, including Climate TechWiki, the references being reflected in the Experts' Reports. For each technology a Technology Fact Sheet (TFS) was completed (See Annex 1) were main characteristics are described, including expected GHG emissions reduction, Economical, Environment and Social impact. Based on the data collected in the TFSs, the technologies were discussed with Stakeholders, permitting to develop long list of technologies and then to proceed to further their examination, having the goal to prioritize them.

Table 4-1. The experts involved in TNA assessment and their area of expertise

No	Expert name	Position, title, Institution	Area of expertise
	Comendant Ion	Ph.D, Research Coordinator, Institute of Power Engineering ASM	Team Leader of Mitigation Team under the TNA Project, Power System, Energy Efficiency, Renewable Energy Sources economic analysis, Climate Change, Energy Regulations, Tariffs
2	Gutu Aurel	Professor, Ph.D, Moldova Technical University	Heat generation technologies, energy efficiency, Residential and Administrative Energy conservation measures and technologies in Residential and Administrative buildings, etc.
3	Cosman Sergiu	Professor, Ph.D, Scientifically-Practical Institute for Biotechnologies in Zootechnics and Animal Medicine	Nutrition and feed technology
4	Sula Andrei	Engineer, National Agency for Energy Regulation	Power sources development, Power generation technologies
5	Ungureanu Dumitru	Professor, PhD, Technical University of Moldova	Environment Protection, Wastewater and Sludge Treatment; Biogas Power Plant.
6	Sobor Ion	Professor, PhD, Technical University of Moldova	Solar and Wind Power Plants

No	Expert name	Position, title, Institution	Area of expertise
7	Dulghieru Valeriu	Dean of Theory of mechanisms and machine parts faculty, Professor, Technical University of Moldova	Wind farms
8	Muntean Alexandru	PhD, Associate professor, State Agricultural University of Moldova	Renewable: Biomass for energy production
9	Codreanu Sergiu	Engineer, ICS RED Union Fenosa S.A.	Transport sector technologies
10	Bucataru Nicolae	Professor, Ph.D, Technical University of Moldova	Enteric Fermentation, Manure Management
11	Cerbari Valerian	Professor, Doctor Habilitatus, pedologist, Head of Pedology Laboratory, Institute of Pedology, Agrochemistry and Soil Protection "N. Dimo"	Soil resources, needs for land use systems improving and sustainable use of soil resources; assessing the GHG emissions from arable soils; soil quality monitoring, soil processing technologies, etc.

4.1. Assessing technologies with Multi-Criteria Decision Analysis (MCDA)

The technology prioritization was done according to the guidance provided during Bangkok training workshop, using TNA Handbook and Multi-criteria analysis manual, applying Multi Criteria Decision Analysis. During technology appraisal, the working group panel led by team leader applied the main 8 steps of MCDA:

1. Establish the decision context;
2. Identify the options to be appraised;
3. Identify objectives and criteria;
4. "Scoring": assess the expected performance of each option against the criteria;
5. "Weighting": assign weights and scores for each of the criteria to reflect their relative importance to the decision;
6. Combine the weights and scores in a linear additive manner for each option to derive an overall expected value;
7. Examine the results;
8. Sensitive analysis;

In order to assess technologies the following steps, works and assumptions have been undertaken:

1. Eight meetings with the participation of 11 national experts were organized where the procedures described in the Chapter 5 and Annex 8 of the Handbook have been followed. Asia & CIS Technology Prioritization Workshop Proceedings were used as well.
2. The criteria for technologies assessing were identified. It was agreed to apply the same criteria for all four categories of technologies and measures. It has been chosen the following benefit criteria: GHG emission reduction, Social, Economical and Environmental. As costs: Investments and Prices. Other costs criteria, as NPV, IRR were not accepted because of: a) big input data uncertainties for technologies and their implementation, b) Moldova is still a

developing country with a low capacity to pay for energy consumed and for which investments and prices are very sensitive criteria in decision making. The hierarchy value tree of Energy and Agriculture sectors in the technological assessment is presented in the Fig. 4.1-1.

3. The experts worked out the Technology Facts Sheets (TFS) were the description of each technology is done and where Benefits and Costs are reflected in details. This information is crucial at the stage of grading each criterion for each technology by both the Experts and Stakeholders. TFSs are presented in Annex 1.

4. Based on criterion selected and agreed on Experts meetings an Excel Spreadsheet was developed for TNA (See Annex 2), having as a guide model MCA Tool Transport. Excel Spreadsheet elaborated has the following sheets and destinations:

   a) **Performance Matrix**. The Matrix is completed based on the data accumulated in TFS. For each technology it reflects the capacity of technology be implemented by 2030, the year to which all the technologies could be manifested altogether, including Long scale ones; Load Factor of the technology capacity in 2030, expressed in hour, i.e. Tm = 8760*LF, LF - Load Factor, %. It is needed to calculate the energy or the production of the technology; Specific investments in the concrete technology; Operation & Maintenance Costs, including specific costs of fuel or energy consumed; the technology GHG emission reduction by 2030 (See Annex 3).

   b) **Prioritization.** In the sheet a detailed guide was elaborated how carry out whole MCDA exercise by the user. There are two tables in the sheet. In the first one the user (See Annex 4):

   b1) Organizes the criteria by clustering them under high-level and lower-level objectives in a hierarchy.

   b2) Carries out "Scoring", i.e. assess the expected performance of each option (technology) against the criteria. The options are assessed on the criteria depending on how well each option performs on that criterion. During this process the scale of 0–100 is used to assess the technologies. The scores depend on how well the technology is performing on each criterion, being used in this process TFS data, Moldova Development Priorities described in the chapter 1.2, Assumptions and uncertainties identified.

   b3) Carries out "Weighting", i.e. Assign weights for each of the criterion to reflect their relative importance to the decision. The weighting is done after the scoring, because weights can only be given to criteria within the decision context. In multi-criteria assessment, evaluation criteria are weighted by experts to reflect the importance of a criterion by considering the difference between the top and bottom of the scales and how much you care about it. This is a standard "swing weighting" method and assistance is provided in the Sheet "**Prioritization"**.

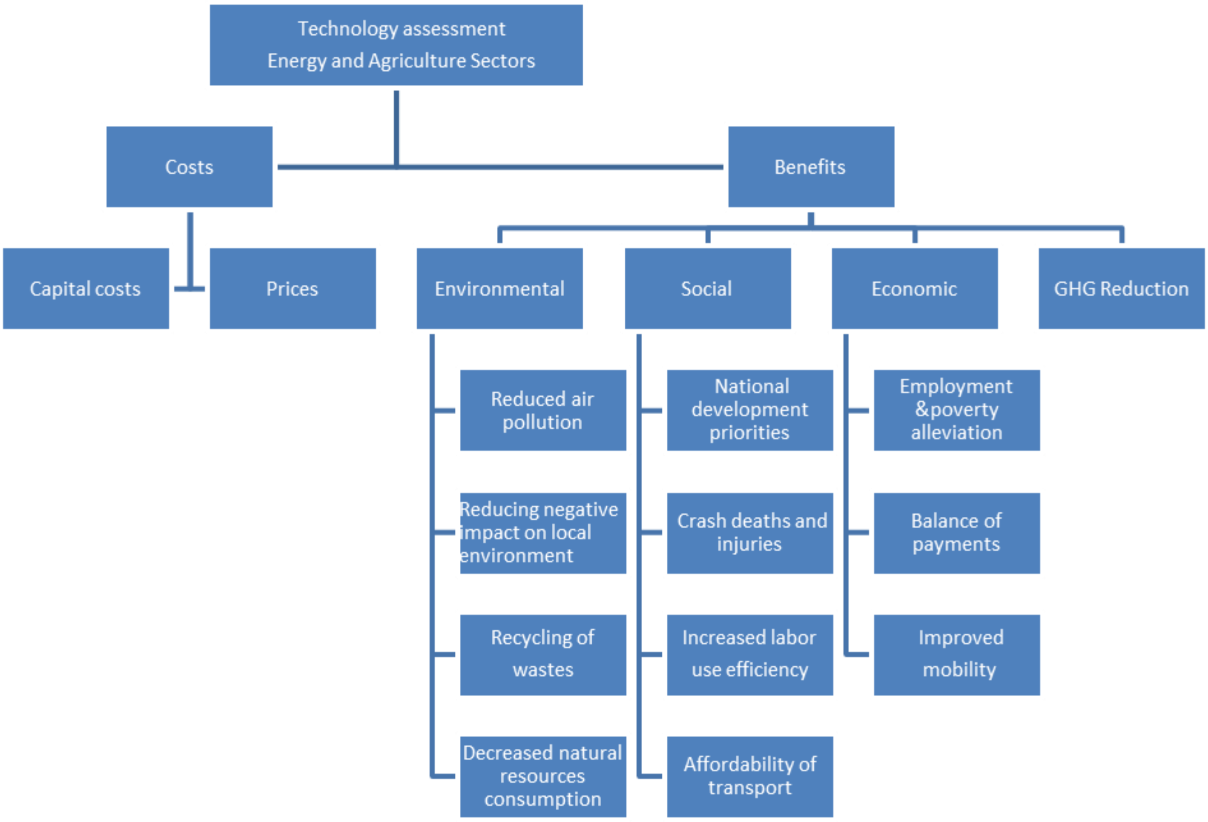

Figure 4.1-1. Hierarchy value tree of Energy and Agriculture sectors in the technological assessment

As soon as the appropriate cells from the first table are filled out in the second table the result of evaluation is obtained automatically, the user having the possibility to prioritize the technologies based on the total scoring obtained per each technology. The results give the overall value of the options, with the highest totals being the most preferred. From this, an initial indication of the top-ranked technology options within each portfolio set is given, relative to the evaluation criteria, weighting system, and scores applied. However, this is regarded as a "first pass" through the problem and it is not considered as the "final" answer. The decision must then be explored in terms of the uncertainties in the inputs and judgments made to check for robustness in the result, and balance in the main objectives for the preferred options and to explore possibilities for improving options.

c) **Cost-Benefits Analysis.** This sheet permits to take into consideration in more detailed manner the costs aspects in TNA assessmenting.

Cost-effectiveness is defined in terms of its use when a target must be reached at the lowest cost, or when there is a budget with which as many activities as possible must be carried out. Cost-effectiveness helps to identify relevant technologies according to how well they reach an environmental objective against a certain cost level. For Moldova the capital cost is the main cost criteria in TNA assessmentment, the experts group decided on their meetings. So that the most appropriate technologies within the country are identified in terms of benefit-to-cost of capital ratio. The appropriate graph from the „Cost-Benefits Analysis" sheet is built automatically when the cells of the first table in the sheet "Prioritization" are filled out, the experts choosing the options corresponded to the highest benefits at the lowest cost of capital.

- **d) National Priorities.** The sheet reflects the main National Development Priorities that should be taken into consideration when the cells of the first table of “Prioritization” sheet are filled out with the scores.
- e) **Priority (Sub) sectors.** The experts are using this sheet at the stage of familiarization with the share of GHG emissions corresponded to the subsector they are responsible for and help them to evaluate more adequately the scales applied to criterion for each option assessed.

5. Each of the experts has followed TNA assessmenting procedures described above after which the results were discussed at the common Experts meetings. Following the Handbook recommendations Sensitive analyses have been done for each of the technologies set chosen, the final results being reflected below. A sensitive analysis is carrying out based on the same Excel Spreadsheet and the same procedures described above in the p. 4.

CHAPTER 5. TECHNOLOGY PRIORITIZATION FOR SECTOR ENERGY-SUBSECTOR ELECTRICITY SUPPLY

5.1. Present status

At present Moldova power demand is covered by local PPs and from import (Ukraine). In the Table 5.1-1 the quantities of electricity produced by each power plant in 2010 is shown.

Table 5.1-1. Moldova PPs and their electricity production in 2010

Indicator	**GWh**	%
Own production, inclusive:	**5932**	**100**
HPP Dubăsari	328	5.5
HPP Costeşti	78	1.3
CHP 1	77	1.3
CHP 2	665	11.2
CHP Nord	57	1.0
CHP Sugar Factory	4	0.1
Condencing PP (MGRES, Transnistria)	4698	79.2
CHP Tirotex	25	0.4
Import	**25**	
Export	**370**	
Own consumption	**5588**	
Right Bank	3915	
Left Bank	1673	

As it is seen from the Table 5.1-2, the fossil fuel power plants are totally obsolete and depreciated, they being commissioned during the time when fossil fuel prices were very low and low attention to GHG emissions was paid. For example, the Moldovan Thermal Power Plants (MGRES), one of the largest power plant in the Eastern European area, is distinguished by the technologies for which the efficiency does not exceed 33-38%. As to CHPs, they were built without taking into consideration the real price for heat produced, it being considered neglected. Because of considerable heat demand decrease (more than three times) since 1990 when former USSR was disintegrated, CHP are not working on full capacity of cogeneration regime, leading to significant inefficiency and high prices for electricity and heat produced.

Table 5.1-2. Commissioning year of Moldova PP

Power Plant	**Unit**	**Capacity, MW**	**Commissioning year**	**Fuel used**
CET Nord	1	12	1970	natural gas/heavy fuel
	1	12	1995	natural gas/heavy fuel

Power Plant	Unit	Capacity, MW	Commissioning year	Fuel used
CET 1	1	5	1961	natural gas/heavy fuel
	2	10	1958	natural gas/heavy fuel
	3	12	1994	natural gas/heavy fuel
	4	27	1961	natural gas/heavy fuel
	5	12	2001	natural gas/heavy fuel
CET 2	1	80	1976	natural gas/heavy fuel
	2	80	1978	natural gas/heavy fuel
	3	80	1980	natural gas/heavy fuel
MGRES	1	200	1964	coal
	2	200	1965	coal
	3	200	1965	coal
	4	200	1966	coal
	5	200	1967	coal
	6	200	1967	coal
	7	200	1970	coal
	8	200	1971	coal
	9	210	1973	heavy fuel
	10	210	1974	heavy fuel
	11	210	1979	natural gas
		40	1980	natural gas
	12	210	1980	natural gas
		40	1982	natural gas

Natural gas is used by PP now. Heavy fuel is applied as a reserve one only. Although no concrete data is available on fuel used at MGRES, it is considered that most electricity produced at this PP is based on natural gas.

Taken into consideration all abovementioned we can conclude that the power produced by Moldova PP is generated at efficiency much lower than it is recorded at modern technologies or at ones foreseen in the future. Their refurbishment or their replacement represents a big source for GHG reduction.

5.2. New technologies to cover Moldova future power demand

In order to cover future electricity demand both type of power generation based on fossil fuel and renewable sources will be developed in Moldova.

For Moldova conditions major renewable sources cannot ensure reliable supply of electricity at any time of load curve, because of: not constant wind flow and solar intensity during the year is recorded; hydro technical reserves are used already, those of small rivers becoming frozen during the winter period when the pick load is marked. As to biomass PPs (cities' waste burning, biogas production, etc.) they are forced to be implemented not in order to cover power demand but to resolve ecological problems of landfills and manure accumulations at agricultural farms. So that all the renewable sources will be implemented at the level the renewable reserves permit to do that and, if the consumers are capable to take up the bill for such energy produced. In this respect country legal framework ensures big incentives to invest in renewable sources. According to the Methodology for the determination, approval and application of tariffs for the electricity generated from renewable energy and biofuels (February, 2009) For each investor wishing to build a renewable energy source the provisions of the Methodology ensures him the recovering of all needed and proved costs plus a return on investments made, much higher than one applied to the traditional national electricity distribution companies. The costs are recovered amongst the tariff and comprise:

1. The cost of fuel purchased for renewable power production;

2. The company O&M costs in year t (CDt) related to production and commercialization of renewable power. They include labor costs; material costs; third parties service cost; other O&M costs; taxes and fees. For the first two years of activity, the companies shall present detailed materials necessary to determine their own O&M costs. O&M costs accepted by ANRE for the year two of activity shall be considered as basic costs (CDo). For each of the following years the basic costs shall be adjusted to Moldova Consumer Price Index (CPIMt, i.e. inflation) of the previous years and corrected to efficiency factor (0.99 in the formula below)

$$CD_t = CD_o \times \prod_{i=1}^{t} 0{,}99 \times (1 + \frac{CPIM_t}{100})$$

3. Cost of capital, comprising both depreciation of investment made and rate of return on net investments put in operation. The rate of return in % is calculated according to the following formula:

$$Rr_t = WACCe.t._t \times K_t$$

Where:

WACCe.t.t - Weighted Average Cost of Capital determined and approved by ANRE for the electricity distribution companies in year "t". In 2008 it reached the level of 15.05%; in 2009 it constitutes 14.24%.

Kt- multiplier coefficient applied for generation renewable energy and bio fuel in year "t". It is established in the manner as following:

- For the first five years of activity (years 1-5) it shall be equal to 1.5;
- For the second five years of activity (years 6-10) it shall be equal to 1.3;
- For the third five years of activity (years 11-15) it shall be equal to 1.1.

For this reasons all renewable sources mentioned in the Tables 3.1-1 are not subject of prioritization in this study. Only those on nuclear and fossil fuels are assessed below to find the best ones.

The long list of technologies for electricity supply selected by the working group is shown in the Table 5.2-1.

Table 5.2-1. Long list of technologies for Electricity Supply

SMALL SCALE /SHORT TERM
1. Combined heat and power plants based on internal combustion engines of at most 500 kW (SS ICE CHP)
2. Small combined heat and power plants based on gas turbine of at most 500 kW (SS GT CHP)
3. Biomass combustion and co-firing for electricity and heat
4. Biogaz CHP
5. Stand-alone wind systems
6. Small Hydro Power Plant
LARGE SCALE/ SHORT TERM
1. Natural gas combined heat and power plants; efficiency 80-85 % (LS CHP)
2. Natural gas combined cycle power plant; efficiency 50 % (LS CC)
3. Natural gas combined cycle combined heat and power plants 50 MWel; 80-85/90% (LS CC CHP)
4. On-shore wind plant connected to the network.
5. Methane Capture at Landfills for Electricity and Heat
LARGE SCALE/ MEDIUM TO LONG TERM
1. Natural gas combined cycle power plant; efficiency 55-60 %; (LaS CC)
2. Natural gas combined cycle power plant; efficiency >60 % (LL CC)
3. Natural gas combined cycle CHP units; efficiency >80-85 % (LS CC CHP)
4. Nuclear units of 25 MW; (SS NUC)
5. Integrated Gasification Combined Cycle (IGCC)
6. CHP on fuel cells
7. Gasification of Municipal Solid Waste for Electricity/Heat production
SMALL SCALE/ MEDIUM TO LONG TERM
1. Wind systems for water and space heating

As soon as the Handbook prescribes that a set of technologies is subject to MCDA if their number is higher than four technologies and such condition is met only for Large scale/Long term technologies from the Long list shown in the Table 5.2-1 (where six PP technologies are specified), below we will proceed to find the best power production technologies for this category of PPs, applying Excel Spreadsheet described above. We will exclude from this category CHP on fuel cells and Gasification of Municipal Solid Waste for Electricity/Heat production, as these technologies are included in Heat production subsector, where three technologies are foreseen for implementation and thus they will be included in the technologies prioritized list automatically.

The remaining power production technologies are subject to MCDA, they are specified below:

1. Natural gas combined cycle power plant; efficiency 55-60 %; (LaS CC1);
2. Natural gas combined cycle power plant; efficiency >60 % (LaL CC2);
3. Natural gas combined cycle CHP units; efficiency >80-85 % (LS CC CHP);
4. Nuclear units of 25 MW; (SS NUC);
5. Integrated Coal Gasification Combined Cycle (IGCC).

Specific parameters of these technologies are reflected in the Table 5.2-2. They are used at the stage of Scoring in the Spreadsheet described above. By 2030 the price for natural gas was taken at the level of 552 $/tone coal equivalent (tce), for coal - 160 $/tce and for nuclear fuel 30.45 $/tce.

Table 5.2-2. Performance Matrix of PPs subject to MCDA

No.	Technology description	Main production parameters			Costs	GHG reduction by 2030
		Technology Implementation Capacity by 2030	Load Factor by 2030	Investment	O&M Costs, including for fuel used	
		MW	Hours	$/kW	$/kWh	tone CO2
1.Technology LaS CC1	Natural gas combined cycle power plant; efficiency 55-60 %;	150	7000	750	0.13	203000
2.Technology LaS CC2	Natural gas combined cycle power plant; efficiency >60 %	300	7000	750	0.12	470000
3.Technology LaS CC CHP	Natural gas combined cycle CHP units; efficiency >80-85 %	150	6300	1300	0.12	212000
4.Technology SS NUC	Nuclear units of 25 MW;	100	7500	2500	0.04	420000
5.Technology IGCC	Integrated Gasification Combined Cycle	200	7000	3000	0.055	390000

As a result the technologies were ranked in an order shown in the Table 5.2-3 and Fig. 5.2-1. The technology positions in the Cost-Benefit coordinates (Fig. 5.2-1) are obtained following the procedures described in the chapter 4.1 (p. 4,c).

Table 5.2-3. Ranking of Large Scale/Long term PPs in MCDAnalyses

Technology	Cost, US$/kW	Benefits	Ranking based on Overall Scores	Ranking based on Cost-Benefits
Natural gas combined cycle power plant; efficiency 55-60 %	750	37	1	**2**
Natural gas combined cycle power plant; efficiency >60 %	750	52	4	**1**
Natural gas combined cycle CHP units; efficiency >80-85 %	1300	38	2	**3**

Nuclear units of 25 MW	2500	52	4	4
Integrated Gasification Combined Cycle	3000	48	3	5

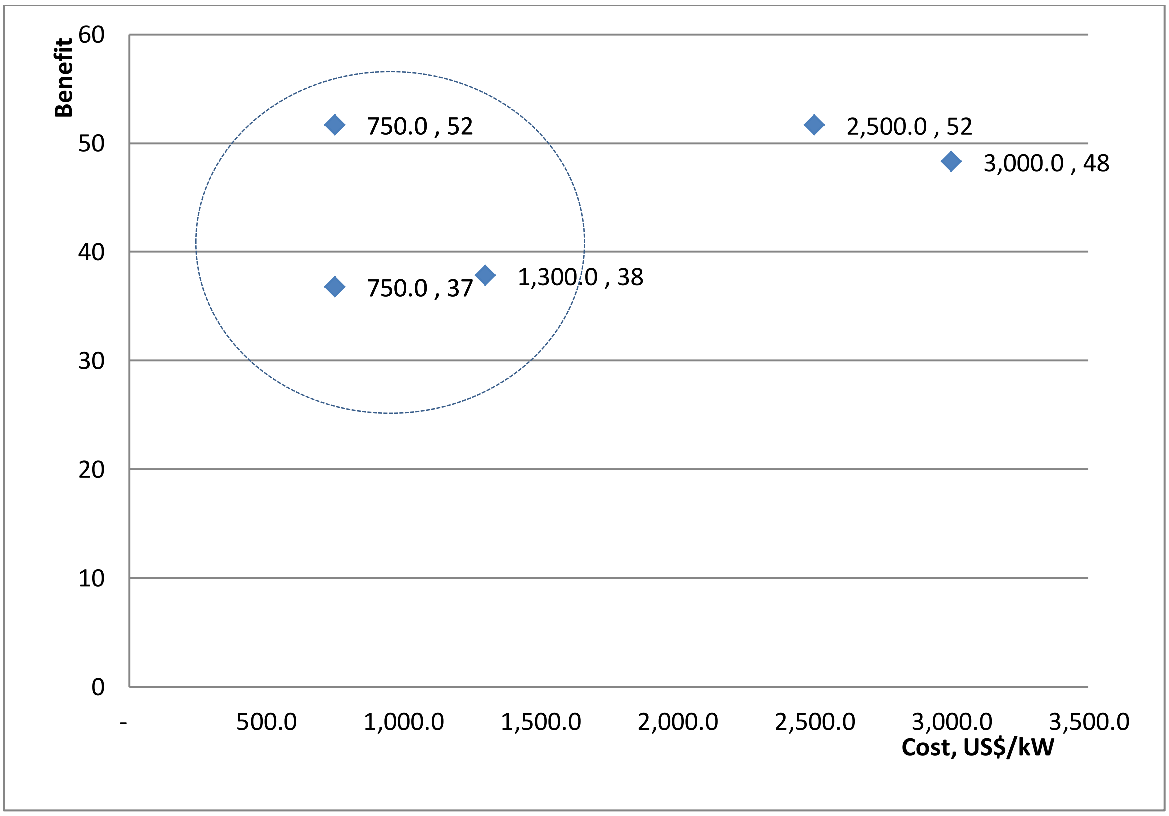

Figure 5.2-1. Large Scale/Long term PPs arrangement in the Cost-Benefits Coordinates

According to the Experts' Scores the priority technology is the Natural gas combined cycle power plant; efficiency 55-60 %. If the costs are taken into consideration as well, the preferable technology is Natural gas combined cycle power plant; efficiency >60 %, the PP on coal changing its priority position from third place (Scoring prioritization) to fifth place (Cost-Benefit Ranking), that happening because of very high specific investments, 3000US$/kW versus 750 US$/kW for Combined Cycle PP.

Sensitivity analysis was carried out in the conditions the specific investments for CC would increase twice times. No changing in the ranking of considered PPs was produced.

So that we can conclude that the first three technologies from the Ranking based on Cost-Benefits should be declared as technologies for future implementation, i.e.:

1. Natural gas combined cycle power plant; efficiency >60 % (LaL CC2);
2. Natural gas combined cycle power plant; efficiency 55-60 %; (LaS CC1);
3. Natural gas combined cycle CHP units; efficiency >80-85 % (LS CC CHP);

Such conclusion could be considered as one final. However, there are additional factors that oblige to revise it. First of all, cogeneration PPs are ones of high priority for implementation if heat demand is disposable, if not - such PP is not feasible. Second, PPs are not working isolated in the power system and their charging depends on either price for electricity they propose to the open market or minimum average electricity production price in the power system. Generally, for the purpose of the country power plant development scenarios elaboration the professional tools are used, as well-known WASP or MARKAL model. They permit to obtain the optimal scenario, i.e. the lowest price for electricity per power system, in the conditions when, as input data, all possible technologies (with their parameters) could be taken into consideration and thus, there is no reason to make beforehand prioritization of the technologies applied as the tool will exclude automatically the technologies worse contributing to the main goal: to get the cheapest electricity in the long term. After the technologies are chosen by WASP or MARKAL software they can be subject to further examination, in order to take into consideration all the benefits (as costs issue is resolved by the optimization tools): Environmental, CO2 reduction, Social, Energy Security (for Moldova is more preferable coal PP than natural gas, because the gas is coming from one country only (GAZPROM, Russia) and passing one country – Ukraine), etc.

Taking into consideration the above mentioned judgment, all PP technologies mentioned in the Table 5.2-1 should be considered as candidates for implementation in the Moldova Power System.

Ranking of PPs technologies not required MCDA

For those sets that do not encompass more than four technologies the prioritization is done based on data reflected in the Performance matrix below (Table 5.2-4). As O&M costs are approximately the same in each of the set, the PPs prioritization is made based on Investment and GHG Emission reduction criteria. So that for Small Scale/Short Term set the champion technology is Combined heat and power plants based on internal combustion engines of at most 500 kW and, for Large Scale/ Short Term – it is Natural gas combined cycle power plant; efficiency 50 %.

Table 5.2-4. PPs ranking in the small sets of technologies

Technology description	Main production parameters		Costs		GHG reduction by 2030	PPs rank
	Technology Implementation Capacity by 2030	Load Factor by 2030	Invest-ment	O&M Costs, including for fuel used		
	MW	hours	$/kW	$/kWh	tone CO2	
SMALL SCALE /SHORT TERM						
Combined heat and power plants based on internal combustion engines of at most 500 kW	10	5000	1150	0.17	10000	1
Combined heat and power plants based on gas turbine of at most 500 kW	5	4500	1100	0.15	4000	2
LARGE SCALE/ SHORT TERM						
Natural gas combined heat and power plants; efficiency 80-85 %	150	5700	1000	0.14	134000	2
Natural gas combined cycle power plant; efficiency 50 %	300	7000	750	0.14	330000	1
Natural gas combined cycle	150	6000	1300	0.15	134000	3

combined heat and power plants 50 MWel; 80-85/90%.						

Taking into consideration the technologies analyses carried out above the final list of prioritized mitigation technologies for Electricity Supply subsector is presented in the Table 5.2-5. No more than two technologies are selected per each set, they being characterized by main parameters: specific investments, GHG emission reduction and up-scaling potential for implementation.

Table 5.2-5. **Summarized table for prioritized mitigation Electricity Supply technologies**

Technology		Investments, $/kWe	GHG Reduction, tCO2	Up-scaling potential
Ranking	**Small scale/Short term**			
1	Combined heat and power plants based on internal combustion engines of at most 500 kW	1150	10 000	20% of demand
2	Combined heat and power plants based on gas turbine of at most 500 kW	1100	5 000	10% of demand
	Small scale /Medium-Long term			
1	Wind systems for water and space heating	1500	100 000	0,001%
	Large scale /Short term			
1	Natural gas combined cycle power plant; efficiency 50 %	750	330 000	20%
2	Natural gas combined heat and power plants; efficiency 80-85 %	1000	134 000	5%
	Large scale /Medium-Long term			
1	Natural gas combined cycle power plant; efficiency >60 %	750	470 000	28%
2	Natural gas combined cycle power plant; efficiency 55-60 %	750	203 000	12%

All the technologies referred to combined and heat productions in cogeneration regime are considered as cross-sector (Electricity and Heat Supply) mitigation technologies.

Further implementation of mitigation technologies selected would require more detailed consideration of the factors influencing their successful promotion, including what a real amount of investments is needed, the period of years for implementation, demand of energy needed during the years, the consumers capacity to bear the costs foreseen, etc. For Electricity supply the appropriate power sources development scenarios should be elaborated in order to determine how selected prioritized power generation units (technologies) would be charged during the years. In this respect, the professional tools should be used, as one like WASP or MARKAL. If in the context of existing and new candidate power units the power units selected in the present study are not charged enough, they should be replaced by other, more appropriate to the TNA goal.

CHAPTER 6. TECHNOLOGY PRIORITIZATION FOR SECTOR ENERGY-SUBSECTOR HEAT SUPPLY

6.1. Present status

At the moment centralized heating from CHP is applied in two municipalities: Chisinau and Balti. Because existing CHP cannot be ensured with designed heat load, they are very inefficient and, as consequence, the price for heat is very high. Because of that and low quality of heat delivered to final consumers, around 20% of apartments and many administrative buildings are supplied by individual boiler houses on natural gas. During the last 5 years Heat Boilers on pellets and bales have been implemented in the many rural administrative buildings (schools, kindergarten, etc.). Coal, natural gas and wood are used for heating production too, applying traditional technology: different stoves, boiler houses, etc. Heat pumps are used as well, heating source being soil or underground water at high depth.

6.2. New technologies to cover Moldova future Heat demand

The long list of technologies for heat supply selected by the working group is shown in the Table 6.2-1.

Table 6.2-1. Long list of technologies for Electricity Supply

SMALL SCALE /SHORT TERM
1. Condensing Heat Boilers
2. Radiating Paneles for local heating
3. Mini and micro CHP on gas
4. Solar Heat Boilers
5. Small and medium Heat Pumps
6. Heat boilers on solid fuel gasification
7. Heat Boilers on pellets and bales
LARGE SCALE/ SHORT TERM
1. Combined steem-gas CHP
2. Big Heat Pumps
LARGE SCALE/ MEDIUM TO LONG TERM
1. Small nuclear CHP (<100MW)
2. CHP on Fuel Sells
3. Gasification of Municipal Solid Waste for Electricity/Heat production
4. Heating Systems on Hydrogen
SMALL SCALE/ MEDIUM TO LONG TERM
1. CHP on motor organic agents (hydrocarbons, freons)
2. Mini and Micro CHP on Fuel Sells
3. Solid Fuel Gasification Heat Boilers

Not all the technologies identified by sub sectors Heat supply have been included in the Long list, having the following reasons to omit them, the decision being taken at experts involved meeting:

1. Charcoal production for cooking and heating. The benefit impact is too small.

2. Second generation of bio-fuel production based on mobile rapid pyrolysis technology. The technology is oriented to produce bio-oil for heat production. Not big quantities of such fuel can be expected be produced in the country. In Moldova the boilers based on liquid fuels are not used. If such appear the reserve fuel would be fossil liquid fuels that are rejected by the population because of security reasons and big costs. The benefit impact is too small.

For heat generation MCDAs is applied to Small scale/Short term category only as more than four technologies are met in this case only. From the list of these technologies (Table 6.2-1) two of them are excluded in the following analyses. They correspond to Solar Heat Boilers and Heat Boilers on pellets and bales. Solar Heat Boilers have a small contribution and cannot compete with stationary heat generation installations as the last ensure heat during all the year. As to Heat Boilers on pellets and bales, they are planned to be broadly implemented in the following years, so that the reserve of biomass for such purposes would be very limited in the future. Up to 2014 around 130 administrative building in rural sector of Moldova will be equipped with heat boilers on agriculture biomass waste (straw bales, etc.), being allocated 14 million Euro, according to UNDP Energy and Biomass Project. So that the following heat generation technologies are subject to TNA assessment:

1. Condensing Heat Boilers
2. Radiating Panels for local heating
3. Mini and micro CHP on gas
4. Small and medium Heat Pumps
5. Heat boilers on solid fuel gasification

The Performance Matrix of these technologies and results of their assessments are shown in the Table 6.2-2, Table 6.2-3 and Fig 6.2-1 respectively. The technology positions in the Cost-Benefit coordinates (Fig. 6.2-1) are obtained following the procedures described in the chapter 4.1 (p. 4,c).

Table 6.2-2. Performance Matrix of Small scale/Short term Heat Sources subject to MCDA

No	Technology description	Main production parameters		Costs		GHG reduction by 2030
		Technology Implementation Capacity by 2030	Load Factor by 2030	Invest-ment	O&M Costs, including for fuel used	
		MW	hours	$/kWt	$/kWh	tone CO2
1.	Condensing Heat Boilers	400	2000	50	35	15,000
2.	Radiating Panels for local heating	8	1000	10	36	6,500
3.	Mini and micro CHP on gas	500	4000	267	22	125,000
4.	Small and medium Heat Pumps	300	3500	1,500	14	100,000
5.	Heat boilers on solid fuel gasification	275	4000	30	7	13,500

Table 6.2-3. Ranking of Small Scale/Short term Heat Sources in MCDA

Technology	Investment, $/kWt	Benefits	Ranking based on Scores	Ranking based on Cost-Benefits
1. Condensing Heat Boilers	1,000	34.3	5	5
2. Radiating Panels for local heating	10	43.6	4	3
3. Mini and micro CHP on gas	267	73.6	1	1
4. Small and medium Heat Pumps	1,500	60.6	3	4
5. Heat boilers on solid fuel gasification	30	61.0	2	2

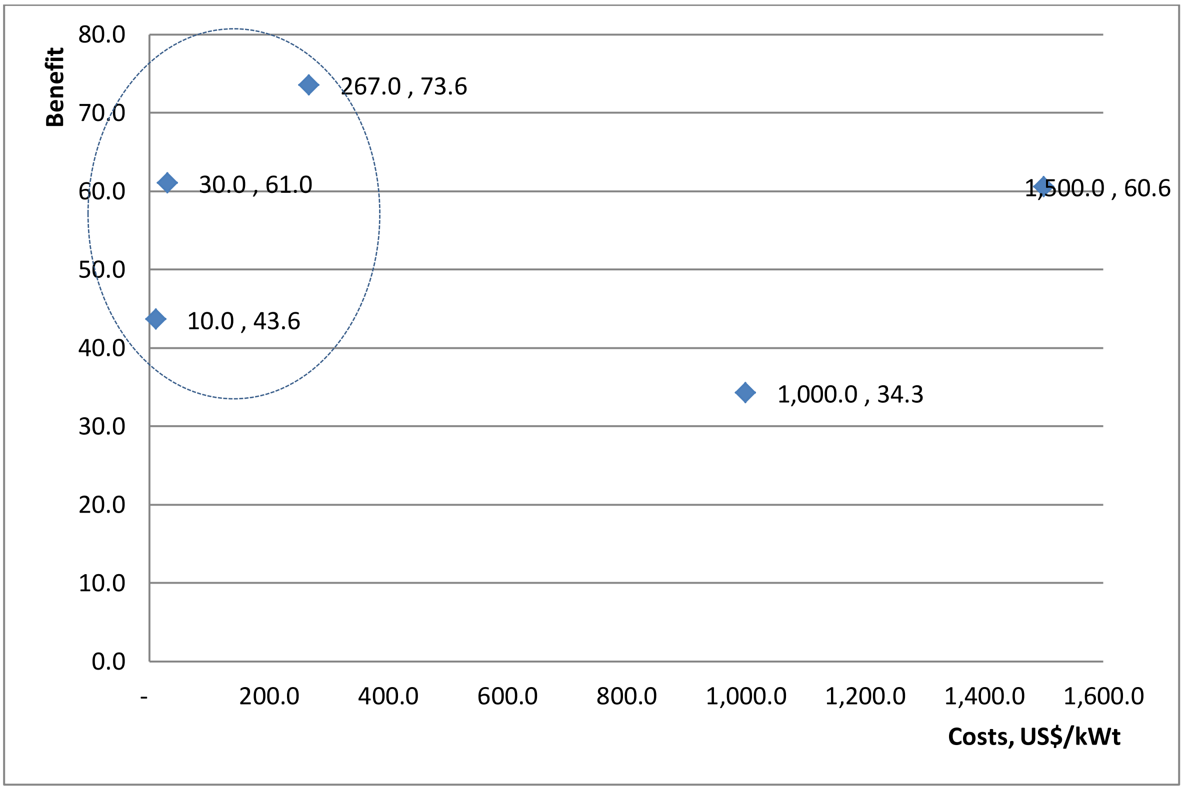

Figure 6.2-1. Small Scale/Short term Heat generation technologies arrangement in the Cost-Benefits Coordinates

As it is seen from the Table 6.2-3 Cost-Benefit analyzing doesn't change the ranking place for first, third and fifth technology while the second and fourth technologies has changed their place in the list of priorities. The sensitive analyzes showed that if for Mini and micro CHP on gas apply the specific investments corresponded to electricity load, that is around 1400$/kWe, not 267 $/kWt for heat load, than it gets 57,4 points and moves near to Small and medium Heat Pump technology. All described above suggest selecting of the following Heat production technologies as ones priority in the Small Scale/Short term list:

a) Heat boilers on solid fuel gasification
b) Radiating Panels for local heating
c) Small and medium Heat Pumps

Ranking of heat generation technologies not required MCDA

1. For Large scale/Short term set Big Heat Pumps is selected in the first position (Table 6.2-4), instead of Combined steam-gas CHP, because: a) there is no certainty the heat demand will be ensured at feasible level for CHP, making the PP not economically viable; b) CHP implementation would lead to more gas dependency to only one gas supplier (GASPROM), decreasing the country energy security.

2. For Large scale/Medium to Long term set the Gasification of Municipal Solid Waste for Electricity/Heat production is selected as champion technology (Table 6.2-4) as: a) Solid Waste need to be processed in a manner not admit more its placement on landfill, because of environment problems such wastes provoke around; b) this technology increase country energy security, because less fuel will be imported; c) GHG emission reduction is high, because wastes on landfills are source of biogas – much danger for climate change.

Second position in this set is allocated to Small nuclear CHP. Such PP increase country energy security and ensure big CO2emission reduction

The third technology in this set is destined for Heating Systems on Hydrogen as it is more attractive in comparison with CHP on Fuel Sells. The first technology increase country energy security and not requires high Heat Load Factor the CHP be feasible.

3. For Small scale/Medium to Long term set the best technology is granted to Heating system on hydrogen (Table 6.2-4) for the same reasons mentioned above. It ensures better country energy security, is cheaper and is not critical to Heat Load Factor as it is happening for CHP.

The second position is occupied by CHP on motor organic agents (hydrocarbons, freons) as it can operate on biomass as well, permitting in such manner to increase country energy security.

Heat generation technologies not required MCDA and their level of priority in each of the sets are presented in the Table 6.2-4.

Table 6.2-4. Ranking of heat generation technologies not required MCDA

Technology	**Ranking**
LARGE SCALE/ SHORT TERM	
Big Heat Pumps	1
Combined steam-gas CHP	2
LARGE SCALE/ MEDIUM TO LONG TERM	
Gasification of Municipal Solid Waste for Electricity/ Heat production	1
Small nuclear CHP (<100MW)	2
Heating Systems on Hydrogen	3
CHP on Fuel Sells	4
SMALL SCALE/ MEDIUM TO LONG TERM	
Solid Fuel Gasification Heat Boilers	1
CHP on motor organic agents (hydrocarbons, freons)	2
Mini and Micro CHP on Fuel Sells	3

6.3. Final list of prioritized Heat Supply technologies

Taking into consideration the technologies analyses carried out above the final list of prioritized mitigation technologies for Heat Supply subsector is presented in the Table 6.3-1. No more than two technologies are selected per each set, they being characterized by main parameters: specific investments, GHG emission reduction and up-scaling potential for implementation.

Table 6.3-1. Summarized table for prioritized mitigation Heat Supply technologies

Technology		**Investments, $/kWt**	**GHG Reduction, tCO2**	**Up-scaling potential**
Ranking	**Small scale/Short term**			
1	Heat boilers using solid fuel gasification	30	13 500	10%
2	Radiating Panels for local heating	10	6500	5%
	Small scale /Medium-Long term			
1	Heat boilers using solid fuel gasification	30	13 500	10%
2	CHP on motor organic agents (hydrocarbons, freons)	500	45 000	1%
	Large scale /Short term			
1	Big Heat Pumps	2000	75 000	5%
2	Combined steam-gas CHP	600	100 000	5%
	Large scale /Medium-Long term			
1	Gasification of Municipal Solid Waste for Electricity/Heat production	3500	80 000	15%
2	Small nuclear CHP	900	410 000	20%

All the technologies referred to combined and heat productions in cogeneration regime are considered as cross-sector (Electricity and Heat Supply) mitigation technologies.

CHAPTER 7. TECHNOLOGY PRIORITIZATION FOR SECTOR ENERGY-SUBSECTOR TRANSPORT

7.1. Present status

Transport Sector plays a significant role in the national economy of the Republic of Moldova, its current contribution to the Gross Domestic Product being circa 12.1 percent (NBS, 2006), and is constantly increasing (from 4.8 percent in 1990, to 12.1 percent in 2005). Transport Sector provides jobs to 71 thousand persons, or to 5.4 percent of the employed population of the country (NBS, 2006).

Moldova 'Transport' category includes greenhouse gases generated by the following emissions sources: 'Civil Aviation', 'Road Transportation', 'Railways', 'Navigation' and 'Other' (Pipeline Transport).

In 2007, energy resources consumption in the transport sector accounted for circa 25.7 percent of the total national energy consumption. This sector represents a significant source of GHG emissions.

The total energy consumption structure under the transport sector in 2007 can be broken down as follows: Diesel Oil accounted for circa 55.6 percent of the total, Gasoline – for 38.7 percent, jet fuel – for 2.7 percent, LPG – for 1.3 percent and LNG, respectively for circa 0.7 percent of the total. Diesel oil and Gasoline is preponderantly used in road transport, to a less extent LPG and LNG; Diesel Oil is preponderantly used in railway and navigation transport, while air transport mostly uses jet fuel (it should be noted that GHG emissions generated by the international bunkers are not included in the total national GHG emissions, but are reported under „Memo Items").

In 2007, circa 92 percent of the total energy consumption in the transport sector was used for road transportation; 5 percent - for railway transport, 2.4 percent - for air transportation, and as little as circa 0.02 percent for navigation.

Present technologies applied in Transport sector correspond to ones known at the world level, those obsolete predominating. No electric transport is used at the moment. The share of road vehicles using compressed natural gas and liquefied petroleum gas as fuel is in increasing process. Bio-fuels (ethanol and biodiesel) utilization is on incipient stage. There is no vehicles production in the country. All the vehicles needed are from the import. Limited age for imported road vehicles is established at the level of 7 years, for trucks and buses being 10 years.

7.2. New technologies for Transport

Following the procedures of MCDAnalysis above described the following transport technologies and measures have been selected:

From the Long list of technologies identified in the Table 7.2-1 it is observed that Small scale/Short term, Large scale/Long term and Small scale/Long term transport technologies are not subject to multi-criteria decision analyses as the number of technologies in these subsectors is less than four. However, MCDA was applied to these sets in order to identify the best transport technologies, but without cost- benefit graph analysis. In the Table 7.2-2 performance matrix of these technologies is presented, it serving for costs and GHG reduction scores establishment for the technologies in the sets. The final scores for each technologies and the rank gained by each of them is shown in the Table 7.2-

3. Hydrogen technology is excluded from the further examination as it is considered too expansive for Moldova economic conditions.

Table 7.2-1. Long list of technologies for Transport

Technology identification
SMALL SCALE /SHORT TERM
Hybrid Electric Vehicles
Regenerative braking in trains
Liquefied Natural Gas in trucks and cars
LARGE SCALE/ SHORT TERM
Biodiesel
Bioethanol from sugar and starch based crops
Bus Rapid Transit systems
Direct Injection for internal combustion engines
Compressed Natural Gas (CNG) in transport
Electronic Road Pricing
Liquefied Petroleum Gas (LPG) in transport
Modal shift in freight transport
Non-motorized Transport
LARGE SCALE/ MEDIUM TO LONG TERM
Transport management systems
Plug in Hybrid Electric Vehicles
Hydrogen technologies
SMALL SCALE/ MEDIUM TO LONG TERM
Electric vehicles
Fuel cells for mobile applications

Table 7.2-2. Performance matrix of Transport technologies not subject of MCDA

Technologies	General parameters		Costs		GHG reduction by 2030
	Technology Implementation Capacity by 2030		Total CAPEX	OPEX	
	Number of transport units	10^6 pass.-km	$ 10^6	$ 10^6/year	tone CO2
Small scale / Short term					
Hybrid Electric Vehicles	3,000	1,118	507	4.3	15,313
Regenerative braking in trains	76	495	0.76	0.08	4,617
Liquefied Natural Gas in trucks and cars	x	2,744	22.0	0.1	85,536
Small scale / Long term					
Electric vehicles	265,000	3,917	10,586	1,059	268,660
Fuel cells for mobile applications	265,000	3,917	13,655	195	659,939
Large scale / Long term					
Transport management systems	265,000	5,017	106	2.7	359,168
Plug in Hybrid Electric Vehicles	265,000	3,917	7,026	100	73,020

Table 7.2-3. Not subject of MCDA Transport technologies ranking

Technologies	Costs		Benefits				TOTAL		Priority	
	Investments	Price	GHG reduction	Social	Economic	Environment	All criteria	Only benefits	All criteria	Only benefits
Small scale / Short term										
Hybrid Electric Vehicles	0.0	0.0	2.0	12.8	21.3	10.6	46.6	46.6	3	1
Regenerative braking in trains	21.3	19.1	0.0	8.9	17.0	8.5	74.9	34.5	1	2
Liquefied Natural Gas in trucks and cars	21.0	17.0	14.9	6.4	6.4	4.3	69.9	31.9	2	3
Small scale / Long term										
Electric vehicles	21.3	19.1	0.0	12.	21.3	6.4	80.9	40.4	1	1
Fuel cells for mobile applications	0.0	0.0	14.9	1.3	2.1	10.,6	28.9	28.9	2	2
Large scale / Long term										
Transport management systems	21.3	19.1	14.9	12.8	21.3	10.6	100.0	59.,6	1	1
Plug in Hybrid Electric Vehicles	0.0	0.0	0.0	6.4	10.6	6.4	23.4	23.4	2	2

For Large scale/Short term technologies MCDA was applied, Scorings being done based on the technologies characteristics reflected in the Performance Matrix from the Table 7.2-4. The final results obtained are presented in the Table 7.2-5, 7.2-6. Cost-benefits analyzes demonstrated (Table 7.2-6 and Fig 7.2-1) that selected transport technologies kept the same ranking as it was established without this exercise. The technology positions in the Cost-Benefit coordinates (Fig. 7.2-1) are obtained following the procedures described in the chapter 4.1 (p. 4,c).

Table 7.2-4. Transport Technologies Performance Matrix subject to MCDA

No.	Technology description	Costs				GHG reduction by 2030
		Technology Implementation Capacity by 2030	Price	Investment	O&M Costs, including for fuel used	
		10^6 pass.-km, 10^3 tone	$/pass.-km	$/10^6 pass.-m	10^6 $	tone CO2
1.	Biodiesel	8,004	0.37	3,584	4.4	98,611
2.	Bioethanol from sugar and starch based crops	14,077	0.30	4,189	5.0	157,758
3.	Bus Rapid Transit systems	3,820	0.02	28,799	0.5	288,121
4.	Direct Injection for internal combustion engines	7,245	0.28	1,420,352	147.0	176,975
5.	Compressed Natural Gas (CNG) in transport	1,118	0.05	401,067	4.5	11,272
6.	Electronic Road Pricing	3,820	0.014	34,036	32.5	93,304
7.	Liquefied Petroleum Gas (LPG) in transport	7,245	0.27	1,489,679	154.2	105,560
8.	Modal shift in freight transport	25.0	0.001	40,000	0.005	4,212
9.	Non-motorized Transport	8,004	0.37	3,584	4.4	98,611

Table 7.2-5. Transport Large scale/Short term prioritized technologies

Technology	Priority
3 prioritized technologies selected:	
1. Biodiesel	**1**
2. Bio ethanol from sugar and starch based crops	**2**
3. Bus Rapid Transit systems	**3**
Other technologies:	
Direct Injection for internal combustion engines	
Compressed Natural Gas (CNG) in transport	
Electronic Road Pricing	
Liquefied Petroleum Gas (LPG) in transport	
Modal shift in freight transport	
Non-motorized Transport	

Table 7.2-6. Cost-benefits analyzes

No.	Technology	Costs, $/10^6 pass.-km	Benefit
1	**Biodiesel**	**3,258**	**47.5**
2	**Bio ethanol**	**3,808**	**46.2**
3	**Bus Rapid Transit System**	**26,181**	**41.5**
4	Direct Injection for internal combustion engines	1,420,352	37.1
5	Compressed Natural Gas (CNG) in transport	401,067	7.1
6	Electronic Road Pricing	34,036	21.4
7	Liquefied Petroleum Gas (LPG) in transport	1,489,679	23.7
9	Non-motorised Transport	40,000	37.9

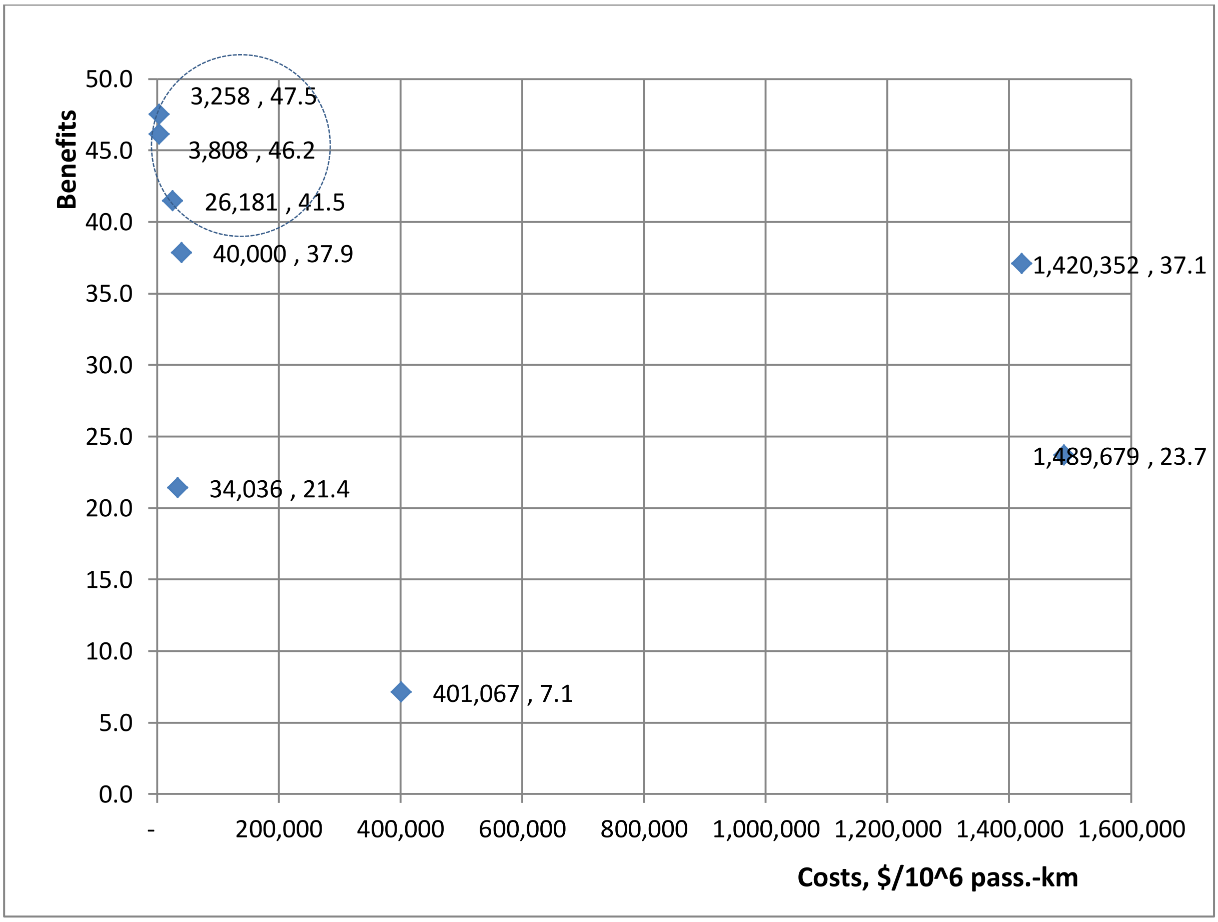

Figure 7.2-1. Transport Large scale/Short term technologies arrangement in the Cost-Benefits Coordinates

Sensitive analyzes

In order to make sensitive analysis for the technologies selected, the following influencing factors were chosen, they being changed as it is shown below:

a) Benefit: -10%;

b) Costs: +10%.

As it is seen from the Table 7.2-7 and Fig. 7.2-2 (The technology positions in the Cost-Benefit coordinates (Fig. 7.2-2) are obtained following the procedures described in the chapter 4.1 (p. 4,c) no changes have been produced in the ranking of transport technologies selected when the influencing factors are worsened in sence of overall score, increasing of Investments and decreasing of benefits. So that the first three technologies from the Table 4.2.2-5 should be considered priority technologies in the Large scale/Short term Transport subsector.

Table 7.2-7. Transport technologies sensitive analysis data

No.	Technology	Initial assessment		The results of sensitive analysis	
		Costs, $/10^6 pass.-km	Benefit	Costs, $/10^6 pass.-km	Benefit
1	**Biodiesel**	**3,258**	**47.5**	**3,584**	**47.5**
2	**Bioetanol**	**3,808**	**46.2**	**4,189**	**46.1**
3	**Bus Rapid Transit System**	**26,181**	**41.5**	**28,799**	**41.5**
4	Direct Injection for internal combustion engines	1,420,352	37.1	1,420,352	38.0
5	Compressed Natural Gas (CNG) in transport	401,067	7.1	401,067	7.2
6	Electronic Road Pricing	34,036	21.4	34,036	21.9
7	Liquefied Petroleum Gas (LPG) in transport	1,489,679	23.7	1,489,679	24.3
9	Non-motorized Transport	40,000	37.9	40,000	37.9

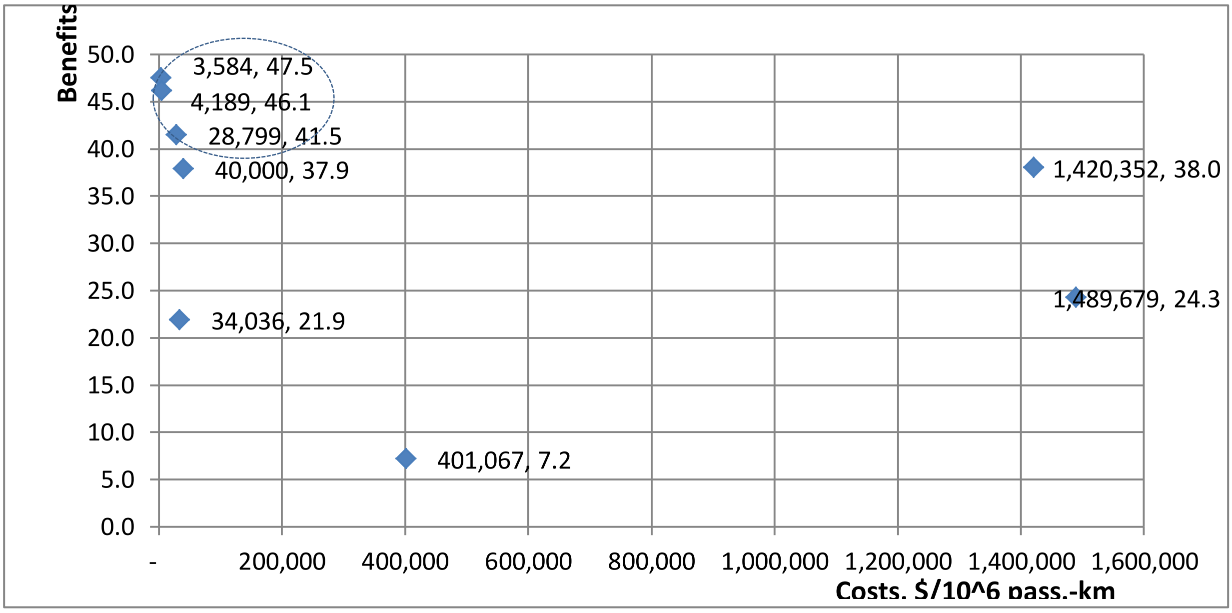

Figure 7.2-2. Transport Large scale/Short term technologies arrangement in the Cost-Benefits Coordinates when the Influencing factors are worsened

7.3. Final list of prioritized Transport technologies

Taking into consideration the technologies analyses carried out above the final list of prioritized mitigation technologies for Transport subsector is presented in the Table 7.3-1. No more than two technologies are selected per each set, they being characterized by main parameters: specific investments, GHG emission reduction and up-scaling potential for implementation.

Table 7.3-1. Summarized table for prioritized mitigation Transport technologies

Technology		Investments, \$/10^6 pass.-km	GHG Reduction, tCO2	Up-scaling potential, 10^6 pass.-km, 10^3 tone
Ranking	**Small scale/Short term**			
1	Hybrid Electric Vehicles	453,380	15,313	10%
2	Liquefied Natural Gas in trucks and cars	8,02 \$ / 10^6tone-km	85,536	30%
	Small scale /Medium-Long term			
1	Electric vehicles	2,702,932	268,660	20%
2	Fuel cells for mobile applications	3,486,486	659,939	0.5%
	Large scale /Short term			
1	Biodiesel	3 584	98 611	0.5%
2	Bioethanol from sugar and starch based crops	4 189	157 758	0.5%
	Large scale /Medium-Long term			
1	Transport management systems	21.123	359,168	50%
2	Plug in Hybrid Electric Vehicles	1,793,919	73,020	20%

CHAPTER 8. TECHNOLOGY PRIORITIZATION FOR SECTOR ENERGY-SUBSECTOR OTHER SECTORS: RESIDENTIAL AND ADMINISTRATIVE BUILDINGS

8.1. Present status

Building wall isolation: For around 10% from total of 30,1 mil.m2 of urban building and for 1-2% from 48,8mil.m2 of rural building wall isolation, windows and doors replacement are already carried out by the owner of buildings during the last 10 years.

Efficient electric lamps: Efficient electricity lamps are used broadly, but because of high cost they are still meet difficulties in their dissemination.

Room temperature regulation: Room temperature regulation is applied only in the new building where each the apartment is metered. In the old ones such tentative have a small effect because heating radiators are connected in series to centralized heating system.

Heat metering for each apartment: At old buildings only one heat meter is installed at the entrance to the building. Remote metering to each apartments are proposed to be installed, they operating based on the radiators temperature. Still now this idea is not accepted because of possible frauds on heating recording.

Efficient appliances: At present appliances type A, A+ and A++ are in the market. But because of high price and long life time of existing appliances the turnover rate is low.

Performant air-conditioning: Air-conditioning installations, broadly used in the country, are designed to produce both cool and heat. When the last function is applied the installation is working as a heat pump being more efficient than boiler house on natural gas, because of high price for gas and relatively low price for electricity. Performance coefficient is around 3.

Other energy efficient installations from the Table 8.2-1 are in the process of implementation in Moldova. For example there are several mini CHP that are operating in the country. But because of low electricity price and lack of heat loading such CHP are not foreseen more in the nearest future.

8.2. New measures and technologies to ensure living comfort

According to the long list of Other Sectors technologies described in the Table 8.2-1 only Small scale/Short term category of technologies meet the condition (more than four technologies in the set) when MCDA is required the prioritized technologies be identified. However, a more attentive examination shows that some measures and technologies represented in the Small scale/Short term category do not exclude each others in their implementation, i.e. all of them can be promoted independently because of different destination: lighting, air-conditioning, efficient appliances. So that if these measures and technologies are excluded from the list there is no necessity to carry out multi-criteria assessment as no more than four of them remained for examination. In the same time when the investments are limited, the lasts should be used for selected technologies promotion, in order to ensure the maximum benefit. In order to identify them MCDAnalyzes is applied below, following the rules described above.

Table 8.2-1. Long list of technologies for Residential and Administrative buildings

Technology identification	
Residential buildings	**Administrative buildings**
SMALL SCALE /SHORT TERM	
1. Room temperature regulation	1. Automatic temperature regulation, inclusive night regime
2. Building construction to optimal orientation	2. Energy protective glasses and pellicles
3. Building wall isolation	3. Building wall isolation
4. Heat metering for each apartment	4. Energy management system implementation
5. Performant air-conditioning	
6. Energy Efficient lamps	5. Energy Efficient lamps
7. Efficient appliances	
SMALL SCALE/ MEDIUM TO LONG TERM	
1. High Efficient Heat, Ventilation and Air-conditioning System (HVAC)	1. High Efficient Heat, Ventilation and Air-conditioning System (HVAC)
2. Passive homes	2. Combined Cogeneration with air-humidification

The following set of measures and technologies are subject to MCDAnalyzes:

Residential buildings:

1. Room temperature regulation
2. Building construction to optimal orientation
3. Building wall isolation
4. Heat metering for each apartment
5. Performant air-conditioning
6. Energy Efficient lamps
7. Efficient appliances

Administrative buildings

1. Automatic temperature regulation, inclusive night regime
2. Energy protective glasses and pellicles
3. Building wall isolation
4. Energy management system implementation
5. Energy Efficient lamps

The Performance Matrix of these technologies and results of their assessments are shown in the Table 8.2-2, Table 8.2-3 and Fig. 8.2-1 and Fig. 8.2-2 respectively. The technology positions in the Cost-Benefit coordinates (Fig. 8.2-1 and Fig. 8.2-2) are obtained following the procedures described in the chapter 4.1 (p. 4,c).

Table 8.2-2. Performance Matrix of Small scale/Short term technologies in R&A buildings subject to MCDA

No.	Technology description	Costs				GHG reduction by 2030
		Technology Implementation Capacity by 2030	Load Factor by 2030	Investment	O&M Costs, including for fuel used	
		kW	hours	$/m2	$/GJ	tone CO2
Residential buildings						
1	Room temperature regulation	550,000	4,000	2.5		215,000
2	Building construction to optimal orientation	350	4000	0		300
3	Building wall isolation	2,000,000	4,000	27.6		750,000
4	Heat metering for each apartment	900,000	4,000	5	0,1	22,000
5	Performant air-conditioning	430,000	300	35	45	2,100
6	Energy Efficient lamps	170,000	1,500	0.66		425,000
7	Efficient appliances	700,000	600	10		50,000
Administrative buildings						
1	Automatic temperature regulation, inclusive night regime	16.35	4,000	2.50		42,000
2	Energy protective glasses and pellicles	0.198	4,300	1.83		5,300
3	Building wall isolation	14.7	4,000	15.20		210,000
4	Energy management system implementation	17.24	8,760	-	-	54,000
5	Energy Efficient lamps	21 550	700	0.66		106,000

Table 8.2-3. Ranking of Small Scale/Short term R&A buildings technologies in MCDAnalyses

Technology	Investment, $/m2	Benefits	Ranking based on Scores (RS)	Ranking based on Cost-Benefits (RCB)
Residential buildings				
Room temperature regulation	2.5	43.6	3	6
Building construction to optimal orientation	0	43.5	4	2
Building wall isolation	27.6	59.4	2	5
Heat metering for each apartment	5	45.5	4	3
Performant air-conditioning	35	14.7	5	7
Energy Efficient lamps	0.66	63.9	1	1
Efficient appliances	10	45.6	4	4
Administrative buildings				
Automatic temperature regulation, inclusive night regime	2.50	54	3	3
Energy protective glasses and pellicles	1.83	58	2	2
Building wall isolation	15.20	52	4	5
Energy management system implementation	-	35	5	4
Energy Efficient lamps	0.66	64	1	1

From the Table 8.2-3 we can conclude that the utilization of Energy Efficient lamps is the champion measure in both Small Scale/Short term Residential and Administrative buildings lists. For the Administrative buildings technologies, no changes are produced in both rankings: based on Scores and based on Cost-Benefits, for the technologies Energy Efficient lamps, Energy protective glasses and pellicles, Automatic temperature regulation, inclusive night regime. As to Residential building more efficacious ranking corresponds to one based on Scores, because:

a) Building wall isolation (second position in RS and fifth position in RCB) has big reserves for energy saving, it is widely accepted and promoted in the country at present. For this reason this measure is kept in the list of prioritized technologies for Administrative buildings.

b) Room temperature regulation option (third position in RS and sixth position in RCB) is an emphatic energy saving oriented measure and can be relatively easy implemented

c) Three technologies have approximately the same score, around 43.5 being more or less credible in estimations, i.e. Building construction to optimal orientation, Heat metering for each apartment and Efficient appliances.

As a consequence the following list of prioritized Small Scale/Short term R&A buildings technologies/ measures are selected (Table 8.2-4):

Table 8.2-4. Selected Small Scale/Short term R&A buildings technologies in MCDAnalyses

Technology	Investment, $/m2	Benefits	Ranking based on Scores (RS)	Ranking based on Cost-Benefits (RCB)
Residential buildings				
Energy Efficient lamps	0.66	63.9	1	1
Building wall isolation	27.6	59.4	2	5
Room temperature regulation	2,5	43,6	3	6
Administrative buildings				
Energy Efficient lamps	0.66	64	1	1
Energy protective glasses and pellicles	1.83	58	2	2
Automatic temperature regulation, inclusive night regime	2.50	54	3	3
Building wall isolation	15.20	52	4	5

For each technology from the Table 4.2.3-3 a ±10% change of investments was applied for sensitive analyzes. No changes in the ranking were produced for Small Scale/Short term R&A buildings technologies selected Investments.

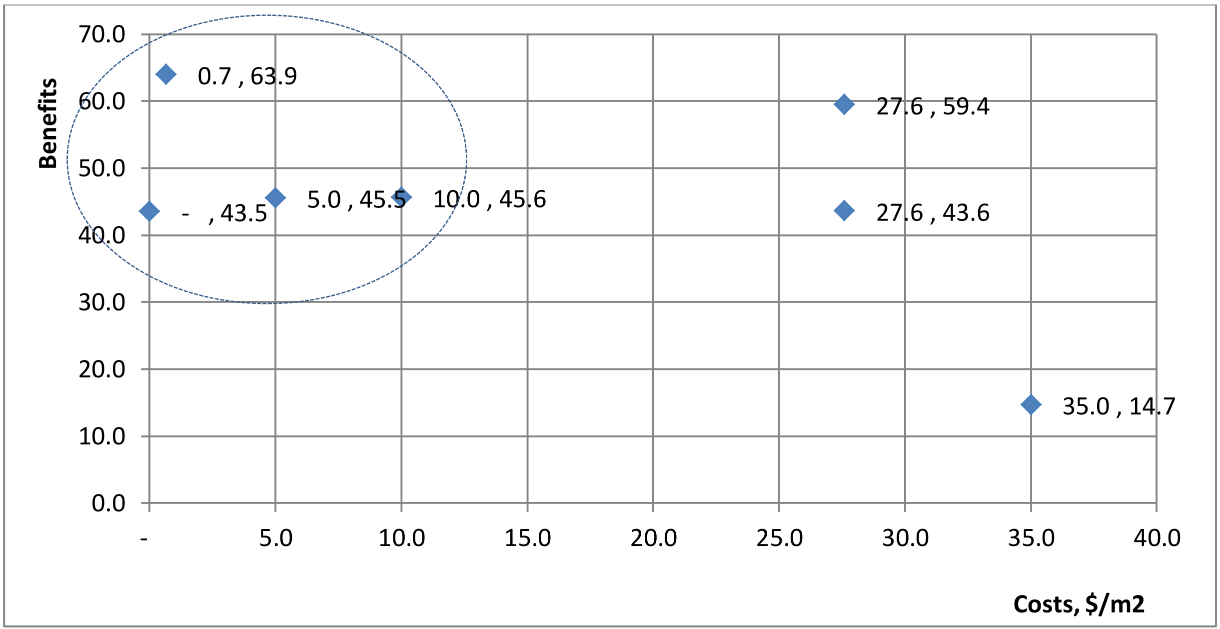

Figure 8.2-1. Small Scale/Short term Residential Buildings technologies arrangement in the Cost-Benefits Coordinates

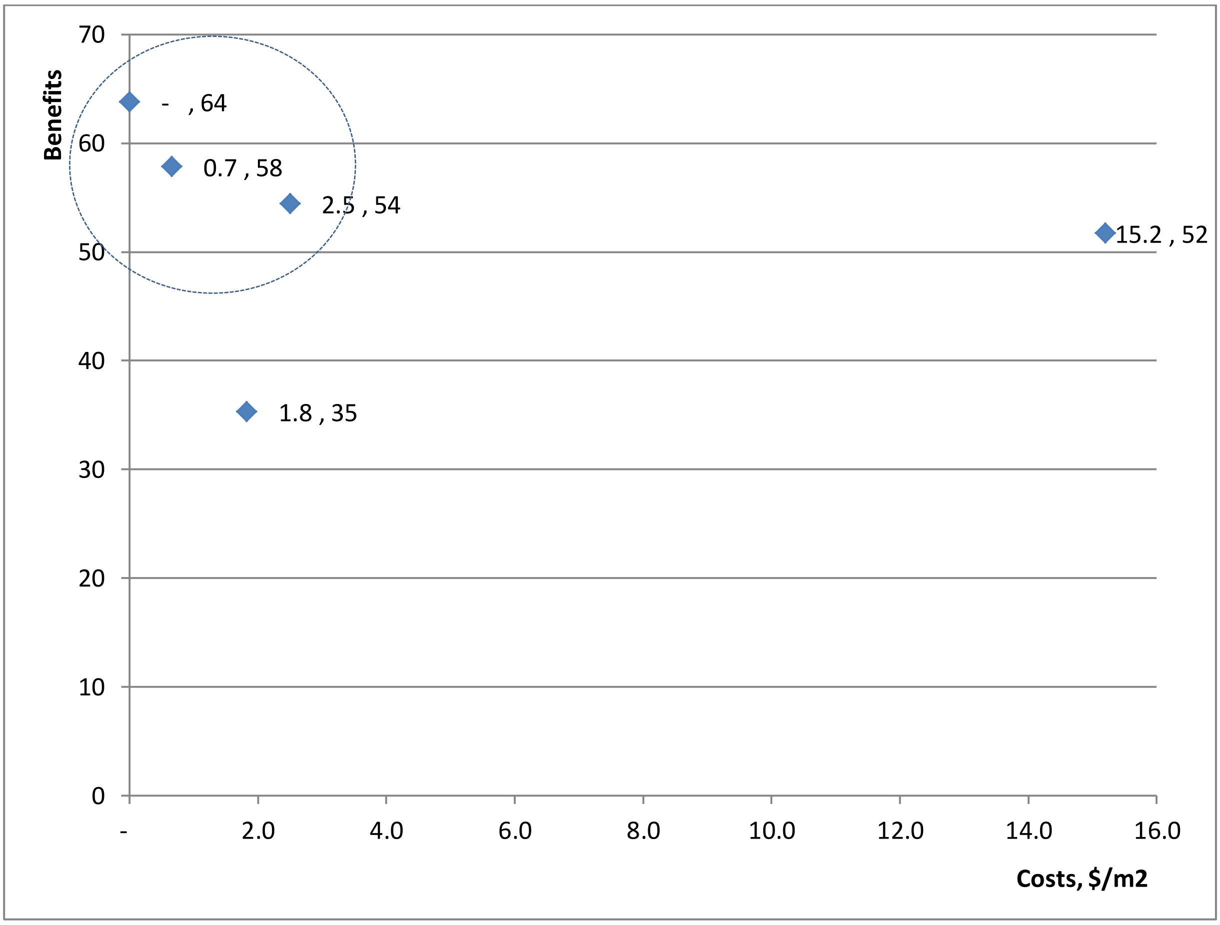

Figure 8.2-2. Small Scale/Short term Administrative buildings technologies arrangement in the Cost-Benefits Coordinates

Ranking of R&A buildings technologies not required MCDAnalyses

As it is reflected in the Table 8.2-1, only Small scale/Long term set of R&A buildings technologies is not subject of MCDAnalyses. The best technology in this set correspond to High Efficient Heat, Ventilation and Air-conditioning System (HVAC) as it has bigger reserves for implementation, is cheaper and is easier for putting in practice, than Passive homes. The entire list of these technologies is presented in the Table 8.2-5.

Table 8.2-5. Ranking of R&A buildings technologies that are not subject to MCDAnalyses

Residential buildings		**Administrative buildings**	
SMALL SCALE/ MEDIUM TO LONG TERM			
Technology	Ranking	Technology	Ranking
High Efficient Heat, Ventilation and Air-conditioning System (HVAC)	1	High Efficient Heat, Ventilation and Air-conditioning System (HVAC)	1
Passive homes	2		

8.3. Final list of prioritized Residential and Administrative technologies

Taking into consideration the technologies analyses carried out above the final list of prioritized mitigation technologies for Residential and Administrative buildings is presented in the Table 8.3-1 and Table 8.3-2. No more than two technologies are selected per each set, they being characterized by main parameters: specific investments, GHG emission reduction and up-scaling potential for implementation.

Table 8.3-1. Summarized table for prioritized mitigation Residential buildings technologies

Technology		Investments, $/m2	GHG Reduction, tCO2	Up-scaling potential
Ranking	**Small scale/Short term**			
1	Energy Efficient lamps	0.66	425 000	30%
2	Building wall isolation	27,6	750 000	40%
	Small scale /Medium-Long term			
1	High Efficient Heat, Ventilation and Air-conditioning System (HVAC)	60	450 000	40%
2	Passive homes	2 000	3 600	0,5%

Table 8.3-2. Summarized table for prioritized mitigation Administrative buildings technologies

Technology		Investments, $/m2	GHG Reduction, tCO2	Up-scaling potential
Ranking	**Small scale/Short term**			
1	Energy Efficient lamps	0.66	106 000	60%
2	Energy protective glasses and pellicles	27.6	5300	30%
	Small scale /Medium-Long term			
1	High Efficient Heat, Ventilation and Air-conditioning System (HVAC)	60	230 000	40%

CHAPTER 9. ENERGY SECTOR TECHNOLOGIES FOR FURTHER EXAMINATION

The final list of technologies selected above in the subsectors of Energy Sector comprises 30 technologies. The further examination of all these technologies would require too much financial and time resources not compatible with those pre-established for TNA Project in Moldova. Following 2012 Bangkok workshop recommendations it was decided to reduce abovementioned number of technologies up to seven. The decision was taken at the appropriate Mitigation Expert meeting having Stakeholders' consultancy. The list of Energy Sector technologies selected for further examination in the frame of TNA Project is presented in the Table 9-1.

Table 9-1. Energy Sector technologies for further examination

No	Technology	Costs	GHG Reduction	Up-scaling potential
Electricity Supply, ($/kWe) / (tCO2)				
1	Combined heat and power plants based on internal combustion engines of at most 500 kW	1150	10 000	20%
Heat Supply, ($/kWt) /(tCO2)				
2	Gasification of Municipal Solid Waste for Electricity/Heat production	3500	80 000	15%
Transport, ($/10^6 pass.-km) /(tCO2)				
3	Hybrid Electric Vehicles	453,488	15,313	10%

CHAPTER 10. TECHNOLOGY PRIORITIZATION FOR SECTOR AGRICULTURE-SUBSECTOR AGRICULTURAL SOILS

10.1. Present status

The GHG emissions from the agricultural soils depend on the carbon balance is kept in the soil during the whole year agricultural work process. The amount of carbon stored in the soil is determined based on plant residues mass and organic fertilizers applied, taking into account the carbon content and humus rating coefficients as well. Positive and balanced carbon content means no CO_2 emissions from the soils. Negative balance (unbalance), when the quantity of carbon left from the soil is higher than one new stocked in the soil, signifies GHG emissions.

Taking into consideration both the dynamic of the land tilled and the types of agricultural methods used in Moldova, during 1990-2010 years, when the transition from the planned to market based economy was promoted, the negative soil balance was recorded with up to 0.6-0.7 t of carbon/he losses.

At present the tilled soils (1.82 million hectares) have lost around 2.1% of humus in the 0-30cm of soil layer that is equivalent to 1.2% of carbon (48.8 t/he), according to direct calculation method. That means around 85.2 million tones of carbon have been lost or 312 million tones of CO2 have been emitted in atmosphere. Nowadays, according to the calculations made, from the 0-30cm of soil layer 0.65 tone of humus/he or 0.38 tone of carbon/he is lost each year, equivalent to 1.4 tone of CO2/he emissions in atmosphere. In absolute value, from all the Moldova soils tilled, around 2.55 million tones of CO2 pollute air annually.

Only a balanced humus concentration in the soil can exclude further GHG emissions from it. To reach this goal friendly practices to the soils should be applied, they leading to organic substance stocking in the soil, finally contributing to enough humus creation in the land. The analyses of possible GHG emission reduction solutions applied to the agricultural soils identify the following measures in this respect:

1. The replacement of deep tilling by one superficial.
2. Predominate straw cereals growing in the crop rotation.
3. Utilization of agriculture organic wastes as fertilizer
4. Utilization of other measures leading to humus increasing in the soil

10.2. New technologies for agriculture soils processing

The long list of technologies for agriculture soils processing selected by the working group is shown in the Table 10.2-1.

The measures specified in the chapter 10.1 can be realized by using the technologies mentioned in the Table 10.2-1. Even the number of technologies per each set is less than four, the experts decided to score Benefits (Social, Economical, Environment and GHG emission reduction), in order to facilitate the selection of best technologies for the set not subject of MCDAnalyses. In the Table 10.2-2 the Scoring for Benefits criteria is presented along with technologies' Performing parameters. Taking them into consideration, in the same table, the rank for each technology in each set was established by experts group.

Table 10.2-1. Long list of technologies for Agricultural Soils

Technology identification
SMALL SCALE /SHORT TERM
Classic tillage, no organic fertilizers
Replacing of plow with heavy disc harrows
LARGE SCALE/ SHORT TERM
Mini-Till tillage with mineral fertilizer application
Mini-Till tillage with agriculture cereal wastes application as fertilizer
LARGE SCALE/ MEDIUM TO LONG TERM
No-Till tillage, with vetchapplication to fertilize soils
Mini-Till tillage, with vetch application to fertilize soils
SMALL SCALE/ MEDIUM TO LONG TERM
Classic tillage with predominant straw cereals cultivation
Classic tillage with vetch application each five year to fertilize soils

Table 10.2-2. Agriculture soil technologies ranking

No.	Technology description	Costs		Benefits and Scoring (from 0 to 100)					Ranking
		Technology Implementation Capacity by 2030	O&M Costs, $/he	GHG emission reduction by 2030		Social	Economic	Environment	
				GHG emission reduction by 2030, tone CO2eq/he	Scoring (from 0 to 100 points)				
SMALL SCALE /SHORT TERM									
1	Classic tillage, without organic fertilizers	Applied to 20% of plough-land	175	1.5	50	50	50	50	1
2	Replacing the moldboard plow with harrow with heavy discs	Applied to 80% of plough-land	120	0.45	30	50	60	50	2
SMALL SCALE/ MEDIUM TO LONG TERM									
3	Classic tillage on slopes with more than 5 ° gradient, in a crop rotation with participation of field seeded crops only	Applied to 20% of plough-land	175	0.75	50	50	70, 10% crop increasing	100, soil erosion reduction by 60%	1
4	Classic tillage. Including a vetch field (two yields per year), as a „green fertilizer field" into a 5 fields crop rotation	Applied to 100% of plough-land	218	2,2	*100*	*60*	70	60	2
LARGE SCALE/ SHORT TERM									
5	Mini-Till soil cultivation system with application of preponderantly mineral fertilizer	Applied to 80% of plough-land	92	0.9	60	50	60	70	1
6	Mini-Till soil cultivation system with use mineral fertilizers and of vegetal waste as fertilizer	Applied to 80% of plough-land	100	1.2	80	60	60	70	2
LARGE SCALE/ MEDIUM TO LONG TERM									
7	The No-Till soil cultivation system with preliminary positive recovery of the post-arable layer and use of vetch as intermediary crop for green fertilizer	Applied to 80% of plough-land	120	No emissions, positive soil balance	100	80	90, 1 t/he crop increasing	80	1
8	Mini-Till soil cultivation system with preliminary positive recovery of the post-arable layer and use of vetch as intermediary crop for green fertilizer	Applied to 80% of plough-land	157	No emissions, positive soil balance	100	80	80	70	2

10.3. Agriculture Sector technologies for further examination

The final list of technologies selected above in the Agriculture Sector comprises 8 technologies. The further examination of all these technologies would require too much financial and time resources not compatible with those pre-established for TNA Project in Moldova. Following 2012 Bangkok workshop recommendations it was decided to reduce abovementioned number of technologies up to three. The decision was taken at the appropriate Mitigation Expert meeting having Stakeholders' consultancy. The list of Agriculture Sector technologies selected for further examination in the frame of TNA Project is presented in the Table 10.3-1.

Table 10.3-1. Agriculture Sector technologies for further examination

No	Technology	Costs	GHG Reduction	Up-scaling potential
Agriculture soils, ($/ha/yr)/(tCO2/ha)				
1	The No-Till soil cultivation system with preliminary positive recovery of the post-arable layer and use of vetch as intermediary crop for green fertilizer	120	No emissions	80%
2.	Mini-Till soil cultivation system with preliminary positive recovery of the post-arable layer and use of vetch as intermediary crop for green fertilizer	157	No emissions	80%
3	Classic tillage. Including a vetch field (two yields per year), as a „green fertilizer field" into a 5 fields crop rotation	218	2.2	80%

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ANNEXES 1-6

Annex 1. Technology Fact Sheets

Electricity Supply

Tehnology 1

Technology Name	**Short term small scale Combined heat and power plants of small capacity, up to 500 kW of technical capacity**
Subsector GHG emission (megatonnes CO2-eq)	**7,7248 Million t CO2 from energy sector in 2005**
Background/Notes, Short description of the technology option	The principle behind cogeneration is simple. Conventional power generation, on average, is only 35% efficient – up to 65% of the energy potential is released as waste heat. More recent combined cycle generation can improve this to 55%, excluding losses for the transmission and distribution of electricity. Cogeneration reduces this loss by using the heat for industry, commerce and home heating/cooling. Cogeneration is the simultaneous generation of heat and power, both of which are used. It encompasses a range of technologies, but will always include an electricity generator and a heat recovery system. Cogeneration is also known as 'combined heat and power (CHP)' and 'total energy'. In conventional electricity generation, further losses of around 5-10% are associated with the transmission and distribution of electricity from relatively remote power stations via the electricity grid. These losses are greatest when electricity is delivered to the smallest consumers. Through the utilization of the heat, the efficiency of cogeneration plant can reach 90% or more. In addition, the electricity generated by the cogeneration plant is normally used locally, and then transmission and distribution losses will be negligible. Cogeneration therefore offers energy savings ranging between 15-40% when compared against the supply of electricity and heat from conventional power stations and boilers. Because transporting electricity over long distances is easier and cheaper than transporting heat, cogeneration installations are usually sited as near as possible to the place where the heat is consumed and, ideally, are built to a size to meet the heat demand. Otherwise an additional boiler will be necessary, and the environmental advantages will be partly hindered. This is the central and most fundamental principle cogeneration. When less electricity is generated than needed, it will be necessary to buy extra. However, when the scheme is sized according to the heat demand, normally more electricity than needed is generated. The surplus electricity can be sold to the network or supplied to another customer via the distribution system (wheeling). As co-generation is the combined production of useful thermal energy and electricity from the same primary fuel it can take on many forms and encompasses a range of technologies, but will always be based upon an efficient, integrated system that combines electricity production and heat recovery. By using the heat output from the electricity production for heating or industrial applications. Small CHP will be defined here as power plants using small internal combustion engines with typically less than 1MW (≈ 500 kW electrical) of technical capacity. Using such small power units results in a range of benefits, including reduced congestion in the electric networks, air pollution and greenhouse gases and better service for end user. Its main drawback compared to large conventional power plants, less capital intensive, is that its efficiency depends greatly of the heat load and good knowledge of the heat and electric load result in good performance of such technology and larger per unit investments. **(source: www.energymanagertraining.com/CHPMaterial/12-V-EDUCOGEN_Cogen_Guide.pdf; climatetechwiki.org).**

Implementation assumptions, How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	The potential of implementation of such technology is estimated at about 10000 kW. Such technology may be implemented at dairy products factories, in hotels, campuses and may be at multi-apartment buildings. It is assumed that the this technology will be implemented at sites with both heat and electricity demands during the whole year. It is envisaged that this technology will use natural gas as fuel.
Implementation barriers	Lack of information regarding benefits, lack of experience in this field and skepticism to implement such a technology. Of course one psychological impediment is the centralized heat supply system in the capital, based on CHPs of old design that is considered inefficient and with high tariffs.
Reduction in GHG emissions (megatonnes CO2-eq)	If implemented the technology will result in annual reduction of 10000 tones of CO2 for 2030
Impact Statements - How this option impacts the country development priorities	Increase country energy security
Country **social** development priorities	Increased efficiency of energy conversion and use; • Lower emissions to the environment, in particular of CO2, the main greenhouse gas; • Large cost savings, providing additional competitiveness for industrial and commercial users, and offering affordable heat for domestic users; • An opportunity to move towards more decentralized forms of electricity generation, where plant is designed to meet the needs of local consumers, providing high efficiency, avoiding transmission losses and increasing flexibility in system use. This will particularly be the case if natural gas is the energy carrier; • Improved local and general security of supply - local generation, through cogeneration, can reduce the risk that consumers are left without supplies of electricity and/or heating. In addition, the reduced fuel need which cogeneration provides reduces the import dependency - a key challenge for Europe's energy future; • An opportunity to increase the diversity of generation plant, and provide competition in generation. Cogeneration provides one of the most important vehicles for promoting liberalization in energy markets; • Increased employment - a number of studies have now concluded that the development of cogeneration systems is a generator of jobs. a. Using this technology there will result in at least 10 % less fuel used to use the same quantity of electricity from the grid and hest produced by heat only boilers. b. Less fuel used means less natural gas imported and less paid for it as well as the decrease of energy dependency.
Country **economic** development priorities – economic benefits	A well-designed and operated cogeneration scheme will always provide better energy efficiency than conventional plant, leading to both energy and cost savings. A single fuel is used to generate heat and electricity, so cost savings are dependent on the price-differential between the primary energy fuel and the bought-in electricity that the scheme displaces. However, although the profitability of cogeneration generally results from its cheap electricity, its success depends on using recovered heat productively, so the prime criterion is a suitable heat requirement. As a rough guide, cogeneration is likely to be suitable where there is a fairly constant demand for heat for at least 4,500 hours in the year. The timing of the site's electricity demand will also be important as the cogeneration installation will be most cost effective when it operates during periods of high electricity tariffs, that is, during the day.
Country **environmental** development priorities	In addition to direct cost savings, cogeneration yields significant environmental benefits through using fossil fuels more efficiently. In particular, it is a highly effective means of

	reducing carbon dioxide (CO_2) and sulphur dioxide (SO_2) emissions. Oxides of nitrogen (NO_x) are also generally reduced by the introduction of modern combustion plant. CO_2 savings The assessment of the carbon savings from a cogeneration project is hotly debated, as it is very difficult to prove what electricity it displaces. This issue has been at the heart of a long running discussion in European markets, with no agreement. Does the cogeneration scheme displace: a. The mix of electricity production in the country? b. The most marginal power plant on the system? c. The next power plant to be built by the power industry? d. The best theoretical power plant available? Depending on the answer the savings in carbon dioxide can vary from 100 kg per MWh to more than 1000 kg MWh. The same issue faces all projects that displace other electricity generation. It is reasonable to assume that most new cogeneration will be gas-fired at least in the next 10 years. For example, a gas turbine with waste-heat-boiler is used here to demonstrate the savings: • Increased efficiency of energy conversion and use; • Lower emissions to the environment, in particular of CO_2, the main greenhouse gas; Reduced air pollution: By replacing of 50 million kWh of electricity to be produced in conventional thermal power plant it will result in reduction of about 10000 tons of CO_2.
Other considerations and priorities such as market potential	Possible opportunities for application of cogeneration Industrial • Pharmaceuticals & fine chemicals • Paper and board manufacture • Brewing, distilling & malting • Ceramics • Brick • Cement • Food processing • Textile processing • Minerals processing • Oil Refineries • Iron and Steel • Motor industry • Horticulture and glasshouses • Timber processing Buildings • District heating • Hotels • Hospitals • Leisure centres & swimming pools • College campuses & schools • Airports • Prisons, police stations, barracks etc • Supermarkets and large stores • Office buildings • Individual Houses • Poultry and other farm sites Market potential is estimated to be about **10000 kW.**
Costs	
Capital costs	The typical investment costs in the small internal combustion engines based CHPs is about 1150 $/kW.
Operational and Maintenance costs	Operational and maintenance costs excluding fuel internal combustion engines is about 168 $/kW per year. The cost of fuel component depends on the natural gas price.
Cost of GHG reduction	The cost of electricity produced by such CHP is lower than the cost of electricity

	produced by thermal power plant electricity of which will be replaced, using the same fuel. In such a case the GHG reduction does not have any cost.		
Lifetime	Economic lifetime is 15-20 years. Technical lifetime is 20-25 years.		
Other	Total energy efficiency is approximately 80-85 %.		
		Old	New
Efficiency	%	36	50
Fixed O&M costs	$/kW*month	2	168
Variable O&M costs	$/MWh	3	0
Investments	$/kW	0	1150
Fuel price	$/tcc	552	552
Time of use of rated capacity	h/an	6000	5000
Fuel consumption	gcc/kWh	341.67	246
Fuel price	$/kgcc	**0.552**	**0.552**
Fuel used	kgcc/kWh	**0.34**	**0.246**
Cost of used fuel	$/kWh	**0.189**	**0.136**
Annual capital costs	$/kW*an		76.667
Per unit fixed O&M costs	$/kWh	**0.004**	**0.015**
Per unit variable O&M costs	$/kWh	**0.003**	**0.034**
Total costs	**$/kWh**	**0.196**	**0.185**

Tehnology 2

Technology Name	**Short term small scale Combined heat and power plants of small capacity, up to 500 kW of technical capacity**
Subsector GHG emission (Mt CO2-eq)	**7,7248 Million t CO2 from energy sector in 2005**
Background/Notes, Short description of the technology option	The principle behind cogeneration is simple. Conventional power generation, on average, is only 35% efficient – up to 65% of the energy potential is released as waste heat. More recent combined cycle generation can improve this to 55%, excluding losses for the transmission and distribution of electricity. Cogeneration reduces this loss by using the heat for industry, commerce and home heating/cooling. Cogeneration is the simultaneous generation of heat and power, both of which are used. It encompasses a range of technologies, but will always include an electricity generator and a heat recovery system. Cogeneration is also known as 'combined heat and power (CHP)' and 'total energy'. In conventional electricity generation, further losses of around 5-10% are associated with the transmission and distribution of electricity from relatively remote power stations via the electricity grid. These losses are greatest when electricity is delivered to the smallest consumers. Through the utilization of the heat, the efficiency of cogeneration plant can reach 90% or more. In addition, the electricity generated by the cogeneration plant is normally used locally, and then transmission and distribution losses will be negligible. Cogeneration therefore offers energy savings ranging between 15-40% when compared against the supply of electricity and heat from conventional power stations and boilers. Because transporting electricity over long distances is easier and cheaper than transporting heat, cogeneration installations are usually sited as near as possible to the place where the heat is consumed and, ideally, are built to a size to meet the heat demand. Otherwise an additional boiler will be necessary, and the environmental advantages will be partly hindered. This is the central and most fundamental principle cogeneration. When less electricity is generated than needed, it will be necessary to buy extra. However, when the scheme is sized according to the heat demand, normally more electricity than needed is generated. The surplus electricity can be sold to the network or supplied to another customer via the distribution system (wheeling). As co-generation is the combined production of useful thermal energy and electricity from the same primary fuel it can take on many forms and encompasses a range of technologies, but will always be based upon an efficient, integrated system that combines electricity production and heat recovery. By using the heat output from the electricity production for heating or industrial applications. Small CHP will be defined here as power plants using small gas turbine based CHP with typically less than 1MW (up to 500 kW electrical) of technical capacity. Using such small power units results in a range of benefits, including reduced congestion in the electric networks, air pollution and greenhouse gases and better service for end user. Its main drawback compared to large conventional power plants, less capital intensive, is that its efficiency depends greatly of the heat load and good knowledge of the heat and electric load result in good performance of such technology and larger per unit investments. **(source: www.energymanagertraining.com/CHPMaterial/12-V-EDUCOGEN_Cogen_Guide.pdf; climatetechwiki.org)**
Implementation assumptions Explain if the technology could have some improvements in the country environment	The potential of implementation of such technology is estimated at about 5000 kW. Such technology may be implemented at dairy products factories, in hotels, campuses and may be at multi-apartment buildings. It is assumed that the this technology will be implemented at sites with both heat and electricity demands during the whole year. It is envisaged that this technology will use natural gas as fuel.
Implementation barriers	Lack of information regarding benefits, lack of experience in this field and skepticism to implement such a technology. Of course one psychological impediment is the centralized heat supply system in the capital, based on CHPs of old design that is considered inefficient and with high tariffs.

Reduction in GHG emissions (Mt CO_2-eq)	If implemented the technology will result in annual reduction of 4000 tones of CO_2 for 2030		
Impact Statements - How this option impacts the country development priorities	Increase country energy security		
Country **social** development priorities	Increased efficiency of energy conversion and use; • Lower emissions to the environment, in particular of CO_2, the main greenhouse gas; • Large cost savings, providing additional competitiveness for industrial and commercial users, and offering affordable heat for domestic users; • An opportunity to move towards more decentralized forms of electricity generation, where plant is designed to meet the needs of local consumers, providing high efficiency, avoiding transmission losses and increasing flexibility in system use. This will particularly be the case if natural gas is the energy carrier; • Improved local and general security of supply - local generation, through cogeneration, can reduce the risk that consumers are left without supplies of electricity and/or heating. In addition, the reduced fuel need which cogeneration provides reduces the import dependency - a key challenge for Europe's energy future; • An opportunity to increase the diversity of generation plant, and provide competition in generation. Cogeneration provides one of the most important vehicles for promoting liberalization in energy markets; • Increased employment - a number of studies have now concluded that the development of cogeneration systems is a generator of jobs. c. Using this technology there will result in at least 10 % less fuel used to use the same quantity of electricity from the grid and hest produced by heat only boilers. d. Less fuel used means less natural gas imported and less paid for it as well as the decrease of energy dependency.		
Country **economic** development priorities – economic benefits	A well-designed and operated cogeneration scheme will always provide better energy efficiency than conventional plant, leading to both energy and cost savings. A single fuel is used to generate heat and electricity, so cost savings are dependent on the price-differential between the primary energy fuel and the bought-in electricity that the scheme displaces. However, although the profitability of cogeneration generally results from its cheap electricity, its success depends on using recovered heat productively, so the prime criterion is a suitable heat requirement. As a rough guide, cogeneration is likely to be suitable where there is a fairly constant demand for heat for at least 4,500 hours in the year. The timing of the site's electricity demand will also be important as the cogeneration installation will be most cost effective when it operates during periods of high electricity tariffs, that is, during the day.		
Country **environmental** development priorities	In addition to direct cost savings, cogeneration yields significant environmental benefits through using fossil fuels more efficiently. In particular, it is a highly effective means of reducing carbon dioxide (CO_2) and sulphur dioxide (SO_2) emissions. Oxides of nitrogen (NO_x) are also generally reduced by the introduction of modern combustion plant. CO_2 savings The assessment of the carbon savings from a cogeneration project is hotly debated, as it is very difficult to prove what electricity it displaces. This issue has been at the heart of a long running discussion in European markets, with no agreement. Does the cogeneration scheme displace: a. The mix of electricity production in the country? b. The most marginal power plant on the system? c. The next power plant to be built by the power industry? d. The best theoretical power plant available? Depending on the answer the savings in carbon dioxide can vary from 100 kg per MWh to more than 1000 kg MWh. The same issue faces all projects that displace other electricity generation. It is reasonable to assume that most new cogeneration will be gas-fired at least in the next 10 years. For example, a gas turbine with waste-heat-boiler is used here to demonstrate the		

	savings: • Increased efficiency of energy conversion and use; • Lower emissions to the environment, in particular of CO2, the main greenhouse gas; Reduced air pollution: By replacing of 22.5 million kWh of electricity to be produced in conventional thermal power plant it will result in reduction of about 4000 tonns of CO2.		
Other considerations and priorities such as market potential	Possible opportunities for application of cogeneration Industrial • Pharmaceuticals & fine chemicals • Paper and board manufacture • Brewing, distilling & malting • Ceramics • Brick • Cement • Food processing • Textile processing • Minerals processing • Oil Refineries • Iron and Steel • Motor industry • Horticulture and glasshouses • Timber processing Buildings • District heating • Hotels • Hospitals • Leisure centres & swimming pools • College campuses & schools • Airports • Prisons, police stations, barracks etc • Supermarkets and large stores • Office buildings • Individual Houses • Poultry and other farm sites Market potential is estimated to be about 5**000 kW.**		
Costs			
Capital costs	The typical investment costs in the small gas turbine based CHPs is about 1100 $/kW.		
Operational and Maintenance costs	Operational and maintenance costs, excluding fuel, of small gas turbine based CHP is about 70 $/kW per year. The cost of fuel component depends on the natural gas price.		
Cost of GHG reduction	The cost of electricity produced by such CHP is lower than the cost of electricity produced by thermal power plant electricity of which will be replaced, using the same fuel. In such a case the GHG reduction does not have any cost.		
Lifetime	**Economic lifetime is up to 20 years. Technical lifetime is 20-25 years.**		
Other	**Total energy efficiency is approximately 80-85 %.**		
		Old	**New**
Efficiency	%	36	50
Fixed O&M costs	$/kW*month	2	70
Variable O&M costs	$/MWh	3	0
Investments	$/kW	0	1100
Fuel price	$/tcc	552	552
Time of use of rated capacity	h/an	6000	4500
Fuel consumption	gcc/kWh	341.67	246

Fuel price	$/kgcc	**0.552**	**0.552**
Fuel used	kgcc/kWh	**0.34**	**0.246**
Cost of used fuel	$/kWh	**0.189**	**0.136**
Annual capital costs	$/kW*an		55.000
Per unit fixed O&M costs	$/kWh	**0.004**	**0.012**
Per unit variable O&M costs	$/kWh	**0.003**	**0.016**
Total costs	**$/kWh**	**0.196**	**0.164**

Tehnology 3

Technology Name	**Short term large scale Combined heat and power plants of large capacity, larger than 1 MW of installed capacity**
Subsector GHG emission (Mt CO2-eq)	**7,7248 Million t CO2 from energy sector in 2005**
Background/Notes, Short description of the technology option	Co-generation is the combined production of useful thermal energy and electricity (Combined Heat and Power, CHP) from the same primary fuel. CHP can take on many forms and encompasses a range of technologies, but will always be based upon an efficient, integrated system that combines electricity production and heat recovery. By using the heat output from the electricity production for heating or industrial applications, CHP plants generally convert 75-80% of the fuel source into useful energy, while the most modern CHP plants reach efficiencies of 90% or more (IPCC, 2007). CHP plants also reduce network losses because they are sited near the end user. large CHPs will be defined here as power plants using internal combustion engines and gas-turbine based CHPs with capacity higher than 1MW of electrical capacity. Using such large power units results in a range of benefits, including reduced air pollution and greenhouse gases and better service for end user. Its main drawback compared to large conventional power plants, less capital intensive, is that its efficiency depends greatly of the heat load and good knowledge of the heat and electric load result in good performance of such technology and larger per unit investments. **(source: climatetechwiki.org)**
Implementation assumptions. Explain if the technology could have some improvements in the country environment.	It is assumed that CHPs of large capacity may be built in cities where there is heat load during the whole year or at industrial sites, or may be used to replace the existing capacities at CHP that are old and does not correspond to actual requirements. It is envisaged that this technology will use natural gas as fuel.
Implementation barriers	Lack of information regarding benefits, lack of experience in this field and skepticism to implement such a technology. Of course one psychological impediment is the centralized heat supply system in the capital, based on CHPs of old design that is considered inefficient and with high tariffs.
Reduction in GHG emissions (MtCO2-eq)	If implemented the technology will result in annual reduction of 134000 tones of CO2 for 2030
Impact Statements	Increase country energy security
Country **social** development priorities	Increased efficiency of energy conversion and use; • Lower emissions to the environment, in particular of CO2, the main greenhouse gas; • Large cost savings, providing additional competitiveness for industrial and commercial users, and offering affordable heat for domestic users; • An opportunity to move towards more decentralized forms of electricity generation, where plant is designed to meet the needs of local consumers, providing high efficiency, avoiding transmission losses and increasing flexibility in system use. This will particularly be the case if natural gas is the energy carrier; • Improved local and general security of supply - local generation, through cogeneration, can reduce the risk that consumers are left without supplies of electricity and/or heating. In addition, the reduced fuel need which cogeneration provides reduces the import dependency - a key challenge for Europe's energy future; • An opportunity to increase the diversity of generation plant, and provide competition in generation. Cogeneration provides one of the most important vehicles for promoting liberalization in energy markets; • Increased employment - a number of studies have now concluded that the development of cogeneration systems is a generator of jobs. Using this technology there will result in at least 10 % less fuel used to use the same quantity of electricity from the grid and hest produced by heat only boilers.
Country **economic** development priorities	A well-designed and operated cogeneration scheme will always provide better energy efficiency than conventional plant, leading to both energy and cost savings.

– economic benefits	A single fuel is used to generate heat and electricity, so cost savings are dependent on the price-differential between the primary energy fuel and the bought-in electricity that the scheme displaces. However, although the profitability of cogeneration generally results from its cheap electricity, its success depends on using recovered heat productively, so the prime criterion is a suitable heat requirement. As a rough guide, cogeneration is likely to be suitable where there is a fairly constant demand for heat for at least 4,500 hours in the year. The timing of the site's electricity demand will also be important as the cogeneration installation will be most cost effective when it operates during periods of high electricity tariffs, that is, during the day. Less fuel used means less natural gas imported and less paid for it as well as the decrease of energy dependency.		
Country **environmental** development priorities	In addition to direct cost savings, cogeneration yields significant environmental benefits through using fossil fuels more efficiently. In particular, it is a highly effective means of reducing carbon dioxide (CO2) and sulphur dioxide (SO2) emissions. Oxides of nitrogen (NOx) are also generally reduced by the introduction of modern combustion plant. CO2 savings The assessment of the carbon savings from a cogeneration project is hotly debated, as it is very difficult to prove what electricity it displaces. This issue has been at the heart of a long running discussion in European markets, with no agreement. Does the cogeneration scheme displace: a. The mix of electricity production in the country? b. The most marginal power plant on the system? c. The next power plant to be built by the power industry? d. The best theoretical power plant available? Increased efficiency of energy conversion and use; • Lower emissions to the environment, in particular of CO2, the main greenhouse gas; Reduced air pollution: By replacing of 855 million kWh of electricity to be produced in conventional thermal power plant it will result in reduction of about 134000 tons of CO2 per year.		
Other considerations and priorities such as market potential	It is estimated that the market potential of such a technology is about 150000 kW.		
Costs			
Capital costs	The typical investment costs in the large scale CHP is about 1000 $/kW, but it may depend on site and on used technology gas turbine or internal combustion engine CHPs.		
Operational and Maintenance costs	Operational and maintenance costs excluding fuel for gas-turbine CHPs is typically about 40 $/kW per year. For internal combustion engine the O$M costs may be doubled. The cost of fuel component depends on the natural gas price.		
Cost of GHG reduction	The cost of electricity produced by such CHP is lower than the cost of electricity produced by thermal power plant electricity of which will be replaced, using the same fuel. In such a case the GHG reduction does not have any cost.		
Lifetime	Economic lifetime is 20 years. Technical lifetime is 20-25 years.		
Other	Total energy efficiency is approximately 80-85 %.		
		Old	**New**
Efficiency	%	36	50
Fixed O&M costs	$/kW*month	2	40
Variable O&M costs	$/MWh	3	0
Investments	$/kW	0	1000
Fuel price	$/tcc	552	552
Time of use of rated capacity	h/an	6000	5700
Fuel consumption	gcc/kWh	341.67	246

Fuel price	$/kgcc	**0.552**	**0.552**
Fuel used	kgcc/kWh	**0.34**	**0.246**
Cost of used fuel	$/kWh	**0.189**	**0.136**
Annual capital costs	$/kW*an		50.000
Per unit fixed O&M costs	$/kWh	**0.004**	**0.009**
Per unit variable O&M costs	$/kWh	**0.003**	**0.007**
Total costs	**$/kWh**	**0.196**	**0.152**

Tehnology 4

Technology Name	**Short term large scale Combined cycle power plants**		
Subsector GHG emission (megatonnes CO2-eq)	**7,7248 Million t CO2 from energy sector in 2005**		
Background/Notes, Short description of the technology option	Combined cycle using a gas turbine, heat recovery steam generator and a steam turbine is one of the mature technology that can be applied at the moment in order to produce electricity at high thermal efficiency. By using CC it can be reduced the amount of fuel to be used for generation of the same quantity of electricity in comparison with the generation of electricity in the steam condensing units. Using such large power units results in a range of benefits, including reduced air pollution, less greenhouse gases and better service for end users. The main drawback compared to large conventional power plants, relies not in the technology itself but in the lack of financial resources for investments. Due to the fact that in the cost of the electricity produced by the conventional steam condensing power units it is not taken into consideration the impact on environmental the price of the electricity produced in such power plants may be lower that the same indicator of the CC units. (**source: climatetechwiki.org)**		
Implementation assumptions. How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	The combined cycles units may be built as new power plants or may replace the existing units in conventional thermal power plants. It is envisaged that this technology will use natural gas as fuel.		
Implementation barriers	Lack of information regarding benefits, lack of experience in this field, lack of financial resources for investments and skepticism to implement such a technology, as well as the fear that the old power plants will sell electricity at lower prices.		
Reduction in GHG emissions (megatonnes CO2-eq)	If implemented the technology will result in annual reduction of 330000 tones of CO2 for 2030.		
Impact Statements - How this option impacts the country development priorities	Increase country energy security		
Country **social** development priorities	Increased efficiency of energy conversion and use; • Lower emissions to the environment, in particular of CO2, the main greenhouse gas; • Large cost savings due to less quantity of natural gas used to generate electricity; • An opportunity to increase the diversity of power plants, and provide competition in generation. • Increased employment - a number of studies have now concluded that the development of cogeneration systems is a generator of jobs.		
Country **economic** development priorities – economic benefits	A well-designed and operated CC will always provide better energy efficiency than conventional plant, leading to both energy and cost savings. Less fuel used means less natural gas imported and less paid for it as well as the decrease of energy dependency.		
Country **environmental** development priorities	In addition to direct cost savings, cogeneration yields significant environmental benefits through using fossil fuels more efficiently. In particular, it is a highly effective means of reducing carbon dioxide (CO2) and sulphur dioxide (SO2) emissions. Oxides of nitrogen (NOx) are also generally reduced by the introduction of modern combustion plant.		

	Increased efficiency of energy conversion and use; • Lower emissions to the environment, in particular of CO2, the main greenhouse gas; Reduced air pollution: By producing of 2.1 billion kWh of electricity will result in reduction of about 330000 tons of CO2 per year.		
Other considerations and priorities such as market potential	It is estimated that the market potential of such a technology is about 300000 kW.		
Costs			
Capital costs	The typical investment costs in large CC, is approximately 750 $/kW.		
Operational and Maintenance costs	Operational and maintenance costs excluding fuel for gas-turbine CC is typically about 36 $/kW per year. The cost of fuel component depends on the natural gas price.		
Cost of GHG reduction	The cost of electricity produced by such CC is lower than the cost of electricity produced by thermal power plant electricity of which will be replaced, using the same fuel. In such a case the GHG reduction does not have any cost.		
Lifetime	Economic lifetime is 20 years. Technical lifetime is 20-25 years.		
Other	Energy efficiency at present is more than 50 %.		
		Old	**New**
Efficiency	%	36	50
Fixed O&M costs	$/kW*month	2	36
Variable O&M costs	$/MWh	3	0
Investments	$/kW	0	750
Fuel price	$/tcc	552	552
Time of use of rated capacity	h/an	6000	7000
Fuel consumption	gcc/kWh	341.67	246
Fuel price	$/kgcc	**0.552**	**0.552**
Fuel used	kgcc/kWh	**0.34**	**0.246**
Cost of used fuel	$/kWh	**0.189**	**0.136**
Annual capital costs	$/kW*an		37.500
Per unit fixed O&M costs	$/kWh	**0.004**	**0.005**
Per unit variable O&M costs	$/kWh	**0.003**	**0.005**
Total costs	**$/kWh**	**0.196**	**0.146**

Tehnology 5

Technology Name	**Short term large scale Combined cycle combined heat and power plant of large capacity (natural gas)**
Subsector GHG emission (Mt CO2-eq)	**7,7248 Million t CO2 from energy sector in 2005**
Background/Notes, Short description of the technology option	Combined cycle using a gas turbine, heat recovery steam generator and a steam turbine is one of the mature technology that can be applied in order to produce electricity at high energy efficiency. The efficiency may be increased if the heat from steam turbine is used. In this case the power plant will be CC CHP. CC CHP can take on many forms and encompasses a range of technologies, but will always be based upon an efficient, integrated system that combines electricity production and heat recovery. By using the heat output from the electricity production for heating or industrial applications, CC CHP plants generally convert 80-85 % of the fuel source into useful energy. Using such large power units results in a range of benefits, including reduced air pollution and greenhouse gases and better service for end users. Its main drawback compared to large conventional power plants, less capital intensive, is that the efficiency of 80 % and more can be reached in case there is heat load, otherwise the efficiency will be in the range of 50-60%. Of course to use heat that will result in the increase the efficiency depends greatly of the heat load and good knowledge of the heat and electric load result in good performance of such technology and larger per unit investments. **(source: climatetechwiki.org)**
Implementation assumptions, How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	It is assumed that combined cycle CHPs of large capacity may be built in cities where there is heat load during the whole year or at industrial sites, or may be used to replace the existing capacities at CHP that are old and does not correspond to actual requirements. It is envisaged that this technology will use natural gas as fuel.
Implementation barriers	Lack of information regarding benefits, lack of experience in this field and skepticism to implement such a technology. Of course one psychological impediment is the centralized heat supply system in the capital, based on CHPs of old design that is considered inefficient and with high tariffs.
Reduction in GHG emissions (megatonnes CO2-eq)	If implemented the technology will result in annual reduction of 140000 tones of CO2 for 2030
Impact Statements - How this option impacts the country development priorities	Increase country energy security
Country **social** development priorities	Increased efficiency of energy conversion and use; • Lower emissions to the environment, in particular of CO2, the main greenhouse gas; • Large cost savings, providing additional competitiveness for industrial and commercial users, and offering affordable heat for domestic users; • An opportunity to move towards more decentralized forms of electricity generation, where plant is designed to meet the needs of local consumers, providing high efficiency, avoiding transmission losses and increasing flexibility in system use. This will particularly be the case if natural gas is the energy carrier; • Improved local and general security of supply - local generation, through cogeneration, can reduce the risk that consumers are left without supplies of electricity and/or heating. In addition, the reduced fuel need which cogeneration provides reduces the import dependency -

	a key challenge for Europe's energy future; • An opportunity to increase the diversity of generation plant, and provide competition in generation. Cogeneration provides one of the most important vehicles for promoting liberalization in energy markets; • Increased employment - a number of studies have now concluded that the development of cogeneration systems is a generator of jobs. Using this technology there will result in more than 15 % less fuel used to use the same quantity of electricity from the grid and hest produced by heat only boilers.		
Country **economic** development priorities – economic benefits	A well-designed and operated combined cycle CHP scheme will always provide better energy efficiency than conventional plant, leading to both energy and cost savings. A single fuel is used to generate heat and electricity, so cost savings are dependent on the price-differential between the primary energy fuel and the bought-in electricity that the scheme displaces. However, although the profitability of cogeneration generally results from its cheap electricity, its success depends on using recovered heat productively, so the prime criterion is a suitable heat requirement. The timing of the site's electricity demand will also be important as the cogeneration installation will be most cost effective when it operates during periods of high electricity tariffs, that is, during the day. Less fuel used means less natural gas imported and less paid for it as well as the decrease of energy dependency.		
Country **environmental** development priorities	In addition to direct cost savings, cogeneration yields significant environmental benefits through using fossil fuels more efficiently. In particular, it is a highly effective means of reducing carbon dioxide (CO2) and sulphur dioxide (SO2) emissions. Oxides of nitrogen (NOx) are also generally reduced by the introduction of modern combustion plant. • Increased efficiency of energy conversion and use; • Lower emissions to the environment, in particular of CO2, the main greenhouse gas; Reduced air pollution: By replacing of 900 million kWh of electricity to be produced in conventional thermal power plant it will result in reduction of about 140000 tons of CO2 per year.		
Other considerations and priorities such as market potential	It is estimated that the market potential of such a technology is about 150000 kW.		
Costs			
Capital costs	The typical investment costs in the large CC CHP is approximately 1300 $/kW.		
Operational and Maintenance costs	Operational and maintenance costs excluding fuel for gas-turbine CC CHP is typically about 60 $/kW per year. The cost of fuel component depends on the natural gas price.		
Cost of GHG reduction	The cost of electricity produced by such CC CHP is lower than the cost of electricity produced by thermal power plant electricity of which will be replaced, using the same fuel. In such a case the GHG reduction does not have any cost.		
Lifetime	Economic lifetime is 20 years. Technical lifetime is 25 years.		
Other	Total energy efficiency is approximately >80 %.		
		Old	**New**
Efficiency	%	36	50
Fixed O&M costs	$/kW*month	2	60
Variable O&M costs	$/MWh	3	0
Investments	$/kW	0	1300
Fuel price	$/tcc	552	552

Time of use of rated capacity	h/an	6000	7000
Fuel consumption	gcc/kWh	341.67	246
Fuel price	$/kgcc	**0.552**	**0.552**
Fuel used	kgcc/kWh	**0.34**	**0.246**
Cost of used fuel	$/kWh	**0.189**	**0.136**
Annual capital costs	$/kW*an		65.000
Per unit fixed O&M costs	$/kWh	**0.004**	**0.009**
Per unit variable O&M costs	$/kWh	**0.003**	**0.009**
Total costs	**$/kWh**	**0.196**	**0.154**

Tehnology 6

Technology Name	**Medium term large scale Combined cycle power plants of large capacity**		
Subsector GHG emission (megatonnes CO_2-eq)	**7,7248 Million t CO_2 from energy sector in 2005**		
Background/Notes, Short description of the technology option	Combined cycle using a gas turbine, heat recovery steam generator and a steam turbine is one of the mature technology that can be applied at the moment in order to produce electricity at high thermal efficiency. By using CC it can be reduced the amount of fuel to be used for generation of the same quantity of electricity in comparison with the generation of electricity in the steam condensing units. Using such large power units results in a range of benefits, including reduced air pollution, less greenhouse gases and better service for end users. The main drawback compared to large conventional power plants, relies not in the technology itself but in the lack of financial resources for investments. Due to the fact that in the cost of the electricity produced by the conventional steam condensing power units it is not taken into consideration the impact on environmental the price of the electricity produced in such power plants may be lower that the same indicator of the CC units. (**source: climatetechwiki.org)**		
Implementation assumptions Explain if the technology could have some improvements in the country environment.	The combined cycles units may be built as new power plants or may replace the existing units in conventional thermal power plants. It is envisaged that this technology will use natural gas as fuel.		
Implementation barriers	Lack of information regarding benefits, lack of experience in this field, lack of financial resources for investments and skepticism to implement such a technology, as well as the fear that the old thermal power plants will sell electricity at lower prices.		
Reduction in GHG emissions (megatonnes CO_2-eq)	If implemented the technology will result in annual reduction of 203000 tones of CO_2 for 2030.		
Impact Statements - How this option impacts the country development priorities	Increase country energy security		
Country **social** development priorities	Increased efficiency of energy conversion and use; • Lower emissions to the environment, in particular of CO_2, the main greenhouse gas; • Large cost savings due to less quantity of natural gas used to generate electricity; • An opportunity to increase the diversity of power plants, and provide competition in generation. • Increased employment - a number of studies have now concluded that the development of cogeneration systems is a generator of jobs. Using this technology there will result in more than 10 % less fuel used to use the same quantity of electricity.		
Country **economic** development priorities – economic benefits	A well-designed and operated CC will always provide better energy efficiency than conventional plant, leading to both energy and cost savings. Less fuel used means less natural gas imported and less paid for it as well as the decrease of energy dependency.		
Country **environmental** development priorities	In addition to direct cost savings, cogeneration yields significant environmental benefits through using fossil fuels more efficiently. In particular, it is a highly effective means of reducing carbon dioxide (CO_2) and sulphur dioxide (SO_2) emissions. Oxides of nitrogen (NOx) are also generally reduced by the introduction of modern combustion plant.		

	Increased efficiency of energy conversion and use; • Lower emissions to the environment, in particular of CO2, the main greenhouse gas; Reduced air pollution: By producing of 1.05 billion kWh of electricity will result in reduction of about 203000 tons of CO2 per year.		
Other considerations and priorities such as market potential	It is estimated that the market potential of such a technology is about 150000 kW.		
Costs			
Capital costs	The typical investment costs in large CC, is approximately 750 $/kW.		
Operational and Maintenance costs	Operational and maintenance costs excluding fuel for gas-turbine CC is typically about 36 $/kW per year. The cost of fuel component depends on the natural gas price.		
Cost of GHG reduction	The cost of electricity produced by such CC is lower than the cost of electricity produced by thermal power plant electricity of which will be replaced, using the same fuel. In such a case the GHG reduction does not have any cost.		
Lifetime	Economic lifetime is 20 years. Technical lifetime is 25 years.		
Other	Total energy efficiency is approximately 55-60 %.		
		Old	**New**
Efficiency	%	36	55
Fixed O&M costs	$/kW*month	2	36
Variable O&M costs	$/MWh	3	0
Investments	$/kW	0	750
Fuel price	$/tcc	552	552
Time of use of rated capacity	h/an	6000	7000
Fuel consumption	gcc/kWh	341.67	223.64
Fuel price	$/kgcc	**0.552**	**0.552**
Fuel used	kgcc/kWh	**0.34**	**0.224**
Cost of used fuel	$/kWh	**0.189**	**0.123**
Annual capital costs	$/kW*an		37.500
Per unit fixed O&M costs	$/kWh	**0.004**	**0.005**
Per unit variable O&M costs	$/kWh	**0.003**	**0.005**
Total costs	**$/kWh**	**0.196**	**0.134**

Tehnology 7

Technology Name	**Long term large scale Combined cycle power plants**
Subsector GHG emission (megatonnes CO_2-eq)	**7,7248 Million t CO_2 from energy sector in 2005**
Background/Notes, Short description of the technology option	Combined cycle using a gas turbine, heat recovery steam generator and a steam turbine is one of the mature technology that can be applied at the moment in order to produce electricity at high thermal efficiency. By using CC it can be reduced the amount of fuel to be used for generation of the same quantity of electricity in comparison with the generation of electricity in the steam condensing units. Using such large power units results in a range of benefits, including reduced air pollution, less greenhouse gases and better service for end users. The main drawback compared to large conventional power plants, relies not in the technology itself but in the lack of financial resources for investments. Due to the fact that in the cost of the electricity produced by the conventional steam condensing power units it is not taken into consideration the impact on environmental the price of the electricity produced in such power plants may be lower that the same indicator of the CC units. (**source: climatetechwiki.org)**
Implementation assumptions, How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	The combined cycles units may be built as new power plants or may replace the existing units in conventional thermal power plants. It is envisaged that this technology will use natural gas as fuel.
Implementation barriers	Lack of information regarding benefits, lack of experience in this field, lack of financial resources for investments and skepticism to implement such a technology, as well as the fear that the old thermal power plants will sell electricity at lower prices.
Reduction in GHG emissions (megatonnes CO_2-eq)	If implemented the technology will result in annual reduction of 330000 tones of CO_2 for 2030.
Impact Statements - How this option impacts the country development priorities	Increase country energy security
Country **social** development priorities	Increased efficiency of energy conversion and use; • Lower emissions to the environment, in particular of CO_2, the main greenhouse gas; • Large cost savings due to less quantity of natural gas used to generate electricity; • An opportunity to increase the diversity of power plants, and provide competition in generation. • Increased employment - a number of studies have now concluded that the development of cogeneration systems is a generator of jobs. Using this technology there will result in more than 15 % less fuel used to use the same quantity of electricity.
Country **economic** development priorities – economic benefits	A well-designed and operated CC will always provide better energy efficiency than conventional plant, leading to both energy and cost savings. Less fuel used means less natural gas imported and less paid for it as well as the decrease of energy dependency.
Country	In addition to direct cost savings, cogeneration yields significant environmental benefits

environmental development priorities	through using fossil fuels more efficiently. In particular, it is a highly effective means of reducing carbon dioxide (CO_2) and sulphur dioxide (SO_2) emissions. Oxides of nitrogen (NO_x) are also generally reduced by the introduction of modern combustion plant. Increased efficiency of energy conversion and use; • Lower emissions to the environment, in particular of CO_2, the main greenhouse gas; Reduced air pollution: By producing of 2.1 billion kWh of electricity will result in reduction of about 470000 tons of CO_2 per year.		
Other considerations and priorities such as market potential	It is estimated that the market potential of such a technology is about 300000 kW.		
Costs			
Capital costs	The typical investment costs in large CC, is approximately 750 $/kW.		
Operational and Maintenance costs	Operational and maintenance costs excluding fuel for gas-turbine CC is typically about 36 $/kW per year. The cost of fuel component depends on the natural gas price.		
Cost of GHG reduction	The cost of electricity produced by such CC is lower than the cost of electricity produced by thermal power plant electricity of which will be replaced, using the same fuel. In such a case the GHG reduction does not have any cost.		
Lifetime	Economic lifetime is 20 years. Technical lifetime is 25 years.		
Other	Total energy efficiency is approximately >60 %.		
		Old	**New**
Efficiency	%	36	60
Fixed O&M costs	$/kW*month	2	36
Variable O&M costs	$/MWh	3	0
Investments	$/kW	0	750
Fuel price	$/tcc	552	552
Time of use of rated capacity	h/an	6000	7000
Fuel consumption	gcc/kWh	341.67	205
Fuel price	$/kgcc	**0.552**	**0.552**
Fuel used	kgcc/kWh	**0.34**	**0.205**
Cost of used fuel	$/kWh	**0.189**	**0.113**
Annual capital costs	$/kW*an		37.500
Per unit fixed O&M costs	$/kWh	**0.004**	**0.005**
Per unit variable O&M costs	$/kWh	**0.003**	**0.005**
Total costs	**$/kWh**	**0.196**	**0.124**

Tehnology 8

Technology Name	**Long term large scale Combined cycle combined heat and power plant of large capacity (natural gas)**		
Subsector GHG emission (megatonnes CO2-eq)	**7,7248 Million t CO2 from energy sector in 2005**		
Background/Notes, Short description of the technology option	Combined cycle using a gas turbine, heat recovery steam generator and a steam turbine is one of the mature technology that can be applied in order to produce electricity at high energy efficiency. The efficiency may be increased if the heat from steam turbine is used. In this case the power plant will be CC CHP. CC CHP can take on many forms and encompasses a range of technologies, but will always be based upon an efficient, integrated system that combines electricity production and heat recovery. By using the heat output from the electricity production for heating or industrial applications, CC CHP plants generally convert 80-85 % of the fuel source into useful energy. Using such large power units results in a range of benefits, including reduced air pollution and greenhouse gases and better service for end users. Its main drawback compared to large conventional power plants, less capital intensive, is that the efficiency of 80 % and more can be reached in case there is heat load, otherwise the efficiency will be in the range of 50-60%. Of course to use heat that will result in the increase the efficiency depends greatly of the heat load and good knowledge of the heat and electric load result in good performance of such technology and larger per unit investments. **(source: climatetechwiki.org)**		
Implementation assumptions Explain if the technology could have some improvements in the country environment.	It is assumed that combined cycle CHPs of large capacity may be built in cities where there is heat load during the whole year or at industrial sites, or may be used to replace the existing capacities at CHP that are old and does not correspond to actual requirements. It is envisaged that this technology will use natural gas as fuel.		
Implementation barriers	Lack of information regarding benefits, lack of experience in this field and skepticism to implement such a technology. Of course one psychological impediment is the centralized heat supply system in the capital, based on CHPs of old design that is considered inefficient and with high tariffs.		
Reduction in GHG emissions (megatonnes CO2-eq)	If implemented the technology will result in annual reduction of 212000 tones of CO2 for 2030.		
Impact Statements - How this option impacts the country development priorities	Increase country energy security		
Country **social** development priorities	Increased efficiency of energy conversion and use; • Lower emissions to the environment, in particular of CO2, the main greenhouse gas; • Large cost savings, providing additional competitiveness for industrial and commercial users, and offering affordable heat for domestic users; • An opportunity to move towards more decentralized forms of electricity generation, where plant is designed to meet the needs of local consumers, providing high efficiency, avoiding transmission losses and increasing flexibility in system use. This will particularly be the case if natural gas is the energy carrier; • Improved local and general security of supply - local generation, through cogeneration, can reduce the risk that consumers are left without supplies of electricity and/or heating. In addition, the reduced fuel need which cogeneration provides reduces the import dependency - a key challenge for Europe's energy future; • An opportunity to increase the diversity of generation plant, and provide competition in generation. Cogeneration provides one of the most important vehicles for promoting		

	liberalization in energy markets; • Increased employment - a number of studies have now concluded that the development of cogeneration systems is a generator of jobs. Using this technology there will result in more than 15 % less fuel used to use the same quantity of electricity from the grid and hest produced by heat only boilers.		
Country **economic** development priorities – economic benefits	A well-designed and operated combined cycle CHP scheme will always provide better energy efficiency than conventional plant, leading to both energy and cost savings. A single fuel is used to generate heat and electricity, so cost savings are dependent on the price-differential between the primary energy fuel and the bought-in electricity that the scheme displaces. However, although the profitability of cogeneration generally results from its cheap electricity, its success depends on using recovered heat productively, so the prime criterion is a suitable heat requirement. The timing of the site's electricity demand will also be important as the cogeneration installation will be most cost effective when it operates during periods of high electricity tariffs, that is, during the day. Less fuel used means less natural gas imported and less paid for it as well as the decrease of energy dependency.		
Country **environmental** development priorities	In addition to direct cost savings, cogeneration yields significant environmental benefits through using fossil fuels more efficiently. In particular, it is a highly effective means of reducing carbon dioxide (CO2) and sulphur dioxide (SO2) emissions. Oxides of nitrogen (NOx) are also generally reduced by the introduction of modern combustion plant. • Increased efficiency of energy conversion and use; • Lower emissions to the environment, in particular of CO2, the main greenhouse gas; Reduced air pollution: By replacing of 945 million kWh of electricity to be produced in conventional thermal power plant it will result in reduction of about 212000 tons of CO2 per year.		
Other considerations and priorities such as market potential	It is estimated that the market potential of such a technology is about 150000 kW.		
Costs			
Capital costs	The typical investment costs in the large CC CHP is approximately 1200 $/kW.		
Operational and Maintenance costs	Operational and maintenance costs excluding fuel for gas-turbine CC CHP is typically about 60 $/kW per year. The cost of fuel component depends on the natural gas price.		
Cost of GHG reduction	The cost of electricity produced by such CC CHP is lower than the cost of electricity produced by thermal power plant electricity of which will be replaced, using the same fuel. In such a case the GHG reduction does not have any cost.		
Lifetime	Economic lifetime is 20 years. Technical lifetime is 25 years.		
Other	Total energy efficiency is approximately >80 %.		
		Old	**New**
Efficiency	%	36	60
Fixed O&M costs	$/kW*month	2	60
Variable O&M costs	$/MWh	3	0
Investments	$/kW	0	1200
Fuel price	$/tcc	552	552
Time of use of rated capacity	h/an	6000	7000
Fuel consumption	gcc/kWh	341.67	205
Fuel price	$/kgcc	**0.552**	**0.552**
Fuel used	kgcc/kWh	**0.34**	**0.205**

Cost of used fuel	$/kWh	**0.189**	**0.113**
Annual capital costs	$/kW*an		60.000
Per unit fixed O&M costs	$/kWh	**0.004**	**0.009**
Per unit variable O&M costs	$/kWh	**0.003**	**0.009**
Total costs	**$/kWh**	**0.196**	**0.130**

Tehnology 9

Technology Name	**Long term large scale, nuclear units of small capacity**
Subsector GHG emission (megatonnes CO2-eq)	**7,7248 Million t CO2 from energy sector in 2005**
Background/Notes, Short description of the technology option	The HPM small nuclear reactor is a next generation design that uses a liquid metal cooled, uranium nitride fueled, fast-spectrum reactor that employs control rods for reactivity control. The reactor has been designed to deliver 70 MW of heat (25 MW of electricity) for a 10-year lifetime, without refueling. Key advantages of the HPM design are: Advanced reactor design – Use of advanced reactor concepts provides for a safer and simpler reactor, elimination of many potential accident scenarios that affect LWRs, and elimination of complex reactor systems. Small reactor – A smaller reactor is more appropriately sized for smaller generation requirements, can directly replace existing diesel fueled generators, and requires no upgrade to existing small electricity distribution systems. 10-year power module replacement – The HPM provides 25 MW(e) continuously for 10 years on its initial fuel load (compared to an 18 to 24 month cycle for current light water reactors). No on-site refueling is required. After 10 years the entire reactor module is replaced. Underground containment vault – The reactor is sited in an underground containment vault to provide isolation from the environment, prevent intrusion or tampering, and avoid harm from natural disasters. Factory-assembled transportable power modules – Factory assembly allows for standard designs, superior quality control, and faster construction and on-site deployment. A standardized design will offer several advantages: Manufacturing process controls will be uniform and will not vary between units. Nuclear fabrication and assembly will be completed at the factory before the unit is shipped, minimizing the nuclear construction capabilities that are necessary on site. On site construction activities will be limited to the reactor vault, the non-nuclear systems, placement of the HPM in the vault, and connection to the HPM to non-nuclear systems and controls. This will significantly reduce the on-site construction complexity and result in a faster construction schedule. Hyperion will provide standard operating procedures, operator training, licensing support, technical support, in-service engineering, and safety analysis, significantly reducing the nuclear expertise and staffing that is required of the owner/operator. Key material selections include: Lead Bismuth Eutectic (LBE) coolant -The core coolant is LBE, which is non-reactive to air and water, with a mixed mean exit temperature of 500C. A solid phase oxygen control system is used to control the oxygen level in the coolant to maintain a protective coating on structural surfaces, limiting corrosion. Uranium Nitride (UN) fuel- The fuel consists of 19.75% enriched (non weapons grade) UN pellets contained in clad tubes made of HT-9. These high-temperature ceramic material pellets deter the ability to separate plutonium from spent fuel. Stainless Steel structural materials (HT-9 and T-91) Quartz radial reflector B4C control rods for reactivity control -There are three independent reactivity shut-down systems in the core: a shutdown rod system composed of six boron carbide (B4C) rods, a control rod system comprising 12 boron carbide (B4C) rods and a reserve shutdown system consisting of a central cavity into which B4C balls may be inserted. Each of the three systems can independently take the core to long-term cold shutdown. The rod shutdown and the ball shutdown systems perform this safety function automatically and instantaneously when triggered. (www.hyperionpowergeneration.com).
Implementation assumptions Explain if the technology could have some improvements in the country environment.	By 2030, it is envisaged that there will be built at least 4 small nuclear reactors of 25 MW electric capacity.
Implementation barriers	Lack of information regarding benefits, lack of experience in this field and skepticism to implement such a technology.

Reduction in GHG emissions (MtCO2-eq)	It is assumed that the generation of 750 million kWh of electricity by this technology will result in 420000 tones of CO2 reduction.		
Impact Statements - How this option impacts the country development priorities	Increase country energy security		
Country **social** development priorities	Implementation of this technology will lead to better environment and to higher affordability of electricity, due to the lower cost of produced electricity.		
Country **economic** development priorities – economic benefits	The price of nuclear fuel is significantly lower than the price of natural gas used to produce the same amount of electricity ant this will result in less payment for natural gas and lower tariffs for electricity. Diversification of primary fuel supply will decrease the dependency on one type of fuel as it is now natural gas, as well as will be decreased the dependency on one country from which the natural gas is imported.		
Country **environmental** development priorities	Such a technology will result in no air pollution or CO2 emissions.		
Other considerations and priorities such as market potential	Due to the fact that this is an emerging technology it is assumed that there will be build 4 units of 25 MW up to 2030.		
Costs			
Capital costs	The typical investment costs in the small nuclear units is in the range of 2500 $/kW.		
Operational and Maintenance costs	Operational and maintenance costs excluding fuel costs is typically about 200-220 $/kW per year. The cost of fuel component depends on the nuclear fuel price and will be cheaper in comparison with the same indicator when using natural gas or coal as the nuclear fuel is cheaper.		
Cost of GHG reduction	The cost of electricity produced by these nuclear units is lower than the cost of electricity produced by thermal power plant electricity of which will be replaced. In such a case the GHG reduction does not have any cost.		
Lifetime	Economic lifetime is 25 years. Technical lifetime is 30 years.		
Other	Such technology will result in no air pollution.		
		Old	**New**
Efficiency	%	36	30
Fixed O&M costs	$/kW*month	2	180
Variable O&M costs	$/MWh	3	2.5
Investments	$/kW	0	2500
Fuel price	$/tcc	552	30.45
Time of use of rated capacity	h/an	6000	7500
Fuel consumption	gcc/kWh	341.67	410
Fuel price	$/kgcc	**0.552**	**0.030**

Fuel used	kgcc/kWh	**0.34**	**0.41**
Cost of used fuel	$/kWh	**0.189**	**0.012**
Annual capital costs	$/kW*an		100.000
Per unit fixed O&M costs	$/kWh	**0.004**	**0.013**
Per unit variable O&M costs	$/kWh	**0.003**	**0.024**
Total costs	**$/kWh**	**0.196**	**0.052**

Tehnology 10

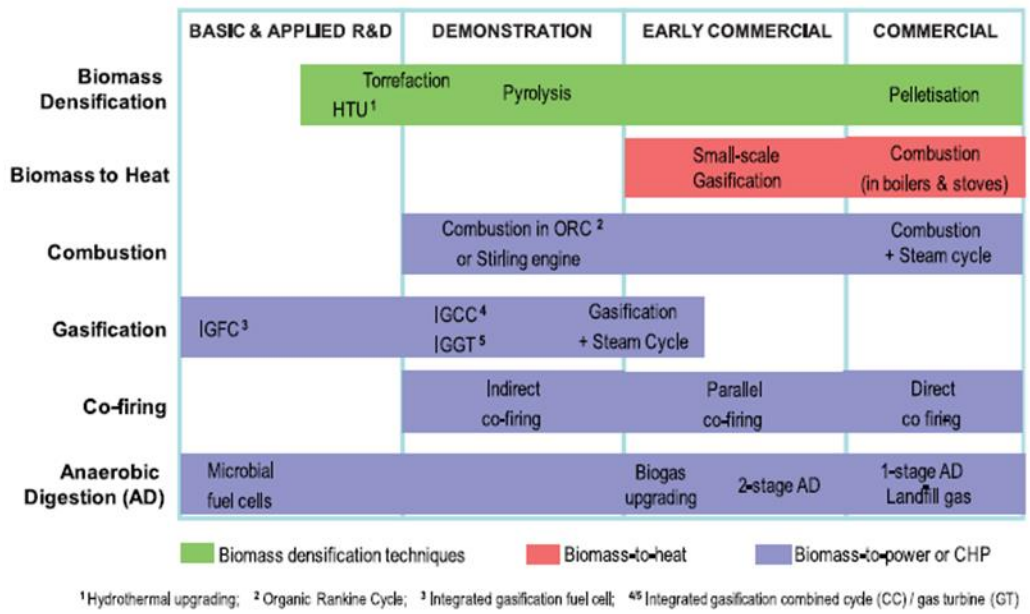
Technology Name	**Long term large scale, IGCC units**
Subsector GHG emission (Mt CO2-eq)	**7,7248 Million t CO2 from energy sector in 2005**
Background/Notes, Short description of the technology option	Coal gasification technology, often referred to as Integrated Gasification Combined Cycle (IGCC), is the process of gasifying coal to produce electricity. The coal is gasified by burning finely-crushed coal in an environment with less than half the amount of oxygen needed to fully burn the coal. Essentially, the coal is not burned directly but undergoes a reaction with oxygen and steam. This produces what is known as synthetic gas or "syngas." This gas is then combusted in a combined cycle generator to produce electricity. The technology integrates the production of purified gas and the production of electricity. In terms of environmental benefits, the technology reduces emissions of sulphur dioxide, particulates and mercury, as well as of carbon dioxide, in particular when combined with carbon capture and storage. Integrated Gasification Combined Cycle (IGCC) technology can reach a higher efficiency rate than typical coal combustion technologies, such as sub-, super- and even ultra-supercritical combustion. Where the latter can reach efficiencies of between 30 to 45%, IGCC plants could achieve an efficiency rate of higher than 45%. The latter is achieved by combining the two cycles of firing the coal gas and using the residual heat to produce electricity. The technology contains the following steps. First, coal is gasified by creating a 'shortage' of air/oxygen in a closed pressurised reactor. The creates a chemical reaction of the coal with the oxygen. The product from this process is a mixture of carbon and hydrogen ($CO + H_2$), which is also called synthesis gas or syngas or fuel gas. The syngas is subsequently cleaned and burned with either pure oxygen or air. This creates a superheated steam with which electricity is generated. The residual heat from this process is cooled down which creates another stream of steam to produce electricity. Efficiency of IGCC could be further increased if the process of purifying the syngas (removing of particulates and sulphur) could be done at higher temperatures. Currently, purification takes place at relatively low temperatures (around 50 ^oC), but techniques to clean at temperatures of around 500-600^oC are tested. This could increase the overall efficiency of IGCC to over 60%. IGCC plants can also be configured to facilitate CO_2 capture before the combustion of the syngas. In this process, the syngas is 'shifted' using steam to convert CO to CO_2, which is then separated for possible long-term sequestration. This means that an IGCC power plant combined with carbon storage technologies can be completely carbon emission free. An example of a zero emission power and chemical plants which combines gasification with CO2 capture and storage can be found in Kedzierzyn in Poland. (source: climatetechwiki.org)
Implementation assumptions Explain if the technology could have some improvements in the country environment.	It is assumed that there will be built at least one unit of IGCC of 200 MW output, due to the fact that the price of coal will not increase at the same rate at the price of natural gas. It is envisaged that this technology will use coal as fuel.
Implementation barriers	Lack of information regarding benefits, lack of experience in this field and of course lack of financial resources for investment due to the fact that the specific investment in such power plant is very high - 3000 $/kW.
Reduction in GHG emissions (Mt CO2-eq)	If implemented the technology will result in annual reduction of 390000 tones of CO2 for 2030.
Impact Statements	Increase country energy security
Country **social** development priorities	Increased efficiency of energy conversion and use; • Lower emissions to the environment, in particular of CO2, the main greenhouse gas; • Large cost savings, providing additional competitiveness for industrial and commercial users, and offering affordable heat for domestic users;

	• An opportunity to increase the diversity of generation plant, and provide competition in generation and promotion of liberalization in energy markets; • Increased employment – construction of such units is a generator of jobs. Using this technology there will result in more than 10 % less fuel used to use the same quantity of electricity. Affordability of electricity: As electricity produced by such unit will be cheaper in comparison with electricity produced by other generation units using natural gas.		
Country **economic** development priorities – economic benefits	Lower costs for coal used as fuel means less natural gas imported and less paid for it as well as the decrease of energy dependency and diversification of fuel import sources.		
Country **environmental** development priorities	IGCC plants have the lowest CO2 emissions among coal power plants (Ordorica-Garcia, 2006). An IGCC plant emits around a quarter less CO2 than a pulverizing coal power plant (appr. 750 g CO2/kWh vs appr. 1 kg). To compare: A natural gas combined cycle plant emits approximately 400 g CO_2/kWh. Coal gasification offers the possibility, when using oxygen in the gasifier, of preparing CO2 as a concentrated gas stream. In this form, it can be captured relatively easily. In a conventional (pulverised) coal or gas fired power plant, CO2 can only be removed after combustion which with current technologies is economically less attractive. In the case of IGCC, CO2 can be removed before the syngas is fed into the gas turbines. According to Ordorica-Garcia (2006), capturing 80% of the CO2 would reduce emission to less than 200 g/kWh, which would involve an energy penalty due to CO2 capture of around 25% of the total auxiliary power output. Reduced air pollution: By replacing of 1.4 billion kWh of electricity to be produced in conventional thermal power plant it will result in reduction of about 390000 tons of CO2 per year.		
Other considerations and priorities such as market potential	It is envisaged that there will be implemented at least one unit of 200 MW output.		
Costs			
Capital costs	The typical investment costs in IGCC will be about 3000 $/kW, taking into account that it is necessary to comply with CO2 reduction requirements.		
Operational and Maintenance costs	Operational and maintenance costs excluding fuel for IGCC units is typically about 120 $/kW per year. The cost of fuel component depends on the coal price.		
Cost of GHG reduction	The cost of electricity produced by these coal units is lower than the cost of electricity produced by thermal power plant electricity of which will be replaced. In such a case the GHG reduction does not have any cost.		
Lifetime	Economic lifetime is 30 years. Technical lifetime is more than 30 years.		
Other	Total energy efficiency is approximately 50 %.		
		Old	**New**
Efficiency	%	36	50
Fixed O&M costs	$/kW*month	2	120
Variable O&M costs	$/MWh	3	0
Investments	$/kW	0	3000
Fuel price	$/tcc	552	160
Time of use of rated capacity	h/an	6000	7000
Fuel consumption	gcc/kWh	341.67	246
Fuel price	$/kgcc	**0.552**	**0.16**
Fuel used	kgcc/kWh	**0.34**	**0.246**
Cost of used fuel	$/kWh	**0.189**	**0.039**

Annual capital costs	$/kW*an		120.000
Per unit fixed O&M costs	$/kWh	**0.004**	**0.017**
Per unit variable O&M costs	$/kWh	**0.003**	**0.017**
Total costs	**$/kWh**	**0.196**	**0.074**

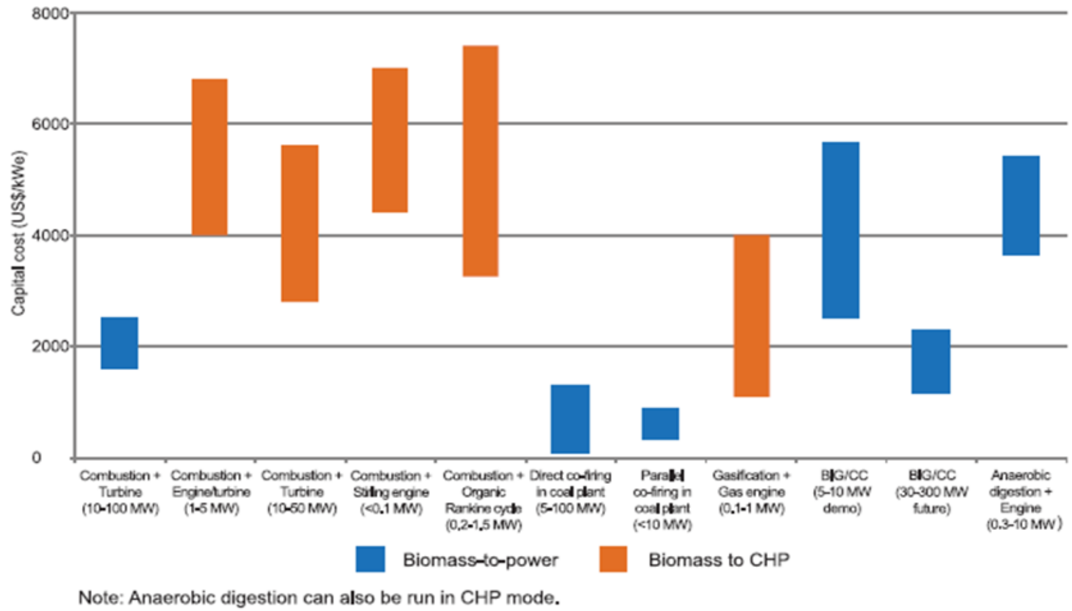
Technology 11

Technology Name	**Biomass combustion and co-firing for electricity and heat**
Subsector	**Electricity supply**
Background\Notes, Short description of the technology option	Combustion is the most common way of converting solid biomass fuels to energy. Worldwide, it already provides over 90% of the energy generated from biomass, a significant part of which in the form of traditional uses for cooking and heating. This is mostly the case in developing countries, where biomass combustion provides basic energy for cooking and heating of rural households and for process heat in a variety of traditional industries in developing countries. However, many of these traditional applications are relatively inefficient and may go together with high indoor air pollution and unsustainable use of forests. Biomass of different forms can also be used to produce power (and heat) in small-scale distributed generation facilities used for rural electrification, in industrial scale applications, as well as in larger scale electricity generation and district heating plants. Several feedstock and conversion technology combinations are available to produce power and combined heat and power (CHP) from biomass. Two technologically mature and cost-attractive options involve burning biomass in standalone units or co-firing it with fossil fuels in standard thermal power plants. Standalone biomass combustion Standalone biomass combustion can be done using different types of feedstock, sizes of applications and conversion routes. a) Biomass-based generators: Vegetable oils, such as jatropha, can replace diesel in diesel generators to produce electricity for off-grid applications or independent mini-grids. b) Biomass-based power plants: The heat produced by direct biomass combustion in a boiler can be used to generate electricity via a steam turbine or engine. The electrical efficiency of the steam cycle is not high but it is currently the cheapest and most reliable route to produce power from biomass in stand alone applications (IEA Bioenergy, 2009). c) Biomass-based cogeneration (CHP) plants: Co-generation is the process of producing two useful forms of energy, normally electricity and heat, from the same fuel source. Co-generation significantly increases the overall efficiency of a power plant (and hence its competitiveness) if there is an economic application for its waste heat (IEA Bioenergy, 2009). In the case a good match can be found between heat production and its demand, combined heat and power (CHP) plants, also called cogeneration plants, can have overall (thermal + electric) efficiencies in the range of 80-90%. The process of using the heat from biomass combustion for industrial processes (e.g. for drying of products such as tiles), is well established in some industries, e.g., pulp and paper, sugar mills, and palm oil mills.) d) Waste-to-energy plants based on Municipal Solid Waste (MSW): Municipal solid waste (MSW) is a very diverse and usually heavily contaminated feedstock, requiring robust technologies and strict controls over emissions, increasing the costs of waste-to-energy facilities, leading to MSW remaining a largely unexploited energy resource despite its significant potential in most countries (IEA Bioenergy, 2009). Biomass co-firing Biomass co-firing (or co-combustion) involves "supplementing existing fossil-based (mostly pulverised coal) power plants with biomass feedstock" (IEA Bioenergy, 2009). The biomass fuels usually considered range from woody to grassy and straw-derived materials and include both residues and energy crops. The fuel properties of biomass differ significantly from those of coal and also vary considerably between

	different types of biomass. Properties of biomass which differ from those of coal are ash contents, a generally high moisture content, potentially high chlorine content, relatively low heating value, and low bulk density. These properties affect design, operation, and performance of co-firing systems (IEA Bioenergy, Task 32, 2002). There are three types of biomass co-firing: a) Direct co-firing: The biomass is burnt directly in the existing coal furnace. Direct co-firing can be done either by pre-mixed the raw solid biomass (generally in granular, pelletised or dust form), with the coal in the coal handling system or by the milling it and directly injecting it into the pulverised coal firing system. b) Indirect co-firing: The biomass is first gassified before the resulting syngas is combusted in the coal furnace; and c) Parallel co-firing: The biomass is burnt in separate boilers, with "utilisation of the steam produced within the main coal power station steam circuits" (IEA Bioenergy, 2009). "Indirect and parallel co-firing options are designed to avoid biomass-related contamination issues, but have proven much more expensive than the direct co-firing approach as additional infrastructure is needed. Parallel co-firing units are mostly used in pulp and paper industrial power plants" (IEA Bioenergy, 2009). **Source: http://climatetechwiki.org/technology/biomass**  **Figure 1: Development status of the main upgrading technologies (green), biomass-to-heat technologies (red) and biomass-to-power and CHP technologies (blue) (source: IEA, 2009)**

Implementation assumptions	Biomass combustion in small-scale application is gaining increasing attention as a means for rural electrification in developing country areas where extension of national grid would be too costly. The technology used for vegetable oil-based power production (e.g. diesel generators) is very well-known and requires little or no adaptation. For industrial applications, direct co-firing in large-scale modern coal plants is today the most cost effective use of biomass for power generation. This technology only requires minor investment to adapt handling and feeding equipment without noticeably affecting boiler efficiency, provided the biomass is not too wet and has been pre-milled to a suitable size. Furthermore, electric efficiencies for the biomass-portion range from 35% to 45%, which is generally higher than the efficiency of biomass dedicated plants (IEA, 2007). A range of liquid biomass materials (e.g. vegetable oil, tallow) is also co-fired in existing plants on a commercial basis, however at a scale much lower than for the solid biomass. The biomass co-firing ratio is mainly controlled by the availability of biomass and is usually limited to around 5-10% on a heat input basis (IEA Bioenergy, 2009). The most cost-effective biomass-to-energy applications are those relatively large scale (30-100 MWe), and using low cost feedstocks which are available in large volumes, such as agricultural residues (e.g. bagasse), or wood residues and black liquor from the pulp and paper industry. However, in a fragmented biomass supply market, the cost of purchasing large quantities of biomass may increase sharply as the distance to suppliers (and thereby logistical cost) increases. At the same time, an increasing number of viable smaller scale plants (5-10 MWe) using other types of residues are emerging throughout Europe and North America (IEA Bioenergy, 2009). In both cases, the biggest challenge is provision of a constant stream of biomass feedstock. Video 1 is an illustration of a biomass installation in the United Kingdom.
Implementation barriers	IEA Bioenergy (2009) sums up the the critical issues in biomass logistics as: "The specific properties of biomass: low energy density, often requiring drying and densification; seasonal availability and problematic storage requiring further pre-treatment. Factors limiting the supply: availability and appropriateness of mechanized equipment; and inadequate infrastructure to access conversion facilities and markets." The main solutions to these issues, according to the IEA Bioenergy (2009) are "the development of advanced densification and other pre-treatment technologies, diversifying procurement geographically and in terms of biomass types, and the optimisation of fuel supply chains from field to plant gate (including the development of specialized harvesting and handling equipment), leading to lowest delivered costs" (IEA Bioenergy, 2009). The sustainability of biomass-based technologies including biomass combustion depends on the current source of existing fossil fuel reserves and their reliability on one the hand and the risks involved with securing sufficient supplies of biomass over a long term, on the other hand (OECD/ IEA, 2007).
Reduction in GHG emissions (megatonnes CO2-eq)	
Impact statements	
Country social development priorities	Increased income and jobs in the agriculture and forestry sectors, which now supply part of the feedstock used in power and heat production (agricultural and forest residues)

	Job creation in the industrial sector for designing, building and operating the plants. Increasing inclusion in the economic system: well-organized farmers unions can gain access to energy markets.
Country economic development priorities – economic benefits	Increasing energy security and saving foreign currency by reducing the dependence on imported fossil feedstock, such as coal. Diverting part of expenses for imported fossil fuels to farmers supplying the biomass feedstock; Diversifying the industrial sector; Supporting rural electrification with all its developmental benefits.
Country environmental development priorities	Reduced GHG emissions from the power sector. Many agricultural and forest residues can be assumed to be carbon neutral, which leads to significant attributable GHG emission reductions. Reduced NOX and SOX emissions compared to coal combustion. NOx emissions can be further reduced by implementing primary and secondary emission reduction measures. The most important consideration when collecting biomass residues for energy use is to not to exceed the biological requirements of the soil (part of residues must be left on the field and on the forest floor to return vital nutrients to the soil). On a macro level, competition between traditional forestry-based sectors (e.g. fiber board and pulp & paper) can develop as increasing amount of woody biomass is combusted or co-fired in power generating facilities.
Costs	
Capital costs	For small-scale combustion units using vegetable oil, the main cost will be feedstock cost. The attractiveness of such installations will depend heavily on the relative prices of diesel and vegetable oil. For industrial scale installations, economies of scale are very important. Investment cost is about 3,500 Euro/kWe for a 5 MWe plant, but goes down to about 2,000 Euro/kWe for a 25 MWe plant. Usually, dedicated biomass power plants were only competitive “when using large quantities of free waste that had to be disposed of, such as MSW, black liquor from the pulp and paper industry and agriculture residues such as bagasse” (IEA Bioenergy, 2009). More recently, an increasing number of viable smaller scale plants using other type of residues (forestry, straw, etc.) are emerging throughout Europe and North America. Co-generation has been shown to reduce the cost of power production by 40-60% for stand-alone plants in the range 1-30 MWe. However, the scale of biomass CHP plants is often limited by the total local heat demand and by its seasonal variation, which can significantly affect economic returns unless absorption cooling is also considered (IEA Bioenergy, 2009).

	 **Figure 2: Capital cost for available biomass-fuelled technologies for power (blue bars) and CHP (orange bars) (source: IEA, 2009)**

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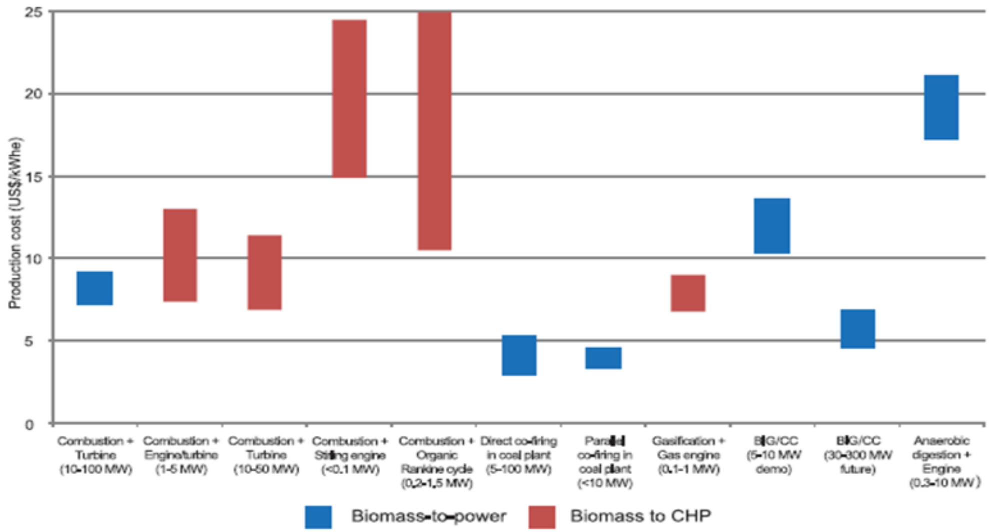
<tr><td></td><td>

Note 1: Anaerobic digestion can also be operated in CHP mode.
Note 2: Production cost can be reduced by 60-80% (depending on technology and plant size) if free biomass feedstock is used, such as MSW, manure, waste water etc.

Figure 3: Production cost for available biomass-fuelled technologies to power (blue bars) and CHP (red bars). For the sake of making comparison possible, the production costs have been calculated based on the capital costs given in Figure 2 and on the following assumptions for each of the technologies considered: (1) Plant lifetime = 20 years, (2) Discount rate = 10%, (3) Heat value=5US$/GJ (for CHP applications only), (4) Biomass cost=3 US$/GJ (source: IEA, 2009)</td></tr>
<tr><td>Operational and Maintenance costs</td><td></td></tr>
<tr><td>Cost of GHG reduction</td><td></td></tr>
<tr><td>Lifetime</td><td></td></tr>
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Technology 12

Technology Name	**Methane Capture at Landfills for Electricity and Heat**
Subsector	**Electricity and Heat Supply**
Background\Notes, Short description of the technology option	Under the anaerobic (oxygen free) conditions of landfill sites, organic waste is broken down by micro-organisms, leading to the formation of landfill gas (LFG). LFG is a gaseous mixture which consists mostly of methane and carbon dioxide, but also of a small amount of hydrogen and occasionally trace levels of hydrogen sulphide. LFG capture projects aim at preventing the emissions of methane and other pollutants from landfills. The basic idea behind the technology is that the landfills are covered (e.g. by a layer of earth) and that LFG is extracted from landfills using a series of wells and a blower/flare (or vacuum) system. This system directs the collected gas to a central point where it can be processed and treated depending upon the ultimate use of the gas. From this point, the gas can be simply flared (thereby converting methane into CO2) or used to generate electricity and/or heat, replace fossil fuels in industrial and manufacturing operations, or fuel greenhouse operations. The gas could also be upgraded (purified) to natural gas standards. A wide variety of gas wells and collection systems are available. The choice will depend to some extent on site-specific factors, such as depth of waste and water table. The choice of the engine depends on many factors, including the gas generation rate and its composition, the plant efficiency, plant availability, necessary gas pretreatment, maintenance requirements, operator's familiarity with the plant, plant flexibility and life expectancy, and cost. The gas yield will depend on the nature of the landfill. For a large modern landfill, useable LFG may be generated for between 15 and 30 years. **Source: http://climatetechwiki.org/technology/lfg_cap**
Implementation assumptions	In industrialised countries, the development of the LFG capture and combustion technology has reached the status of deployment of the technology into the market. Activities are focussed on developing the technology to a level of commercial application by making technical improvements and reducing costs. For example, the US Landfill Methane Outreach Program (LMOP) promotes LFG as an important local energy resource by informing local governments and communities about the benefits of LFG recovery and by building partnerships between state agencies, industry, energy service providers, local communities, and other stakeholders (US EPA, 2003). As explained above, methane is formed in the landfill through a biological/chemical process called Anaerobic Digestion. In the absence of oxygen (i.e. under anaerobic conditions), organic waste is decomposed by bacteria so that a mix of gases result: biogas. Biogas composition (e.g. the percentage of methane per unit of biogas) can vary significantly across locations as this depends on such factors as climatic, industrial and agricultural production characteristics, energy types and usage, and waste management practices. The most important energy services to be addressed by LFG is generation electricity and heat. For example, in the USA, two-thirds of the currently captured LFG is used for the generation of electricity (US EPA, 2003). Electricity generation can take place using a variety of different technologies, including internal combustion engines, (micro)turbines, Stirling engines (external combustion engine), Organic Rankine Cycle engines, and fuel cells. The main part of methane capture takes place via internal combustion (reciprocating) engines or turbines. At smaller landfills, microturbine technology is often used. Some to these technologies (Stirling and Organic Rankine Cycle engines and fuel cells) are still in the development phase. Next to electricity and heat, LFG can also be used for: firing pottery and glass blowing kilns; powering and heating greenhouses; heating water for aquaculture (e.g. fish farming).

	Globally, without additional measures, methane emissions from municipal solid waste are expected to increase by around 19% above 1990 levels by the year 2050 (US EPA, 2005). This increase could largely take place in developing countries for reasons explained above. Among developing countries, China and India have the highest methane emissions from landfills (US EPA, 2005). However, commercialisation of waste gas captured from landfills as a source of energy for electricity and heat generation could become an emerging area in several developing countries: LFG, when purified, could replace natural gas and it could be applied as vehicle fuel in the form of compressed natural gas. The Methane to Markets Partnership, launched in 2004 and signed by 19 national governments and more than one hundred private organizations, aims to offer a platform for collaborative working to facilitate methane capture and use projects internationally.
Implementation barriers	The feasibility of landfill gas capture and use in our country could be limited by the following barriers: lack of legislation: Although countries usually have in place legislation on reduction of the harmful impact of waste and environment conservation, in many developing countries legislation enforcing landfill gas extraction with or without utilization is absent. unfavourable financial performance: As shown by several CDM projects in the field of LFG capture and use (see cdm.unfccc.int), the financial performance of such projects is generally insufficient to attract enough investment funding from financial institutes (i.e. the project is unattractive compared to the interest rates provided by local banks). In the case of the CDM, projects are financially supported through the sale of carbon credits based on the avoidance of methane emissions. Generally, waste management is driven by municipalities with little or no private sector involvement: With waste taxes being too low, municipalities generate insufficient income for waste management in an environmentally friendly way. From the CDM LFC capture project pipeline (see for an example of a CDM project in Bangladesh: http://cdm.unfccc.int/UserManagement/FileStorage/FS_334865036) it can also be concluded that lack of technology know-how and lack of availability of equipment are important barriers. There could be a lack of social acceptability, for example, when landfills are a source of live for nearby communities. There is also the institutional aspect of waste not systematically being collected in several areas in developing countries.
Reduction in GHG emissions (megatonnes CO2-eq)	Combustion of LFG for the production of energy contributes to GHG emission reduction in two ways. LFG capture prevents the release of methane into the atmosphere (as a GHG methane is 21 times as powerful as CO2) and the electricity subsequently produced by LFG combustion produces less CO2 emission than conventional fossil fuel combustion. Nonetheless, also energy production from LFG results in CO2 emissions (due to the reaction of methane - CH4 - with oxygen - O2). However, since LFG partly originates from biomass in the landfills, part of this CO2 had already been sequestered earlier in the biomass cycle and will be sequestered again in plants, trees, etc. For calculation of GHG emission reduction of large scale methane capture at landfills project, it is recommended to apply the Approved Consolidated Methodology ACM0001 (Consolidated baseline and monitoring methodology for landfill gas project activities --- Version 11) under the Clean Development Mechanism of the UNFCCC Kyoto Protocol (CDM). This methodology helps to determine a baseline for GHG emissions in the absence of landfill gas capture. In addition, for the part of delivering the electricity production with the captured methane to the grid, greenhouse gas emission reductions can be calculated using the Approved Consolidated Methodology ACM0002 which helps to calculate an average grid-based emission factor in the absence of the landfill gas capture project: Consolidated methodology for grid-connected electricity generation from renewable sources --- Version 11.

	General information about how to apply CDM methodologies for GHG accounting can be found at: http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html For an overview of CDM projects in the field of landfill gas capture for power production, see http://cdmpipeline.org/publications/CDMpipeline.xlsx, in the worksheet 'CDM PROJECTS'.
Impact Statements	
Country social development priorities	In a study on sustainable development contributions that could be delivered by LFG capture and combustion projects in developing countries implemented under the CDM, the following aspects were identified (Netherlands Ministry of Foreign Affairs, 2007): Improved groundwater quality as the management of the site could relatively easily be combined with leachate collection and disposal action, Improvement of local air and safety (fewer emissions of SOx, NOx, and particulates) through burning less coal for electricity generation and reduction of landfill gas released into the air, Reduces the risk of dangerous methane gas concentrations in landfills and reduced exposure of residential areas to odour, Small increase in local employment, and In some cases, additional payment by the project sponsor to support community programmes for stakeholders, including support for people living nearby the sites and who are affected by the project (e.g. the sites under the baseline conditions could be considered a source of living for some groups). The process of designing, constructing and operating LFG capture plants creates jobs associated with the design, construction, and operation of energy recovery systems. LFG projects involve engineers, construction firms, equipment vendors, and utilities or end-users of the power produced. Many of these costs are spent locally for drilling, piping, construction, and operational personnel, helping communities to realise economic benefits from increased employment and local sales. By linking communities with innovative ways to deal with their LFG, it helps them enjoy increased environmental protection, better waste management, and responsible community planning.
Country economic development priorities – economic benefits	
Country environmental development priorities	
Costs	
Capital costs	In 2005, the World Bank published an assessment of the capital costs of investments in LFG capture for electric power production (World Bank, 2005). One plant assessed was a hypothetical 5-MW (electric) power station in the USA, with the following performance assumptions.
Operational and Maintenance costs	Performance assumptions US 5-MW power station based on LFG.

Installed power	5 MW
Capacity used	80%
Fuel type	methane
Lifetime	20 years
Gross generated electricity	35 GWh/year

Source: World Bank, 2005

For this LFG recovery plant, the following capital cost assumptions were made (based on experience with municipal solid waste plants):

Breakdown of capital costs of typical MSW/ LFG capture plant	%
Equipment	44
Civil	29
Engineering	3
Construction	19
Contingency	5

Source: World Bank, 2005

Based on these assumptions the capital cost, operation and management costs, and other costs associated were annualised to estimate generation costs as follows:

Municipal Waste-to-Power Generation Costs	(2004 USDcents/kWh)
Capital	4.78
Fixed operation and maintenance	0.11
Variable operation and maintenance	0.13
Fuel	1.00
Total	6.02

Source: World Bank, 2005

For the calculations, it has been assumed that the feedstock would be provided free of charge. However, a provision for royalties to an assumed municipal corporation from the sale of electricity and manure was included under variable costs.

This estimation was then refined including future cost projections and uncertainty analysis. Assuming a decrease in equipment cost of 15% by 2015, the exercise resulted in the following investment costs varying between USD 2.5 and USD 3.5 per kWh between 2010 and 2015. Based on this capital cost projection, the electricity generation costs for the plant would vary between USD 0.05 and 0.064 per kWh during the same period of time.

These figures provide insight in the financial aspects of LFG capture and use projects, although the order of magnitude of the cost items may be different across countries and between industrialised and developing countries.

As explained above, LFG capture and use projects have been established under the CDM, where they generally strongly benefit from the value of the Certified Emissions Reductions to be generated through the projects. For example, the Landfill Gas to Energy Facility project at the Nejapa Landfill Site in El Salvador has presented the following overview of how the internal rate of return of the project changes with on changes in revenues and costs, and the market value of greenhouse gas emission reduction.

Project case	Internal rate of return (IRR)
Base case	- 2.60
Increase in project revenues	02.ian
Reduction in project costs	02.dec
Base case + CER market value	15

Cost of GHG reduction	
Lifetime	

Technology 13

Technology Name	**Stand-alone wind systems**
Subsector GHG emission	2005 year: Category 1A1-Energy Industry (Stationary fuel burning for electricity and heat production). CO2 emission: $2986{,}6 \cdot 10^3$ t [*Comunicarea Naţională Doi a Republicii Moldova elaborată în cadrul Convenţiei-cadru a Organizaţiei Naţiunilor Unite privind schimbarea climei./* Ministerul Ecologiei şi Resurselor Naturale / Programul Naţiunilor Unite pentru Mediu; Coord.: Violeta Ivanov, Georgr Manful; Grupul de sinteză: V. Scorpan, M. Ţăranu,, P. Todos, I. Boian.-Ch.: „Bons Offices" SRL, 2009-323 p. ISBN 978-9975-80-313-7, tab. 2.11, pag. 105]
Background/Notes, Short description of the technology option	**Stand-alone wind systems** are equipped with small wind turbines (up to 20 kW) and are designed for electric power production are mainly used to supply remote, off-grid loads, such as homes and other remote small consumers. Often they are used in combination with batteries and/ or small diesel generation systems. The most difference between large and small wind turbines is the design of the transmission – generation system. Most small wind turbines are direct-driven, variable-speed systems with permanent magnet generators, hence a power converter is required to get a constant frequency if needed. Such a wind turbine design requires no gearbox. This approach is suitable for small wind turbines, as they operate with a much higher rotor speed than large wind turbines. This approach is also regarded as more reliable and less costly for maintenance. Also the power and speed regulation of small wind turbines vary significantly, e.g. mechanically controlled pitch systems or yaw systems instead of electronically controlled systems. Vertical and horizontal furling are also used for power control of small systems. In high winds, a vertical furling wind turbine will tilt the rotor skywards, giving the wind turbine the appearance of a helicopter. A horizontal furling turbine swings the rotor towards the tail during high wind speeds. Most of the small wind turbines that are currently deployed around the world have three blades, but there are also models with two, four or more at the micro-scale. Rotor diameter is below 20 m and most of the commercial small wind turbines have a rotor diameter below 10 m. These turbines are mounted typically on 12 to 24 m towers. For the rotor, technology trends are towardsadvanced blade manufacturing methods based mainly on alternative manufacturing techniques such as injection moulding, compression moulding and reaction injection moulding. The advantages are shorter fabrication time, lower parts cost, and increased repeatability and uniformity, but tooling costs are higher. Sources: 1. *The IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation Wind Energy.* June 2011. *2. Wind Energy: the facts*, EWEA, - 2009
Implementation assumptions, How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	The market for wind energy systems with electric output in stand-alone configuration is currently growing. Often a combination with other regenerative sources such as photovoltaic systems is intended. The range of ratings considered is from below 1 kW up to around 20 kW. Low investment cost is a criterion especially in this area. Small turbines are normally equipped with fixed blades. Effort and cost for maintenance should be low, in view of suitability for rural or less developed areas. Safe operation properties are indispensable, considering operation by unskilled persons in residential areas. Most stand-alone systems are for low-voltage ac output. They are mostly equipped with an energy storage device, generally a lead-acid battery of suitable capacity. The 2030 technology implementation capacity was estimated as following: According to the preliminary general agricultural census from 2011 there are over 900 000 agricultural soil owners, from which 2600 are distinguished by a area more than 10 he. As a rule, the appropriate areas of soil do not have access to the electricity network. 1 km of the grid costs around 18-20 th. USD. In order to cover the demand the owners prefer to ensure the electricity demand by installing small generators, 1-5 kW. An alternative solution would be the use of wind farms. In the concept that the soil owner with the area more than 10 he would use wind farms at a capacity of 10kW each, the total capacity would be 26MW.

Implementation barriers	Lack of investments. The legal framework is ambiguous and is not completed
Reduction in GHG emissions	Assuming that the next 20 years will be installed 26 MW wind power, by 2030 CO2 emissions will be reduced by $56{,}8 \cdot 10^3$ t annually.
Impact Statements - How this option impacts the country development priorities	
Country social development priorities	Increase number of employees
Country economic development priorities – economic benefits	**Increased energy security.** Lack of own natural fossil fuel reserves is obliging the country to import 95 % of energy resources needed. 70 % of electricity demand is covered by import. All natural gas is coming from GAZPROM
Country environmental development priorities	Reduced soil degradation
Other considerations and priorities such as market potential	Less air pollution. Work conditions improvement, less costs for transportation and stock of liquefied fuel.
Costs	
Capital costs	Average costs for current stand-alone wind turbines (rated power 1-10 kW)vary from $2800 to $5600 per installed kW. However, the price for the first 10 farms at the capacity of 10kW each didn't exceed $3000 per kW in 2010, inclusive taxes and the cost of accumulators at the capacity of 48 kWh. For this reasons it was accepted the specific cost of 3000 $/kW.
Operational and Maintenance costs	O&M cost for large farms was estimated at the level of 1.7 c$/kWh. For the wind farms at a smaller capacity O&M costs are less and are equal to 1,4 c$/kWh (multiplier is lack, cooling system is absent, etc.).
Cost of GHG reduction	Cost of GHG reduction is 68,7 USD/tCO2
Lifetime	20 years
Other	-

Technology 14

Technology Name	Wind systems for water and space heating
Subsector GHG emission	2005 year: Category 1A1-Energy Industry (Stationary fuel burning for electricity and heat production). CO2 emission:: $2986{,}6 \cdot 10^3$ t [*Comunicarea Națională Doi a Republicii Moldova elaborată în cadrul Convenției-cadru a Organizației Națiunilor Unite privind schimbarea climei./* Ministerul Ecologiei şi Resurselor Naturale / Programul Naţiunilor Unite pentru Mediu; Coord.: Violeta Ivanov, Georgr Manful; Grupul de sinteză: V. Scorpan, M. Ţăranu,, P. Todos, I. Boian.-Ch.: „Bons Offices" SRL, 2009-323 p. ISBN 978-9975-80-313-7, tab. 2.11, pag. 105]
Background/Notes, Short description of the technology option	The proposed technology is different from the other by thermal generator that converts the induced eddy currents energy by a multi pole permanent magnet inductor directly into heat. The power of air flow is proportional to the cube of wind speed. Wind energy conversion system must work effectively across the range of variation of wind speed in the given site, for example, from 3 to 20 m / s. However, rated power of small wind power systems, (up to 30 kW) corresponds to wind speed of 11-12 m/s. In other words, at the wind speed of 20 m/s wind energy conversion system should have an overload factor of 5-6. In reality, this factor is equal to 1,2-1,3 [www.urbanwind.net. *Catalogue of European Urban Wind Turbine Manufacturers;* www.urbanwind.net. *Urban Wind Turbines Technology Review: A Companion Text to the Catalogue of European Urban Wind Turbine Manufacturers]* , being limited, primarily, by permanent magnet electrical generator. The permanent magnet generator overload factor is limited by properties of using materials: insulation, enamelled copper wire and permanent magnets. The conversion efficiency increases when using eddy current generator. In short terms, we can extract more energy from available wind potential. Moreover, the eddy current generator must have an overload factor equal minimum to 2. There are not technical or economic difficulties to produce of such eddy current heater. It does not contain electrical insulation, copper, electrical sheet steel or other expensive materials that would limit the overloads. Sources: Xiaohong Liu et all., *The Study of The Heat Device in Wind-Magnetic Water Heater,* Advanced Materials Research, Vol. 201-203, 2011, pp. 460-464. I. Dirba1, J. Kleperis, *Practical Application of Eddy Currents Generated by Wind*, Annual Conference on Functional Materials and Nanotechnologies–FM&NT, 2011, Series: Materials Science and Engineering 23, pp. 1-5.
Implementation assumptions, How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	There are several reasons why wind energy conversion systems should be used more widely for the production of heat or hot water for residential using. Arguments are as follows: 1. Energy consumption structure of a country. As an example the Republic of Moldova: the total energy consumption in 2009, equivalent to 2,071 million t.o.e., only 16 % was consumed in the form of power [12], and other resources that constitute 84 % were consumed in the form of heat and mechanical energy. The heat is used mainly for space heating and hot water housing. Of total gas consumption in 2010 which is 1090 million m^3, 31,2 % was consumed by households [13]. In other words, was consumed to produce heat. 2. In 2010 the share of natural gas in a Gcal cost was 712 MDL and will keep upward trend. Wind equipment for heat production is simply and cheaper than for power production. 3. The problem of accumulation of heat and its use during periods when the wind doesn't blow is solved simply and cheaply. The ratio between the cost of electric battery and a heat accumulator with the same capacity is more than 10, and exploitation period for heat accumulator is greater.
Implementation barriers	Lack of investments. The legal framework is ambiguous and is not completed.

Reduction in GHG emissions (megatonnes CO2-eq)	Assuming that the next 20 years will be installed 52 MW wind power for water & space heating, by 2030 CO2 emissions will be reduced by $16{,}7 \cdot 10^3$ t annually.
Impact Statements - How this option impacts the country development priorities	
Country social development priorities	Increase leaving confort for rural sector
Country economic development priorities – economic benefits	Increased energy security, Establishment of an integrated and stable agricultural system
Country environmental development priorities	Less pollutant air
Other considerations and priorities such as market potential	
Costs	
Capital costs	1400 Euro/kW
Operational and Maintenance costs	20 $/kW-yr
Cost of GHG reduction	Cost of GHG reduction is 124,7 USD /tCO2
Lifetime	20 years
Other	-

Technology 15

Technology Name	On-shore wind plant connected to the network.
Subsector GHG emission	2005 year: Category 1A1-Energy Industry (Stationary fuel burning for electricity and heat production). CO2 emission: $2986{,}6 \cdot 10^3$ t [*Comunicarea Naţională Doi a Republicii Moldova elaborată în cadrul Convenţiei-cadru a Organizaţiei Naţiunilor Unite privind schimbarea climei.*/ Ministerul Ecologiei şi Resurselor Naturale / Programul Naţiunilor Unite pentru Mediu; Coord.: Violeta Ivanov, Georgr Manful; Grupul de sinteză: V. Scorpan, M. Ţăranu,, P. Todos, I. Boian.-Ch.: „Bons Offices" SRL, 2009-323 p. ISBN 978-9975-80-313-7, tab. 2.11, pag. 105]
Background/Notes, Short description of the technology option	The conversion of the kinetic energy in the wind into electrical power is known as wind energy. There are a number of ways in which this conversion can be done. However after a period of experimentation and development one design has come to dominate the market. This is known as the horizontal axis wind turbine (HAWT) with its archetypal three-bladed rotor. A large wind turbine primarily consists of a main supporting tower upon which sits a nacelle (the structure containing the mechanical to electrical conversion equipment). Extending from the nacelle is the large rotor (three blades attached to a central hub) that acts to turn a main shaft, which in turn drives a gearbox and subsequently an electrical generator. In addition to this there will be a control system, an emergency brake (to shut down the turbine in the event of a major fault) and various other ancillary systems that act to maintain or monitor the wind turbine. Modern multi megawatt wind turbines have main towers that are typically 70 to 120 metres high supporting rotors with a similar range of diameters. Inside the tower there is a mechanism that ensures that the nacelle/rotor faces into the wind (i.e. is yawed correctly) to give maximum generation and maintain symmetric loads on the three blades and drive shaft. Generally the three blades are constructed from composites which provide a relatively high strength (required due to the large bending moments they experience) whilst maintaining a low weight and size given their length. Modern designs have a relatively low rotational speed in the order of 10 revolutions per minute (partly due to the desire to keep noise levels low) and thus typically require a gearbox to increase the speed of the drive shaft to match the rated generator speed. While most wind turbines use gearboxes (or indirect drive systems) there also exist direct drive configurations whereby the generator is coupled directly to the slow moving rotor. These types of designs do not require gearboxes and thus avoid the reliability issues that have been known to trouble certain gearbox designs. However the larger generator size that is required in order to obtain the correct generation frequency faces its own challenges in regards to construction and cost. Even for indirect systems, differences exist in the type of generator that can be used. Older designs tend to be classed as 'fixed speed' meaning that the rotor always rotates at the same speed under all wind conditions. For a number of reasons many modern turbines use generators that allow for variable speed generation whereby the rotational speed is optimised to the incoming wind speed and the generator provides output at a range of frequencies. The resulting fluctuations in voltage and frequency are corrected by power electronics in order to provide electricity suitable for export to the grid. The advantages of this approach include reduced harmful torque fluctuations into the gearbox, increased conversion efficiency, the ability to continue operation during a grid disturbance and the ability to provide reactive power. These last two are increasingly being demanded of wind parks by transmission system operators. Further improvements to the level of energy capture are obtained by most modern turbines by changing the angle of the blades. This 'variable pitch' system rotates the blades about their own axes so that for changing wind conditions the optimum efficiency is achieved. The system also acts to control the turbine, angling the blades 'out of the wind' during periods of high wind speed to prevent damage and providing the primary method for disabling the device. In spite of continuing advances in turbine technology, there is an inherent physical limit as to the amount of energy in the wind that can be extracted. A theoretically perfect (yet

	infeasible to construct) wind turbine could only ever extract 59 percent of the available energy, also known as the Betz limit. Modern turbines reach a conversion efficiency of approximately 50 percent, close to this theoretical limit and very close to the practical limit that is imposed by the drag of the blades. Source: Tony Burton et all. *Wind Energy Handbook*, John Wiley & Sons, Ltd, 2001- 617 p. ISBN 0-471-48997-2
Implementation assumptions, How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	The first requirement when considering the possibility for wind energy is the identification of a suitable site that has a high level of resource, i.e. it is windy. More specifically it should be windy at the height above the ground at which the rotor will be situated. The surface friction of the earth's surface, local topology and surface cover means that wind speeds are lower near the ground than they are higher up. Even at good sites there will be many times when a wind turbine is operating below its rated power (its nominal capacity) or producing no power at all because of a lack of wind. This means that although a turbine may be rated at, for example, 2 MW it will produce a certain percentage of the theoretical power it could have produced had it operated continuously. This percentage is the capacity factor. For onshore wind turbines this capacity factor varies between sites depending on the amount and consistency of the wind. In Europe capacity factors are in the order of 20 to 30 percent, in China on average approximately 23 percent, in India around 20 percent while in the US roughly 30 percent [6]. Based on measurements made in different locations were calculated annual average wind speeds at 90 m height above the ground. Annual average wind speed varies between 6,17 and 7,78 m/s. When using wind turbines designed for Wind Class IEC IIIA we get a capacity factor of 0,3. **Grid integration** The primary perceived problem with wind energy is related to the intermittency of supply. The variability of wind on any given day, week or month means that the amount of power that is produced can change accordingly. In the short term wind levels and thus power generation can be estimated from meteorological reports with a reasonable degree of accuracy. However this does not solve the issue those on days when there is little or no wind, an alternate form of generation is required, requiring additional backup capacity that would not be needed for traditional base-load power stations. To date there have been a large number of studies of the integration of wind energy into electricity networks. IPCC study [6] provides a good summary of the related literature which broadly concludes that at levels of penetration of up to 20 percent of supply the effects of variability and associated costs are relatively low. Thus, for Moldova in the next 5 years installed wind power capacity will be limited to about **250 MW.**
Implementation barriers	Lack of investments. The legal framework is ambiguous and is not completed.
Reduction in GHG emissions	Assuming that the next 20 years will be installed 550 MW wind power, by 2030 CO2 emissions will be reduced by $834,8 \cdot 10^3$ t annually.
Impact Statements - How this option impacts the country development priorities	
Country social development priorities	**Reduce unemployment.** Will be created about 220 new jobs [7] (Operations & maintenance & other direct employment).
Country economic development priorities – economic benefits	**Increased energy security.** Lack of own natural fossil fuel reserves is obliging the country to import 95 % of energy resources needed. 70 % of electricity demand is covered by import. All natural gas is coming from GAZPROM
Country environmental development priorities	Wind energy has a net positive impact on climate change mitigation (see Reduction in GHG emissions above). In terms of other ecological effects related to the installation, the turbines have a relatively small environmental footprint and are often constructed on agricultural or brown-field sites, which limit their impact on local habitats or ecosystems. There are, nonetheless, ecological impacts that need to be taken into account

	when assessing wind energy. Potential ecological impacts of concern for onshore wind power plants include the population-level consequences of bird and bat collision fatalities and more indirect habitat and ecosystem modifications.
Other considerations and priorities such as market potential	-
Costs	
Capital costs	Investment costs are the most significant costs of wind generation. The upfront investment costs, such as the cost of the turbine, foundation, electrical equipment, grid connection, etc, typically make up around three-quarters of the levelised cost of wind generation. In the absence of any Moldova-specific data, we refer to publicly available data to estimate investment costs. There is some variation between the investment costs reported in our different data sources. We recommend using an investment cost of $2100 per kW of installed capacity. This cost is *Capacity-Weighted Average Investment Cost* from IPCC Special Report that was published in June 2011. We use this source because it is a recent estimate of investment costs and is also a reasonable average of different data sources. The EWEA estimate is significantly lower, however this is explained by the fact that it dates back to 2006.
Operational and Maintenance costs	O & M costs are related to a limited number of cost components, and include: Insurance, Regular maintenance, Repair, Spare parts, Administration. Based on experiences in Germany, Spain, the UK and Denmark, O&M costs are generally estimated to be around 1,7 to 2,1 c$ per kWh of wind power produced over the total lifetime of a turbine . We recommend for Moldova to use 1,7 c$/kWh.
Cost of GHG reduction	Cost of GHG reduction is 69,2 USD /tCO2
Lifetime	20 years
Other	-

Heat Supply

Technology Name	**Condensing boilers** /Caldaie a condensazione SIME. Benessere in evoluzione/ http://www.caldaie-climatizzatori.com/prodotti.php?filtro=id_ordinamento&id=14
Subsector GHG emission (megatons CO2-eq)	5.067 mln. t CO_2 in thermal power sector in 2010
Background/Notes, Short description of the technology option	Condensing boilers /Caldaie a condensazione SIME. Benessere in evoluzione/ use latent heat of condensation of vapors from combustion gas, increasing boiler efficiency by 10 -15%. Vapor condensation takes place when the gas temperature drops below 50 ^{0}C. This is possible if the water incoming into the boiler has a temperature of 30-40 ^{0}C, in relatively small heating systems. These boilers' productivity is up to 100 kW of heat. To avoid corrosion of surfaces the boiler is manufactured of special steel, which increases its cost by up to 2 times.
Implementation assumptions. How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	Energy consumption for heating by 2020 is expected to reach 46.6 PJ, CO2 emissions amounting to 1.89 mln. t. Increased cost of the boiler until recently made them non-competitive. Current tariffs for natural gas have made them competitive and they started to be implemented more widely. However, the share of condensing boilers in total consumption of heat can not exceed 5%.
Implementation barriers	- Increased investment - Decreased effect if the required temperature of water is higher (when outdoor temperature drops) - Lack of efficiency increasing effect in hot water preparation.
Reduction in GHG emissions (megatons CO2-eq)	0,0092 Million t CO2e for 2020
Impact Statements – Impact of this option on the country development priorities	
Country **social** development priorities	Consumers pay less for fuel
Country **economic** development priorities – economic benefits	Reduced consumption, and subsequently, a reduction by 3.5 mil.m^3/year of natural gas import
Country **environmental** development priorities	Reduction in CO and NO_x emissions
Other considerations and priorities	-
Costs	
Capital costs	Investments in condensing boilers are about 2 times higher than in simple boilers
Operational and Maintenance costs	Operational and maintenance costs, provided the price of gas in 2030 is 1.0 USD/m^3 , will be 35.4 USD/GJ.
Cost of GHG reduction	The total cost of installed boilers will be 20 thousand USD Emissions reduced in between 2010-2030 will amount to 150 thousand t CO_2eq. Therefore the cost of GHG reduction is 130 USD /tCO2
Lifetime.	Lifetime – 10 years

Technology Name	**Solid fuel gasification boilers** / ORLAN BOILER OPERATING ON WOOD WASTE. Romstal. Universul instalaţiilor www.romstal.*ro/*
Subsector GHG emission (megatons CO2-eq)	5.067 mln.t CO_2 in thermal power sector in 2010
Background/Notes, Short description of the technology option	These boilers allow adjustment of heat productivity to the amount of incoming air, thus enabling the automation of the process of solid fuels combustion in boilers of small and medium productivity / ORLAN BOILER OPERATING ON WOOD WASTE. Romstal. Universul instalaţiilor www.romstal.*ro/*. These boilers also allow to increase efficiency by 2-5 % and reduce CO emissions.
Implementation assumptions. How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	By 2030 energy consumption for heating purposes is expected to reach 46.6 PJ, CO2 emissions - to 1.89 mln.t. Given this level of consumption, the share of gasification boilers can not exceed 1%, of which 80% is expected to operate on wood and 20% - on coal.
Implementation barriers	- Increased investments
Reduction in GHG emissions (megatons CO2-eq)	0.135 Mt.CO_2eq.
Impact Statements – Impact of this option on the country development priorities	
Country **social** development priorities	Greatly reduces the time of servicing operation and improves the climate in rooms.
Country **economic** development priorities – economic benefits	insignificant
Country **environmental** development priorities	Reduction in CO emissions
Other considerations and priorities such as market potential.	-
Costs	
Capital costs	8.25 mil.$
Operational and Maintenance costs	Operational and Maintenance costs – 6.7 $/GJ.
Cost of GHG reduction	3.03 $/t
Lifetime.	Lifetime – 10 years
Other	-

Technology Name	**Radiant panels for local heating**
Subsector GHG emission (megatons CO2-eq)	5.067 mln.t CO_2 in thermal energy sector in 2010
Background/Notes, Short description of the technology option	Electric or hydrocarbons, mainly natural gas, based radiator panels are used for local heating in large premises: industrial buildings, sports halls, trade areas. They feature low inertia and directed flow of heat that can heat only the room and only during the required period of time [Commercial gas infrared heater. [http://www.archiexpo.com/prod/detroit-radiant-products-company/commercial-infrared-gas-radiators-52180-473099.html]
Implementation assumptions. How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	By 2020 energy consumption for heating is expected to reach 46.6 PJ, CO2 emissions - to 1.89 mln.t. The share of radiant panels at such level of consumption will be insignificant - 0.1 5.
Implementation barriers	- Relatively few cases of use - .
Reduction in GHG emissions (megatons CO2-eq)	0.0065
Impact Statements - How this option impacts the country development priorities	
Country **social** development priorities	Improve indoor climate. Reduce energy consumption
Country **economic** development priorities – economic benefits	Annual savings of 150 thousand m^3 of gas
Country **environmental** development priorities	Reduction in CO and NO_x emissions
Other considerations and priorities such as market potential	-
Costs	
Capital costs	Investments of 80 thousand USD are much lower than in traditional heating systems
Operational and Maintenance costs	Operational and maintenance costs will consist almost entirely of cost of gas, and other primary sources of energy - 35.9 USD / GJ in 2030 at expected gas price of 1.0 USD per m3
Cost of GHG reduction	12.56 USD/t CO2
Lifetime.	Lifetime – 8 years
Other	-

Technology Name	**Micro- and mini-CHP operating on natural gas** www.dgc.eu/publications/pdf/jdw_**mini_micro**_cogen11.pdf
Subsector GHG emission (megatons CO2-eq)	5.067 mln.t CO_2 in thermal power sector in 2010
Background/Notes, Short description of the technology option Context / Notes. Short description of the technology option	Micro-and mini-CHP-s with electrical power from a few kW to several MW and heat index 1-2, using piston engines or micro-and mini-gas turbines are used by individual consumers and consumer groups, both in residential sector, as well as in industry. Co-generation installations can reduce fuel consumption on average by 25%, increase safety and ensure the independence of consumers.
Implementation assumptions. How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	High thermal efficiency of small installations and full automation of operation makes them more attractive to consumers. It is expected that by 2020 micro-and mini-CHPs could achieve a 10% share on the heat supply market for consumers in various sectors. By 2020 the installed capacity may reach 500 MWt which at 0.5 workload would produce about 7.8 PJ heat per year.
Implementation barriers	- Increased investments. - Relatively small price for the electric power bought from external sources.
Reduction in GHG emissions (megatons CO2-eq)	1.25 mln.t CO_2 can be reduced between 2010 – 2030.
Impact Statements – Impact of this option on the country development priorities	
Country **social** development priorities	Increases safety and ensures consumers' independence
Country **economic** development priorities – economic benefits	Reduced consumption and consequently, of natural gas import by 65 ml m^3 per year by 2030
Country **environmental** development priorities	Reduction in CO and NO_x emissions
Other considerations and priorities such as market potential	-
Costs	
Capital costs	Total investment of about 330 million USD in which the thermal part will account for 130 million USD.
Operational and Maintenance costs	Operational and maintenance costs will be 21.9 USD / GJ if the expected price of natural gas by 2030 is 1.0 USD per m3
Cost of GHG reduction	141 USD/t
Lifetime.	Lifetime – 14 years

Technology Name	**High and medium power heat pumps** http://www.junkers.ro/ro/ro/ek/infocenter/download/6_Pliant_pompa_caldura.pdf
Subsector GHG emission (megatons CO2-e)	5.067 mln.t CO_2 in thermal power sector in 2010
Background/Notes, Short description of the technology option Context / Notes, Short description of the technology option	Heat pumps (HP) raise the temperature of low potential heat sources (LHS) to values needed by consumers. Low potential heat sources (LHS) can be the atmospheric air, soil, surface waters and ground waters, as well as a number of technological sources (ventilation air, sewage, cooling fluids of power plants and technological equipment, in the long run - heat from asphalt roads, etc). Heat pumps use one kWh of electricity to get 3 to 5 kWh of heat. Heat pumps can be used in a number of technological processes that require simultaneous heating and cooling (grinding, drying, etc). Heat pumps do not eliminate any emissions. Lately, ozone-active refrigerants are being replaced with environmentally safe hydrocarbons.
Implementation assumptions. How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	High efficiency of the heat pumps, easy servicing and environmental friendliness make them increasingly attractive. Heat pumps of air-air type, which can be used for rooms conditioning in summer have become very popular in urban areas, in the Republic of Moldova inclusively. Heat pumps of air-ground and ground-water types are used increasingly wider. It is expected that by the year 2020 HP will ensure 10% of the heat supply for heating, hot water consumption and technological processes.
Implementation barriers	- Large investments. - Limited knowledge of the HP technology by consumers.
Reduction in GHG emissions (megatons CO2-eq)	A reduction of 1.03 mln.t CO_2 can be achieved between 2010 – 2030
Impact Statements - Impact of this option on the country's development priorities	
Country **social** development priorities	Increase safety and ensures consumers' independence
Country **economic** development priorities – economic benefits	A reduction of 100 mil m^3 of natural gas per year can be achieved by 2030.
Country **environmental** development priorities	Reduction in CO and NO_x emissions
Other considerations and priorities such as market potential	-
Costs	
Capital costs	Total investments will amount to cca 465 mil.USD
Operational and Maintenance costs	Operational and maintenance costs will be 13.5 USD/GJ
Cost of GHG reduction	450 USD/t
Lifetime	Lifetime – 20 years
Other	-

Technology Name	**CHP on motor organic agents** Lucien Y. Bronicki ORGANIC RANKINE CYCLE POWER PLANT FOR WASTE HEAT RECOVERY, http://www.ormat.com/
Subsector GHG emission (megatons CO2-eq)	5.067 mln.t CO_2 in thermal energy sector in 2010
Background/Notes, Short description of the technology option	Lately turbine plants operated by the action of organic matter vapors - freons and hydrocarbons (methane, butane, isobutan, pentane) are being developed. These plants can operate at low pressures and temperatures with relatively high electrical efficiency. They can run on different fuels, including biomass and also recover heat from gas exhausted from engines and industrial plants. A wide range of operating powers is the advantage of such plants.
Implementation assumptions. How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	Will be implemented in district heating industrial enterprises, etc. It is possible to install a total thermal power of 200 MW.
Implementation barriers	- Little operating practice. - Lack of commercial production
Reduction in GHG emissions (megatons CO2eq)	Reduce 0.45 mln.t CO_2 in between 2010 – 2030
Impact Statements - Impact of this option on the country's development priorities	
Country **social** development priorities	Create jobs Increase energy security of the country
Country **economic** development priorities – economic benefits	Reduce import of fuel
Country **environmental** development priorities	Reduce harmful emissions
Other considerations and priorities such as market potential	-
Costs	
Capital costs	Investments in the thermal part will be cca 100 mln.USD
Operational and Maintenance costs	Operational and maintenance costs -16.7 USD/GJ
Cost of GHG reduction	14 USD/t
Lifetime	Lifetime – 15 years
Other	-

Technology Name	**Micro and Mini CHPs on Fuel Cells** ЭНЕРГЕТИЧЕСКИЕ УСТАНОВКИ НА БАЗЕ ТОПЛИВНЫХ ЭЛЕМЕНТОВ. http://www.newchemistry.ru/letter.php?n_id=6721
Subsector GHG emission (megatons CO2-eq)	GHG emissions accounted for 5.067 mln.t CO_2 in thermal energy sector in 2010
Background/Notes, Short description of the technology option	It is expected that fuel cells - electrochemical generators will become increasingly widely spread because of advantages over other electricity and heat generation technologies: lower emissions, more compact, have no moving parts, so they have a longer life (assumingly 30 years), produce less noise. Low temperature installations (200 ... 230 0C), which are at piloting stage have electrical efficiency of 30 ... 37% and global efficiency - 80 ... 85%. They are being used in some facilities in the USA, Japan etc.
Implementation assumptions. How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	Is expected that by 2030 the Republic of Moldova will be able to install about 10 MWt.
Implementation barriers	- Strict fuel requirements - Lack of service experience of - Lack of commercial proposals.
Reduction in GHG emissions (megatons CO2-eq)	To achieve reduction 0.14 mln.t CO_2eq./year by 2030
Impact Statements - Impact of this option on the country's development priorities	
Country **social** development priorities	Create additional jobs
Country **economic** development priorities – economic benefits	Reduce fuel consumption by cca 6 thousand tone coal equivalent (t.c.e) per year by 2030
Country **environmental** development priorities	Reduction of harmful emissions
Other considerations and priorities such as market potential	-
Costs	
Capital costs	Investments in thermal parts will be cca 20 mln.USD
Operational and Maintenance costs	Operational and maintenance costs – 30 USD/GJ
Cost of GHG reduction	46 USD/t CO_2eq
Lifetime.	Lifetime – 20 years
Other	-

Technology Name	**Heating systems with hydrogen** http://www.ecomagazin.ro/hidrogen-pentru-caldura-din-case/
Subsector GHG emission (megatons CO2-eq)	5.067 mln.t CO_2 in thermal power sector in 2010
Background/Notes, Short description of the technology option	Many specialists predict a more intensive development of hydrogen energy, especially, as this is a method of storing energy for diurnal, annual electric load curves flattening, of storing energy produced by wind and solar plants. In addition, hydrogen is the cleanest fuel, burning of which generates only water vapors. It should be mentioned that hydrogen is the most convenient fuel for fuel cells.
Implementation assumptions. How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	
Implementation barriers	- Technologies are at development and implementation stage. - Hydrogen is a costly fuel - 5…12 USD/kg
Reduction in GHG emissions (megatons CO2-eq)	If 500 kW will be installed by 2030, it will entail a reduction of 0.43 Mt.CO_2eq.
Impact Statements - Impact of this option on the country's development priorities	
Country **social** development priorities	Improve indoor climate.
Country **economic** development priorities – economic benefits	Wide possibilities for import and domestic production increase the country's energy security
Country **environmental** development priorities	Exclude harmful emissions
Other considerations and priorities such as market potential	-
Costs	
Capital costs	At 500 kW power – 250 thousand USD
Operational and Maintenance costs	Operational and maintenance costs –72.8 $/GJ.
Cost of GHG reduction	0.06 $/t
Lifetime.	Lifetime – 10 years
Other	-

Technology Name	**CHP with gas-steam combined cycle** R.Kehlhofer, R.Bachmann, H.Nielsen, J.Warner. Combined-Cycle Gas Steam Turbine Power Plants. 2nd Edittion. PennWell, Tulsa, Oklahoma, 1999.
Subsector GHG emissions (megatons CO2-eq)	5.067 mln.t CO_2 in thermal power sector in 2010
Background/Notes, Short description of the technology option	CHP with gas-steam combined cycle, are plants where 60-70% of electric power is produced by gas turbines and 30 - 40% -by turbines with steam produced in heat boilers on account of exhaust gases from gas turbines. Total electrical efficiency of these plants reaches 40 -60% and overall efficiency - from 80 to 90%. Electric power of such plants can be from 50 MW to 500 MW, depending on the consumer demand, heat index – from 0.5 to 1.0.
Implementation assumptions. How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	In Moldova such CHPs can be built in Chisinau and Balti, to replace physically and morally obsolete existing CHPs, in cities like Orhei, Soroca, where it may reduce some of the technological thermal load. It is expected that a total of 500 MW can be installed by 2030
Implementation barriers	- Large investments - Availability of cheap electricity imported from countries with lower gas prices.
Reduction in HG emissions (megatons CO2-eq)	3.0 Million t CO2eq by 2030
Impact Statements - Impact of this option on the country's development priorities	
Country **social** development priorities	Create additional jobs Increase electric security of the country
Country **economic** development priorities – economic benefits	Reduce import of electricity, Reduce import of fuel compared to condensing power plants
Country **environmental** development priorities	Reducing harmful emissions compared to district and individual heating systems, which have become very popular.
Other considerations and priorities such as market potential	
Costs	
Cos Capital costs **s**	Investments in thermal part – 300 mln USD
Operational and Maintenance costs	Operational and maintenance costs will be 18 USD/GJ
Cost of GHG reduction	52 USD/t
Lifetime	Lifetime – 15 years

Technology Name	**High Power Heat Pumps** Г.Хайнрих, Х.Найорк, В.Нестлер. Теплонасосные установки для отопления и горячего водоснабжения. Пер.с нем., М.Стройиздат.1985.
Subsector GHG emission (megatons CO2-eq)	5.067 mln.t CO_2 in thermal power sector in 2010
Background/Notes, Short description of the technology option	High power heat pumps - more than 20 MW, can be implemented in specific locations with availability of a heat source with potentially reduced productivity.
Implementation assumptions. How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	In towns on the banks of the Dniester river the potential source of affordable reduced productivity fuel (RPF) is the river water filtered through the ground to accumulate the warmth of water during summer and autumn. In Balti and Chisinau municipalities such sources could operate in combination with CHPs.
Implementation barriers	- Large investments. - Scarcity of RPF sources
Reduction in GHG emissions (megatons CO2-eq)	Provided by 2030 the installed power is 50 000 kW, it will be possible to reduce 0.17 Mt.CO2eq.
Impact Statements - Impact of this option on the country's development priorities	
Country **social** development priorities	Increase security of heat supply
Country **economic** development priorities – economic benefits	Reduce natural gas consumption by100 mil. m^3 per year by 2030
Country **environmental** development priorities	Exclude harmful emissions
Other considerations and priorities such as market potential	
Costs	
Capital costs	At 50 MW power – 100 mil. USD
Operational and Maintenance costs	Operational and Maintenance costs –13.1 $/GJ.
Cost of GHG reduction	600 $/t
Lifetime	20 years
Other	-

Technology Name	**Low power nuclear CHP (few dozens MW)** Mini Nuclear Power Plants Could Power 20,000 Homes. http://www.physorg.com/news145561984.html
Subsector GHG emission (megatons CO2-eq)	5.067 mil. t CO_2 in thermal power sector in 2010
Background/Notes, Short description of the technology option	In Los Alamos laboratories, U.S.A. low power NPP blocks (few dozens MW) have been developed and put into circulation. The plants are enclosed in concrete blocks, delivered to the consumer, sited in an underground containment vault, do not require any intervention in the operation. After the fuel is consumed, the blocks are retrieved and returned back to the deliverer.
Implementation assumptions. How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	The blocks are meant to supply electricity and heat to remote settlements.
Implementation barriers	- Not available so far - Possible fear about radioactive pollution
Reduction in GHG emissions (megatons CO2-eq)	Provided by 2030 the installed power is 450 MWt (150 MWe), it will be possible to reduce 0,81 mil. t CO_2.
Impact Statements - Impact of this option on the country's development priorities	
Country **social** development priorities	Increase security of heat supply
Country **economic** development priorities – economic benefits	Reduce import of fuel
Country **environmental** development priorities	Exclude harmful emissions
Other considerations and priorities such as market potential	-
Costs	
Capital costs	Investments in thermal part - 400 mln.USD
Operational and Maintenance costs	-
Cost of GHG reduction	50 USD/t
Lifetime.	Lifetime – 10 years
Other	-

Technology Name	**CHP on Fuel Cells** ЭНЕРГЕТИЧЕСКИЕ УСТАНОВКИ НА БАЗЕ ТОПЛИВНЫХ ЭЛЕМЕНТОВ. http://www.newchemistry.ru/letter.php?n_id=6721
Subsector GHG emission (megatons CO2-eq)	GHG emissions accounted for 5.067 mil. t CO_2 in thermal power sector in 2010
Background/Notes, Short description of the technology option	Fuel cells - electrochemical generators are expected to become widely used due to certain advantages over other power and heat generating technologies: lower emissions, more compact, have no moving parts, so they have a longer life (assumingly 30 years), produce less noise. High temperature plants (700 ... 1000 0C), which are currently being developed and tested have an electrical efficiency of up to 50%. These can serve as basis for combined fuel cell- steam turbine plants which will increase electric efficiency to 60 ... 70% and overall efficiency - to 85 ... 90%.
Implementation assumptions. How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	It is expected that the total installed power in the Republic of Moldova by 2030 will be about 200 MWt (400 MWe).
Implementation barriers	- Increased investment - Higher fuel requirements - Lack of service experience - Lack of commercial proposals.
Reduction in GHG emissions (megatons CO2-eq)	It is expected to reduce about 0.380 mil. t CO_2eq./year by 2030
Impact Statements - Impact of this option on the country's development priorities	
Country **social** development priorities	Additional jobs
Country **economic** development priorities – economic benefits	By 2030 reduce fuel consumption by more than 160 thousand tone coal equivalent (t.c.e) per year
Country **environmental** development priorities	Reduce harmful emissions
Other considerations and priorities such as market potential	-
Costs	
Capital costs	Investments in thermal part of cca 320 mil.USD
Operational and Maintenance costs	Maintenance costs – 25 USD/GJ
Cost of GHG reduction	42 USD/t CO_2eq
Lifetime.	Lifetime –20 years
Other	-

Technology Name	**Buildings walls insulation** http://www.iuses.eu/materiali/ro/MANUAL_PENTRU_ELEVI/Eficienta_energetica_in_cladiri.pdf
Subsector GHG emission (megatons CO_2-eq)	GHG emissions in the buildings sector in 2009 accounted for 2825 Gg, of which 75% (2120 Gg) - from residential buildings.
Background/Notes Short description of the technology option	By the end of 2009 Moldova's housing stock was 78.9 mil. m^2, of which 30.1 m^2 in urban sector and 48.8 mil. m^2 - in rural sector. Extrapolation of the trend data for the years 2002-2009 resulted in 86.2 mil. m^2 for 2030, of which 34.6 mil. m^2 in urban sector and 51.6 mil. m^2 in rural sector. In 1997, when buildings walls insulation requirements changed, the housing stock was 73.2 mil. m^2. In buildings constructed until 1997 the average heating intensity was 70 W/ m^2 in urban sector, and 160 W/ m^2 in rural sector-. After 1997 these values dropped to 50 W/ m^2 and 130 W/ m^2 , respectively. In the last decade insulation measures have been implemented in about 10% of old buildings in urban areas and 1-2% of buildings in rural areas: walls insulation, replacement of old windows with new multiple glazed units, replacement of doors, etc. Heat consumption in the residential sector in 2010 was 47.3 PJ, and is expected to reach 58.1 PJ[3] in 2030.
Implementation assumptions. How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	Until now rehabilitation of buildings in the country has been made at the initiative of consumers – home- and apartments owners. To enhance this process it is necessary to organize it as a national program at municipalities level, with a certain share of subsidies. Thus, by 2030, it would be possible to rehabilitate all buildings in urban areas and 50% of buildings in rural areas.
Implementation barriers	- Large investments. - Lack of interest from the part of central and locale public administration.
Reduction in GHG emissions (megatons CO2-eq)	Reduction of 7.5 mln.t CO_2 in between 2010 – 2030
Impact Statements - Impact of this option on the country's development priorities	
Country **social** development priorities	Improve indoor comfort. Reduce consumers spending.
Country **economic** development priorities – economic benefits	By 2030 reduce fuel consumption by more than 300 thousand tone coal equivalent (t.c.e) per year
Country **environmental** development priorities	Reduce harmful emissions
Other considerations and priorities such as market potential	-
Costs	
Capital costs	Total investments of cca 1 400 mil.USD
Operational and Maintenance costs	Operational and Maintenance costs unchanged
Cost of GHG reduction	Provided the cost of investment is 1400 million USD and the amount of emissions reduced in 2010-2030 is 7,5 mil. t , the specific cost of reduction will be 190 USD / t.
Lifetime.	Lifetime – 30 years
Other	-

Technology Name	**Programmed regulation of temperature in rooms** Source: http://www.energysavingtrust.org.uk/In-your-home/Heating-and-hot-water/Thermostats-and-controls
Subsector GHG emission (megatons CO2-eq)	GHG emissions in the buildings sector in 2009 accounted for 2825 Gg, of which 75% (2120 Gg) - from residential buildings.
Background/Notes, Short description of the technology option	In the district heating systems temperatures of heat is regulated at the heat source, by regulating the temperature of water in the heat pipes. At the same time, reducing the temperature from 18 - 20 0C to "standby" ("night") value of 10 - 12 0C during the time the rooms are not used, would result in a 20 - 30% reduction of heat consumption.
Implementation assumptions. How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	Can be implemented in buildings within the district heating network which account for approx. 60% of urban housing stock. Installation of thermostats (cost - 10 - 12 USD per piece) at every heating element will allow to switch the temperature in rooms to 10 -12 0C when they are not used - about 50% of the time.
Implementation barriers	- Organizational impediments related to possible disorders in the hydraulic operations of the system. - Significant works in apartments and efforts to convince all residents of the building about the need. - Lack of interest from the part of central and local public administration.
Reduction in GHG emissions (megatons CO2-eq)	Reduction of 2.2 mil.t CO_2 in between 2010 – 2030.
Impact Statements - Impact of this option on the country's development priorities	
Country **social** development priorities	Improve indoor comfort. Reduce consumers spending.
Country **economic** development priorities – economic benefits	By 2030 reduce fuel consumption by more than 120 thousand tone coal equivalent (t.c.e) per year
Country **environmental** development priorities	Reduce harmful emissions
Other considerations and priorities such as market potential	-
Costs	
Capital costs	Total investments of cca 45 mil.USD
Operational and Maintenance costs	Operational and Maintenance costs will increase insignificantly
Cost of GHG reduction	
Lifetime.	Lifetime – 10 years
Other	-

Technology Name	**Heat metering per apartment** http://www.google.md/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=2&ved=0CCcQFjAB&url=http%3A%2F%2Fsiteresources.worldbank.org%2FEXTEAPASTAE%2FResources%2F2822887-1163788250255%2FChina%2BDH%2BWS%2B2005%2B6%2BMetering.pdf&ei=dsieT8RNlPfhBNzN5akO&usg=AFQjCNGITeqFuPfiNqd3IigrlHj0vgB4tQ&sig2=-yNh2ICyA6CHYhDlpq4OOg
Subsector GHG emission (megatons CO2-eq)	GHG emissions in the buildings sector in 2009 accounted for 2825 Gg, of which 75% (2120 Gg) - from residential buildings.
Background/Notes, Short description of the technology option	Currently the residential buildings have heat meters. Implementation of the heat consumption regulation by heating elements will enable consumers to adjust their own consumption. The switch from a vertical distribution to the horizontal one will require metering by apartments. This will reduce consumption by at least 5%.
Implementation assumptions. How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	Can be implemented in buildings within the district heating network which account for approx. 60% of urban housing stock.
Implementation barriers	- Significant investments. - Significant works in apartments for switching to a new heat distribution system.
Reduction in GHG emissions (megatons CO2-eq)	Reduction of 0.22 mln.t CO_2 in between 2010 – 2030
Impact Statements - Impact of this option on the country's development priorities	
Country **social** development priorities	Improves indoor comfort. Reduce consumers spending.
Country **economic** development priorities – economic benefits	By 2030 reduce fuel consumption by more than 120 thousand tone coal equivalent (t.c.e) per year
Country **environmental** development priorities	Reduce harmful emissions
Other considerations and priorities such as market potential	-
Costs	
Capital costs	Total investments of cca 90 mil.USD
Operatonal and Maintenance costs	Operational and Maintenance costs will increase insignificantly
Cost of GHG reduction	
Lifetime.	Lifetime – 15 years
Other	-

Technology Name	**Energy Efficient lamps** http://www.iuses.eu/materiali/ro/MANUAL_PENTRU_ELEVI/Eficienta_energetica_in_cladiri.pdf
Subsector GHG emission (megatons CO2-eq)	GHG emissions in the buildings sector in 2009 accounted for 2825 Gg, of which 75% (2120 Gg) - from residential buildings.
Background/Notes, Short description of the technology option	Incandescent lamps currently in use (Class E) have luminous efficiency of 10-12 lm / W, while energy efficient lamps (Class A) **-** 50 lm / W. If currently energy intensity of illumination in residential buildings is on average 10 W/m2, fluorescent lamps will reduce it to 2 W/m2.
Implementation assumptions. How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	Given the overall floorage by 2030 is 86.2 mil. m^2, energy efficient lamps will save more than 1 million MWh / year.
Implementation barriers	- A ten times higher price of lamps is a psychological barrier for consumers, which will gradually disappear.
Reduction in GHG emissions (megatons CO2-eq)	Reduction of 7.5 mil.t CO_2 In between 2010 – 2030
Impact Statements - Impact of this option on the country's development priorities	
Country **social** development priorities	Improves indoor comfort. Reduce consumers spending.
Country **economic** development priorities – economic benefits	By 2030 reduce fuel consumption by more than 120 thousand tone coal equivalent (t.c.e) per year
Country **environmental** development priorities	Reduce harmful emissions
Other considerations and priorities such as market potential	-
Costs	
Capital costs	Total investments of cca 57 mil.USD
Operational and Maintenance costs	Operational and Maintenance costs will increase insignificantly
Cost of GHG reduction	
Lifetime.	Lifetime – 1.0 years
Other	-

Technology Name	**Energy efficient home appliances** http://www.iuses.eu/materiali/ro/MANUAL_PENTRU_ELEVI/Eficienta_energetica_in_cladiri.pdf
Subsector GHG emission (megatons CO2-eq)	GHG emissions in the buildings sector in 2009 accounted for 2825 Gg, of which 75% (2120 Gg) - from residential buildings.
Background/Notes, Short description of the technology option	Home appliances are increasingly wider used in everyday life, increasing the amount of energy used. It is therefore necessary to implement as widely as possible efficient energy devices of class A, A +, A + + that reduce electricity consumption by 60-80%.
Implementation assumptions. How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	The total power of home appliances in Moldova can be assessed at 3.5 million kW. Increasing their efficiency by 20% by 2030 will allow to save over 2.1 million MWh per year.
Implementation barriers	- Long life of home appliances of 15-20 years and relatively high cost. Consumers are reluctant to change an old fridge, a TV, a washing machine, etc which is functional but not energy efficient.
Reduction in GHG emissions (megatons CO2-eq)	Reduction of 0.9 mil.t CO_2 in 2010 – 2030
Impact Statements - Impact of this option on the country's development priorities	
Country **social** development priorities	Reduce consumers spending
Country **economic** development priorities – economic benefits	By 2030 reduce fuel consumption by more than 50 thousand tone coal equivalent (t.c.e) per year
Country **environmental** development priorities	Reduce harmful emissions
Other considerations and priorities such as market potential	-
Costs	
Capital costs	Total investments of cca 430 mil.USD
Operational and Maintenance costs	Maintenance costs will increase insignificantly
Cost of GHG reduction	
Lifetime	Lifetime – 10-20 years
Other	-

Technology Name	**Building construction to optimal orientation** http://www.sustainable-buildings.org/wiki/index.php/Building_Orientation
Subsector GHG emission (megatonnes CO2-eq)	GHG emissions in the buildings sector in 2009 accounted for 2825 Gg, of which 75% (2120 Gg) - from residential buildings.
Background/Notes, Short description of the technology option	Most apartment blocks have a length of 3-5 times the width. If positioned with the narrow part to the north, where heat losses are 10% higher, the heat losses can be reduced by 0.15%.
Implementation assumptions. How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	When planning and designing buildings location, orientation of the narrow part of the building towards north (south) should be observed. This need occurs in one building from ten.
Implementation barriers	- Architects may pose some impediments
Reduction in GHG emissions (megatons CO2-eq)	Reduction of 0.0003 mln.t CO_2 in between 2010 – 2030
Impact Statements - Impact of this option on the country's development priorities	
Country **social** development priorities	Reduce consumers spending
Country **economic** development priorities – economic benefits	By 2030 reduce fuel consumption by more than 160 thousand tone coal equivalent (t.c.e) per year
Country **environmental** development priorities	Reduce harmful emissions
Other considerations and priorities such as market potential	-
Costs	
Capital costs	No need for additional investments
Operational and Maintenance costs	Maintenance costs will not increase
Cost of GHG reduction	
Lifetime.	Lifetime – 30 years
Other	-

Technology Name	**Performant air-conditioning** www.performanceair.biz/
Subsector GHG emission (megatons CO2-eq)	GHG emissions in the buildings sector in 2009 accounted for 2825 Gg, of which 75% (2120 Gg) - from residential buildings.
Background/Notes, Short description of the technology option	Air conditioning installations are increasingly widely implemented in the residential sector. Dual purpose conditioning systems – air conditioning / heating are very popular. There are the largest air conditioners by electrical power - with consumption of more than 1 kW. It is therefore necessary to choose the most performant plants.
Implementation assumptions. How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	If, by 2030, 5% of residential space will be provided with air conditioners, the installed capacity will be over 430 thousand kW cold air. The electrical power required in the network will be over 170 thousand kW. A 10% saving will reduce electricity consumption by more than 5 million kWh per year.
Implementation barriers	- Long (15-20 years) life time of the equipment and relatively high cost per unit. Consumers are reluctant to replace functional plants.
Reduction in GHG emissions (megatons CO2-eq)	Reduction of 0.02 mln.t CO_2 in between 2010 – 2030
Impact Statements - Impact of this option on the country's development priorities	
Country **social** development priorities	Reduce consumers spending
Country **economic** development priorities – economic benefits	By 2030 reduce fuel consumption by more than 175 thousand tone coal equivalent (t.c.e) per year
Country **environmental** development priorities	Reduce harmful emissions
Other considerations and priorities such as market potential	-
Costs	
Capital costs	Total investment of cca.130 mil.$, however, with insignificant difference versus energy inefficient installations.
Operational and Maintenance costs	Maintenance costs of cca. 38 $/GJ cold air, however, not higher than for old installations.
Cost of GHG reduction	
Lifetime.	Lifetime – 15 years
Other	-

Technology Name	**Passive homes** www.casepasive.eu/concept
Subsector GHG emission (megatons CO2-eq)	GHG emissions in the buildings sector in 2009 accounted for 2825 Gg, of which 75% (2120 Gg) **-** from residential buildings.
Background/Notes, Short description of the technology option	Passive homes is a new concept, in line with European standards in construction industry. It ensures reduced maintenance costs through energy efficient design. Passive homes provide a comfortable indoor climate with heating energy consumption of no more than 15 kWh / (m^2year), preferably from renewable energy sources.
Implementation assumptions. How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	If by 2030 passive homes account for 5% of residential space, heating only will save by 60 TJ of energy per year.
Implementation barriers	- Increased investment. - At present possible for small and medium houses only.
Reduction in GHG emissions (megatons CO2-eq)	Reduction of 0.036 mln.t CO_2 In between 2010 – 2030
Impact Statements - Impact of this option on the country's development priorities	
Country **social** development priorities	Reduce consumers spending
Country **economic** development priorities – economic benefits	By 2030 reduce fuel consumption by more than 2.1 thousand tone coal equivalent (t.c.e) per year
Country **environmental** development priorities	Reduce harmful emissions
Other considerations and priorities such as market potential	-
Costs	
Capital costs	Total 710 mil USD
Operational and Maintenance costs	1.11 $/m^2$
Cost of GHG reduction	6500 USD/t CO_2eq
Lifetime.	Lifetime – 30 years
Other	-

Technology Name	**Highly Efficient Heat, Ventilation and Air-conditioning Systems (HVAC)** http://en.wikipedia.org/wiki/HVAC
Subsector GHG emission (megatons CO2-eq)	GHG emissions in the buildings sector in 2009 accounted for 2825 Gg, of which 75% (2120 Gg) - from residential buildings.
Background/Notes, Short description of the technology option	HVAC (heating, ventilation, and air conditioning) refers to indoor comfort technology. The three core functions of heating, ventilation and air conditioning are interdependent, particularly with the need to ensure thermal comfort and indoor air quality within acceptable installation reasonable operation and maintenance costs. HVAC systems can provide ventilation, reduce air infiltration, and maintain pressure correlation between spaces. Though designed for industrial and administrative buildings, also can be implemented in modern residential buildings with enhanced level of comfort.
Implementation assumptions. How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	If by 2030 HVAC systems account for 5% of residential space, energy consumption will drop by more than 1245 mil. MWh/ year.
Implementation barriers	- Increased investment. - Insufficient experience in construction and operation.
Reduction in GHG emissions (megatons CO2-eq)	Reduce 4.5 mln.t CO_2 in between 2010 – 2030
Impact Statements - Impact of this option on the country's development priorities	
Country **social** development priorities	Reduce consumers spending
Country **economic** development priorities – economic benefits	By 2030 reduce fuel consumption by more than 150 thousand tone coal equivalent (t.c.e) per year
Country **environmental** development priorities	Reduce harmful emissions
Other considerations and priorities such a market potential	-
Costs	
Capital costs	Total investments – 258 mil USD
Operational and Maintenance costs	6.63 USD/m^2
Cost of GHG reduction	28.84 USD/t CO_2eq
Lifetime	Lifetime – 15 years
Other	-

Technology Name	**Buildings walls insulation**
Subsector GHG emission (megatons CO2-eq)	GHG emissions in the buildings sector in 2009 accounted for 2825 Gg, of which 75% (2120 Gg) **-** from residential buildings.
Background/Notes, Short description of the technology option	By the end of 2009 Moldova's housing stock was 78.9 mil. m^2, of which 30.1 m^2 in urban sector and 48.8 mil. m^2 - in rural sector. Extrapolation of the trend data for the years 2002-2009 resulted in 86.2 mil. m^2 for 2030, of which 34.6 mil. m^2 in urban sector and 51.6 mil. m^2 in rural sector. In 1997, when buildings walls insulation requirements changed [8], the housing stock was 73.2 mil. m^2. In buildings constructed until 1997 the average heating intensity was 70 W/ m^2 in urban sector, and 160 W/ m^2 in rural sector. After 1997 these values dropped to 50 W/ m^2 and 130 W/ m^2 , respectively. According to energy consumption in the tertiary sector accounts for 25% of the residential sector. Assumingly, tertiary urban sector is 30% of the residential sector, and rural sector is 15%. Buildings rehabilitated so far by insulation of walls, replacement of old windows with new glazing units, replacement of old doors, etc.. account for 10% of the old buildings in the urban and rural sectors.
Implementation assumptions. How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	Until present, rehabilitation of administrative buildings is being done at the initiative of consumers from external funds. To enhance this process is necessary to organize this process through a state program. Thus, by 2030, it would be possible to have all administrative buildings rehabilitated.
Implementation barriers	- Large investments. - Lack of interest from the part of central and local public administration.
Reduction in GHG emissions (megatons CO2-eq)	Reduction of 2.1 mln.t CO_2 in between 2010 – 2030
Impact Statements - Impact of this option on the country's development priorities	
Country **social** development priorities	Improves indoor comfort . Reduce consumers spending
Country **economic** development priorities – economic benefits	By 2030 reduce fuel consumption by more than 90 thousand tone coal equivalent (t.c.e) per year
Country **environmental** development priorities	Reduce harmful emissions
Other considerations and priorities such as market potential	-
Costs	
Capital costs	Total investments of cca 223 mil.USD
Operational and Maintenance costs	Operational and Maintenance costs will not change
Cost of GHG reduction	Specific cost of reductions will be 105 USD/t
Lifetime.	Lifetime – 30 years
Other	-

Technology Name	**Automatic temperature regulation, including "night" mode** http://www.google.md/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=11&ved=0CCIQFjAAOAo&url=http%3A%2F%2Fwww.rehau.com%2Fcms%2Fservlet%2Flinkableblob%2FUS_en%2F110046%2Fdata%2FDualSensingDigitalThermostatInstructions_855865_04-11-data.pdf%3Fview%3DDEFAULT&ei=2_SeT4vhBbH64QTGtOSpDg&usg=AFQjCNGjAQWvsfeJg3msPZFAqT4lW0pevw
Subsector GHG emission (megatons CO2-eq	GHG emissions in the buildings sector in 2009 accounted for 2825 Gg, of which 75% (2120 Gg) - from residential buildings.
Background/Notes, Short description of the technology option	Administrative buildings work five days a week, on average, 10 hours a day. The remaining time the temperature can be lowered to "night" mode of 10 - 12 0C. This would allow to save more than 700 TJ thermal energy per year.
Implementation assumptions. How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	This process does not require special efforts except for the knowledge and initiative from the part of decision-makers.
Implementation barriers	- Lack of knowledge and initiative from the part of decision-makers.
Reduction in GHG emissions (megatons CO2-eq)	Reduction of 0.42 mln.t CO_2 in between 2010 – 2030.
Impact Statements - Impact of this option on the country's development priorities	
Country **social** development priorities	Reduce consumers spending
Country **economic** development priorities – economic benefits	By 2030 reduce fuel consumption by more than 24 thousand tone coal equivalent (t.c.e) per year
Country **environmental** development priorities	Reduce harmful emissions
Other considerations and priorities such as market potential	-
Costs	
Capital costs	Total investments of cca 12 mil.USD
Operational and Maintenance costs	Operational and Maintenance costs will not change
Cost of GHG reduction	The specific cost of reduction will be 29 USD/t
Lifetime.	Lifetime – 10 years
Other	-

Technology Name	**Replacement of Incandescent lamps with Energy Efficient lamps** http://www.reegle.info/index.php?searchTerm=energy%20saving%20lamps&site=clean_energy_search&search=Search&gclid=CLjvmdG23a8CFQpj3wodT0quAg
Subsector GHG emission (megatons CO2-eq)	GHG emissions in the buildings sector in 2009 accounted for 2825 Gg, of which 25% (706 Gg) - from administrative buildings.
Background/Notes, Short description of the technology option	Incandescent lamps currently in use (Class E) have luminous efficiency of 10-12 lm / W, while the energy efficient lamps (Class A) - 50 lm / W. If energy intensity of illumination is 10 W/m2 on average, for fluorescent lamps it will be 2 W/m2.
Implementation assumptions. How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	Currently energy intensity of illumination is 10 W/m2 on average, for fluorescent lamps it will be 2 W/m2. For area of 21.55 million m2 in 2030 energy efficient lamps will save more than 250 million kWh / year.
Implementation barriers	- Cost of lamps is 10 times higher and is a psychological barrier for consumers which will gradually disappear.
Reduction in GHG emissions (megatons CO2-eq)	Reduction of 1.06 mil.t CO_2 in between 2010 – 2030.
Impact Statements - Impact of this option on the country's development priorities	
Country social development priorities	Improve indoor comfort conditions. Reduce consumer spending.
Country economic development priorities – economic benefits	By 2030 reduce fuel consumption by more than 31 thousand tone coal equivalent (t.c.e) per year
Country environmental development priorities	Reduce harmful emissions
Other considerations and priorities such a market potential	-
Costs	
Capital costs	Total investments of cca 14.2 mil.USD
Operational and Maintenance costs	Operational and Maintenance costs of 15 USD/GJ
Cost of GHG reduction	The specific cost of reduction will be 13.4 USD/t
Lifetime.	Lifetime – 1,0 years
Other	-

Technology Name	**Energy protective glasses and pellicles** Солнцезащитная пленка. http://etalon-dnepr.com/sun.html
Subsector GHG emission (megatons CO2-eq)	GHG emissions in the buildi gs sector in 2009 account d for 2825 Gg, of which 75% (2120 Gg) - from residential buildings.
Background/Notes, Short description of the technology option	Energy protective glasses and pellicles installed on windows reduce heat losses in winter by 20-60% and the heat input during the operation of air conditioning systems by 40 - 80%.
Implementation assumptions. How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	Can be used on large windows in rooms with of different destination. Taking into account that these account for 10% of the surface of tertiary buildings windows, the total area is 192 000 m^2.
Implementation barriers	- High cost of the protective pellicles and glasses. - So far insufficient knowledge of the effect.
Reduction in GHG emissions (megatons CO2-eq)	Reduction of 0.053 mln.t CO_2 in between 2010 – 2030.
Impact Statements - Impact of this option on the country's development priorities	
Country social development priorities	Improves indoor comfort. Reduce consumers spending.
Country economic development priorities – economic benefits	By 2030 reduce fuel consumption by more than 182 thousand tone coal equivalent (t.c.e) per year
Country environmental development priorities	Reduce harmful emissions
Other considerations and priorities such as market potential	
Costs	
Capital costs	Total investments of 3.95 mil.USD
Operational and Maintenance costs	-
Cost of GHG reduction	The specific cost of reductions will be 74 USD/t
Lifetime.	Lifetime – 15 years
Other	-

Technology Name	**Energy management system implementation** ISO launches ISO 50001 energy management standard. http://energymanagement.com.my/
Subsector GHG emission (megatons CO2-eq)	GHG emissions in the buildings sector in 2009 accounted for 2825 Gg, of which 75% (2120 Gg) – from residential buildings.
Background/Notes, Short description of the technology option	Energy Management System (EnMS), introduced by ISO 50 001, is a range of management processes that allow more appropriate management of the enterprise (organization) for maintenance and systematic improvement of energy performance. It includes collection, processing and analysis of data on consumption per points of consumption of all forms of energy and energy carriers (electricity, heat, cold, compressed air, natural gas, other fuels, etc.) and informing the top-management about the data collected, as well as making proposals on elimination of gaps and energy wise necessary improvements. By monitoring energy consumption the EnMS allows to prevent violation of regulations and equipment maintenance modes, track trends in consumption growth and timely remove the reasons that entailed it, identify the enterprise (organization)'s priorities in terms of implementing energy efficiency enhancement measures. The practice of enterprises in the EU countries show that implementation of EnMS can result in energy consumption reduction by 10 ... 20%.
Implementation assumptions. How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	If by 2030 about 80% of facilities implement EMS, it will reduce energy consumption by 5%, and will save 125mil. MWh / year. EnMS implementation costs are assumed to be 1.7 USD/ m^2 (5000 USD per a facility of 3000 m^2.
Implementation barriers	- Little knowledge about EnMS.
Reduction in GHG emissions (megatons CO2-eq)	Reduction of more than 0.54 mln.t CO_2 in 2010 – 2030
Impact Statements - Impact of this option on the country's development priorities	
Country **social** development priorities	Reduce consumers spending
Country **economic** development priorities – economic benefits	By 2030 reduce fuel consumption by cca. 125 mil. kWh per year
Country **environmental** development priorities	Reduce harmful emissions
Other considerations and priorities such as market potential	-
Costs	
Capital costs	Total investments of 28.7 mil. USD
Operational and Maintenance costs	-
Cost of GHG reduction	-26.6 USD/t CO_2eq.
Lifetime	Lifetime – 20
Other	-

Transport

A. Small scale

#	Name and short description of technology
1	**Hybrid Electric Vehicles** /http://climatetechwiki.org/technology/hev/ *General Description* One approach to lowering the CO_2 emission from traffic is the hybridization of vehicles. A hybrid vehicle uses two or more distinct power sources, i.e. hybrid electric vehicles (HEVs) combine an internal combustion engine and one or more electric motors. Vehicles employed in urban areas like small passenger cars, local delivery trucks and city busses benefit from hybridization and show substantially lower CO_2 emissions, ranging from 23 to 43% depending on the traffic dynamics. For passenger cars there are various levels of hybridization possible all giving rise to various amount of CO_2 emission reductions at different costs. Small passenger cars benefit the most from strong downsizing in combination with micro hybridization. Cars running most of their kilometers on motorways do not benefit from hybridization mostly because on motorways vehicles drive at more or less constant speeds. Hybrid vehicles are still more expensive than traditional vehicles using an internal combustion engine. They have the advantage of higher fuel efficiency and reduced CO2 emissions without additional infrastructure requirements. Currently there are four different levels of hybridization available in vehicles (Larsen, 2004): (1) Micro hybrids do not use electric motors to propel the vehicle; (2) Mild hybrids have electric motors which are used to propel the vehicle but cannot drive solely electrically; (3) Full hybrid cars are parallel hybrids which can be propelled fully electric at low speeds and use the internal combustion engine at higher speeds or when the electric energy stored in the car battery is low; (4) Series hybrid cars are full electric vehicles which use the internal combustion engine as a generator to produce electricity. *Implementation* Hybrid electric vehicles (cars, buses, local delivery vans) are most feasible for use in urban traffic, where there is a frequent need for breaking. Regenerative braking and electric motors of a hybrid car moving at a speed of 30-40 km / h lower CO2 emissions by 33-40% compared to a car using conventional fossil fuels (liquefied petroleum gas, diesel oil, gasoline). Hybrid vehicles do not show significant improvements in fuel consumption when driven on highways. A large advantage of hybrid vehicles compared to other options for reducing GHG emissions in transport is the fact that no additional infrastructure investments are required. It is assumed that by 2030 urban passenger transport will switch from diesel buses to hybrid ones. Research has demonstrated that, depending on the traffic dynamics, the hybrid buses have 23 – 43% lower CO_2 emission and 18-39% lower NO_x emissions compared to similar new non hybrid diesel articulated buses. *Implementation barriers* - Compared to a traditional fossil fuel powered vehicle, the purchase cost of a hybrid electric vehicle is higher; GHG emissions reduction (megatons CO2-eq) – 15 thousand tons CO_2 in 2030. *Impact on development priorities :* *a) Social* - Reduce health risks. *b) economic* - enhance energy security by reducing imports of fossil fuels; - improve balance of payments; *c) environment* - improving quality of local air; *d) other*

	Investments Micro hybridization is the cheapest solution, while full hybridization of vehicles is still a relative expensive technique. Estimates of additional costs for the full hybridization of a light passenger car range from €2800,- (Sharpe) to €4800,- (Erdmann et al., 2006) offering up to 20% reduction in CO2 emissions. The purchase costs of a hybrid bus can be 30% higher than a comparable non hybrid bus (Chandler and Walkowics, 2006) but the total operating costs of a hybrid bus are approximately 15% lower. Thus, taking into account the cost of purchasing a conventional diesel bus of $ 130,000 the purchase cost of a hybrid bus can be $ 169,000. The cost to change the entire urban buses fleet is cca. 507 million USD. *Operation and maintenance costs* are estimated at 8.5% of the annual cost of investment, or $ 4.3 million for the entire bus fleet. *Cost of GHG reduction* – 4.324 $/ton CO_2. *Technology lifetime* – 10 years. *Other* Source: http://climatetechwiki.org/technology/hev
2	**Liquefied Natural Gas in trucks and cars** /http://climatetechwiki.org/technology/lng/ *General Description* The use of Liquefied Natural Gas (LNG) in transport is a suitable option to power, large long distance trucks in areas where gas is transported as LNG because there are indigenous gas supplies and no gas network. The use of LNG in passenger cars is far less viable because on average passenger cars stand idle more often, which would give rise to high evaporative losses. The use of LNG requires storage facilities for the cold (-162 ^{0}C) liquid natural gas at the roadside refueling stations and special fuelling equipment which can handle cryogenic temperatures. In addition, the trucks must be equipped with special dual fuel engines to be able to use LNG. Moreover, the fuel tank on board of the truck needs to be adapted for LNG usage. These requirements make the use of LNG relatively expensive. Nevertheless, the use of LNG in the transport sector can still have substantial environmental benefits. It has been stated that a truck powered by a dual fuel LNG-diesel engine can emit up to 75% lower NO_x emissions and about 13% lower Well-To-Wheel CO_2 emissions compared to diesel powered trucks. Overall, the technology to use LNG as a transport fuel is well developed. *Implementation* Implementation of this technology will require construction of 24 filling stations countrywide and purchasing the same number of special trucks for LNG transportation. *Implementation barriers* - lack of required infrastructure; - lack of investments. GHG emissions reduction (megatons CO2 equivalent) – 85.5 thousand tons CO_2 in 2030. *Impact on development priorities:* *a) social* - create jobs; - decrease health risks. *b) economic* - decrease for goods shipping costs. *c) environmental* - air quality improvement. *d) other*

	Investments A 2006 study estimates that natural gas can be economically produced and delivered as LNG in a price range of about $2.5-$4.6 per Giga Joule, (Centre for Energy Economics, 2006). The financial benefits of LNG over CNG (compressed natural gas) are mainly lower transportation costs, which makes the LNG technology efficient only in countries with large areas and lack of natural gas network: transportation of CNG / LNG at 100 km - 4.7 / 0.6 $ / GJ, at 400 km - 18.3 / 2.3 $ / GJ. In most cases the LNG is re-gasified in the port and transported further inland via pipelines. However, when the LNG is to be used directly in trucks, it has to be transported via special LNG trailers to the inland refueling sites. According to research in the field, it has been stated that investment costs for infrastructure with a capacity of 2.4 TWh / year (Petterson, 2006) are: production - 1.8 $ / GJ, transportation in special trailers - 0.045 $ / GJ or 385 000 $ / trailer, fuelling station - $ 0.063 / station or 530 000 $ / station. Taking into account the size of the Republic of Moldova, it is estimated that by 2030 energy consumption for goods transportation will be cca.40 thousands TJ, and the market share of this fuel will be 20%. In order to meet these needs, the country will need to have 24 stations countrywide with a total investment of $ 12.7 million and the same number of trailers to transport the fuel, with a total investment of $ 9.2 million. Consequently, the total investment in infrastructure is estimated at $ 22 million. *Operation and maintenance costs* – are estimated at 10% from annual investment costs or $ 0.12 million. *GHG reduction cost* - taking into account the needed investment of $ 22 million, technology lifetime, annual maintenance and operating costs, the GHG reduction cost is $ 273 / ton CO2. *Technology lifetime*: 10 years – for GNL transportation trucks and 40 years – for filling stations. *Other* Source: http://climatetechwiki.org/technology/lng
3	**Regenerative braking in trains** /http://climatetechwiki.org/technology/regenerative_braking_in_trains/ *General description* Employing regenerative braking in trains can lead to substantial CO_2 emission reductions, especially when applied to full stop service commuter trains (8 – 17%) and to very dense suburban network trains (about 30%). Regenerative braking applied to freight trains can also lead to CO_2 emission reductions, albeit considerably lower than for full stop service trains (about 5%). When regenerative braking is employed, the current in the electric motors is reversed, slowing down the train. At the same time, the electro motors generate electricity to be returned to the power distribution system. Regenerative breaking is a mature technology. It can be more easily applied to AC powered trains than to DC powered systems. In DC powered railway systems usually higher investment costs are needed. *Implementation* Regenerative braking is a mature technology. In Europe, from country to country, implementation of this technology differs significantly, however the overall penetration rate is high. Various types of trains can be equipped with regenerative braking: electric trains, hybrid diesel locomotives and subway trains. The more frequently a train stops, the more it can benefit from regenerative breaking. Virtually all locomotives are diesel-electric, so the capacity to do regenerative braking is available. It is assumed that regenerative braking will be applied to 50% of available locomotives in the country, including passengers locomotives and maneuvering in train stations. *Implementation barriers* *GHG emissions reduction (megatons CO_2 equivalent)* – 4.6 thousand tons CO_2 in 2030. *Impact on development priorities:* a) *social and economic* - Contribution by the use of regenerative breaking to socio-economic development is expected to be low. *b) environmental* The effects of regenerative braking on air quality depend mainly on the way the electricity is produced. In

	general, the introduction of regenerative braking on electric trains and subway trains will have no direct effect on the local air quality. However, lowering the electricity demand will lower the emission of air pollutants, like NO_x, SO_2 and particulate matter in power generation, if power generation is based on fossil fuels. For diesel powered locomotives, hybridization can have a positive direct effect on air quality, depending on the usage pattern. Locomotives used solely on a marshalling yard can achieve very high reductions in emissions, due to frequent need for braking. However, the reduction in local air pollution will be limited when the locomotive is used in long-haul freight trains. *c) other* *Investments* - cca.10 thousand USD per train, implementation for 50% of locomotives requires investments of $ 0.76 million. *Operation and maintenance costs* – cost *GHG reduction cost* – 1.856 $/ton CO_2. *Technology lifetime* – 10 years. *Other* Source: http://climatetechwiki.org/technology/regenerative_braking_in_trains

B. Large scale

#	Name and short description of technology
1	**Biodiesel** /http://climatetechwiki.org/technology/biodiesel/ *General description* Biodiesel is used as a diesel substitute, and is generally blended with fossil diesel to various degrees. In Europe, the fuel standard permits only up to 5% biodiesel blend, mainly due to limitations imposed by fuel and vehicle specifications. Using blends over 20% may require some modest vehicle adaptations. Higher biodiesel fuel blends are sometimes used in fleet vehicles (e.g. trucks and buses) (IEA Bioenergy, 2009). Depending on the feedstock and conversion route, we can distinguish 1^{st} and 2^{nd} generation biodiesel 1^{st} generation biodiesel can be produced from various vegetable oils, such as rapeseed, palm, soybean and palm oil and animal fats (Source: climatetechwiki.org). There are various routes to produce 1^{st} generation diesel-type fuels from biomass. Transesterification, the most common route, is a catalytic process where fat or oil is combined with an alcohol (usually methanol). Two important by-products of this conversion route are glycerin and animal feed in the form of press cakes. The alternative route, hydrogenation, a process resembling oil refining, has so far seen limited deployment, although it produces a renewable diesel of superior quality (with higher blending potential) to that obtained via transesterification (IEA Bioenergy, 2009). *Implementation* Transesterification and hydrogenation are technically mature and commercially available 1st generation technologies that produce biodiesel from vegetable oil and animal fats. (IEA Bioenergy, 2009). The bulk of global biodiesel production is in Europe, which accounts for the largest part of the global biodiesel supply (with Germany and France the largest European producers), as a result of past support for domestic bio-fuel production. Implementation of biodiesel production technologies is part of the commitment of the Republic of Moldova to mitigate emissions in transport sector, one of the measures being to accomplish a 20% share of bio-fuel in conventional fuels mix. *Implementation barriers* - Production of biodiesel depends mainly on sufficient provision of economical vegetable oils and animal fats used as feedstock. The production of biomass, is limited by the availability of land and crop yields. Yield improvements require significant investment into fertilizers, mechanization and training of farmers to improve agricultural practices. - The specific properties of biomass: low energy density, often requiring drying and densification; seasonal availability and problematic storage; - Factors limiting the supply: availability and appropriateness of mechanized equipment; and inadequate infrastructure to access conversion facilities and markets. *GHG emissions reduction (megatons CO_2 equivalent)* – 110 thousand tons CO_2 in 2030. *Impact on development priorities:* a) *social* - Job creation in the agriculture and forestry sectors, which is particularly relevant for developing countries with significant unused land resources and a large pool of unskilled workers; - Job creation in the industrial sector (e.g. a 125 million liter ethanol plant would employ cca 270 people (Gnansounou et al., 2005); - Increasing farm incomes: provided the additional income is distributed equitably, increasing the income in the primary sector, which employs the majority of the workforce, can support rural development and significantly improve living standards; - Increasing inclusion in the economic system: well-organized farmers unions can gain access to energy markets.

	b) Economic - Increasing energy security by producing and using bio-fuels locally, thus reducing the dependence on imported fossil oil; - Saving foreign currency by displacing fossil oil imports; - Earning foreign currency by producing bio-fuels for export. - Diversifying the industrial sector. *c) Environmental* - GHG emission reduction: most bio-fuels offer net GHG savings compared to fossil fuels, unless forest land areas are cleared to make way for bio-fuel feedstock plantations. *d) other* *Investments* Depending on the feedstock used and scale of the plant, production costs can differ significantly. Because of lower average costs, larger plants (of capacity greater than 200 million liters per year) have dominated among new installation. Production costs range from roughly \$0.50/l to \$1.60/l, (IEA Bioenergy, 2009). For a plant with a production capacity of 220 million liters / year investment costs are \$ 26.1 million. *Operation and maintenance costs* - are estimated at \$ 0.02 / liter, given the plant capacity of 220 million liters / year, \$ 4.4 million / year. *GHG reduction cost*– 278 \$/ton CO_2. *Technology lifetime* – 50 years. *Other* Source: http://climatetechwiki.org/technology/biodiesel
2	**Bio-ethanol from sugar and starch based crops** /http://climatetechwiki.org/technology/ethanol/ *General description* Liquid bio-fuels for transport have to a certain extent been in use for a very long time. In recent years however, they are enjoying renewed interest in both developed and developing countries as a result of the need to curb rising emissions from the transport sector, reduce dependence on increasingly expensive fossil oil imports and increase farm incomes. An important advantage of bio-fuels is that they can easily be integrated into the existing transport infrastructure, thus avoiding the significant investment costs associated with other renewable options for the transport sector. (Source: climatetechwiki.org). Depending on the feedstock and conversion route, we can distinguish 1st and 2nd generation bio-ethanol. 1st generation bio-ethanol, also known as carbohydrate ethanol, can be produced from sugar or starch based crops. When replacing gasoline in transport, it can lead to substantial reduction in CO2 emission. The main countries producing 1st generation bio-ethanol are the US and Brazil. Bio-ethanol is mixed with gasoline in proportions varying from 5 to 85%. The lower blends are compatible with conventional gasoline engines. Blends above 10% ethanol content are only suitable for use in modified engines. The least complicated way to produce ethanol is to use biomass that contains so-called six-carbon sugars that can be fermented directly to ethanol. If producing ethanol from starch based crops another processing step is required. Production of ethanol from sugars starts by grinding up the feedstock to extract the sugar, which is then added to yeast for the fermentation process. In a closed anaerobic chamber, the yeast secretes enzymes that digest the sugar, yielding several products, including lactic acid, hydrogen, carbon dioxide and ethanol (WWI, 2007). The most common feedstock include sugarcane, sugar beets, sweet sorghum and other sugar containing plants. Producing ethanol from starch-based crops requires another step in the process called saccharification, which entails breaking the large starch molecules into simpler sugars. There are two main methods for refining starches into sugars, primarily differing in the pre-treatment of feedstock. In the “wet milling” process the grains are soaked in water, usually with a sulphurous acid, to separate the starch-rich endosperm from the high-protein germ and high-fiber husks. In addition to ethanol, the process results in a number of high-value co-products,

such as grain oil, gluten feed, germ meal, starches, dextrin and sweeteners. (WWI, 2006) The simpler “dry milling process” entails grinding the unprocessed heterogeneous seed into granules. Compared to wet mills, dry mills are less capital intensive and produce fewer co-products.

Implementation

Production of ethanol through biological fermentation of sugars extracted from sugar and starch crops is a technically mature and commercially available process. Bio-fuels are generally not yet competitive with fossil fuels, therefore many governments around the world offer special incentives for non-fossil based fuels. In Brazil, the successful implementation of ethanol program resulted in bio-ethanol contributing some 50% of fuel consumption in the gasoline market from sugar-cane ethanol (Pelkmans et al., 2009). Similar program is underway and a number of other countries worldwide. Over 50% of global bio-ethanol production is concentrated in the U.S.A.

Implementation of bio-ethanol technologies is part of the commitment of the Republic of Moldova to mitigate emissions in transport sector, one of the measures being to accomplish a 20% share of bio-fuel in conventional fuels mix.

Implementation barriers

- Production of bio-ethanol depends mainly on sufficient provision of economical biomass used as feedstock. The production of 1st generation bio-ethanol is limited by the availability of suitable land and water resources and crop yields.
- The production of bio-ethanol involves moving and storing large amount of feedstock. Therefore a bio-ethanol production plant should be located close to the source of feedstock or in (or very close to) a logistical hub, such as a harbor, if the biomass needs to be imported.
- The specific properties of biomass: low energy density, often requiring drying and densification; seasonal availability and problematic storage requiring further pre-treatment.
- Factors limiting the supply: availability and appropriateness of mechanized equipment; and inadequate infrastructure to access conversion facilities and markets.

GHG emissions reduction (megatons CO_2 equivalent) – 175 thousand tons CO_2 in 2030.

Impact on development priorities:

a) *Social*

- Job creation in the agriculture and forestry sectors, which is particularly relevant for developing countries with significant unused land resources and a large pool of unskilled workers;
- Job creation in the industrial sector (e.g. a 125 million liter ethanol plant would employ cca 270 people (Gnansounou et al., 2005);
- Increasing farm incomes: provided the additional income is distributed equitably, increasing the income in the primary sector, which employs the majority of the workforce, can support rural development and significantly improve living standards;
- Increasing inclusion in the economic system: well-organized farmers unions can gain access to energy markets.

b) *Economic*

- Increasing energy security by producing and using bio-fuels locally, thus reducing the dependence on imported fossil oil;
- Saving foreign currency by displacing fossil oil imports;
- Earning foreign currency by producing bio-fuels for export.
- Diversifying the industrial sector.

c) *Environmental*

- GHG emissions reduction: most bio-fuels offer a net GHG savings compared to fossil fuels, unless forest land area is cleared to make way for bio-fuel feedstock plantations.

d) *other*

Investments

	Depending on the feedstock used and scale of the plant, production costs can differ significantly. Because of lower average costs, larger plants (of capacity greater than 200 million liters per year) have dominated among new installation. Production costs vary from US$0.31/l to US$0.87/l (IEA Bioenergy, 2009). For a plant with a production capacity of 250 million liters / year investment is $ 53.6 million. *Operation and maintenance costs* are estimated at 0,02 $/liter or, taking into account the plant capacity of 250 million liters/year, of $5.0 million /year. *GHG reduction cost* – 334 $/ton CO_2. *Technology lifetime* – 50 years. *Other* Source: http://climatetechwiki.org/technology/ethanol
3	**Bus Rapid Transit systems** /http://climatetechwiki.org/technology/brt/ *General description* A bus rapid transit system (BRT) is a high-capacity transport system with its own right of way, which can be implemented against relatively low cost. It is a key technology in cities in developing countries, which can change the trend of modal shifts towards public transportation, thereby bringing about a range of benefits, including reduced congestion, air pollution and greenhouse gases and better service to poor people. Its main drawback compared to other urban transport systems is its demand for urban space. A BRT system can take in one direction approximately 10-20 thousand passengers per hour and can reach levels up to 40 thousand passengers. This is a much higher value than for conventional buses - 5000 passengers per hour in one direction. A BRT system can run at an average speed of 20 km/hour (Source: climatetechwiki.org). *Implementation* It is assumed that by 2030, BRT systems will be one of the main factors of sustainable urban transport, capturing a share of 25% of all transport needs. This shift to BRT is expected to come from the buses (20%) and cars (80%). It is assumed that the new BRT buses will be powered by diesel engines. *Implementation barriers* - lack of investments; - need for urban space. *GHG emissions reduction megatons CO_2 equivalent)* – 320 thousand tons CO_2 in 2030. *Impact on development priorities:* *a) social* - Social equality and poverty reduction by providing affordable high-quality transport - Reducing the number of accidents – the modal split towards more use of public transport for 25% of passengers would reduce the number of accidents by 20%. b) *economic* - Increase in energy supply security, due to reduction for imported oil - Economic prosperity by reducing travel times and congestion - Improving the balance of payments by reducing imports of fossil fuels. - *c) Environmental* - Reducing air pollution, because if taking into account the number of passengers, buses are less pollutant. A significant reduction of pollution is determined by a 20% reduction in the number of cars - Biodiversity conservation. - *d) other*

	Investments Estimates for investment cost for BRT systems vary widely depending on the required capacity, length of roads to be constructed, the number of stations, type of buses, control systems etc. In case of minor changes in the roads system, the investments range from $1.35 up to $ 3.5 million / km, or can increase to $4.8 - 8.2 million / km. Taking into account the needs of Chisinau, construction of about 50 km of road is needed what will require an investment of $ 2 million / km, or a total of $ 100 million. Taking into account that by 2030 the BRT system will take over 3.8 billion passenger-km, the investment per passenger-km will be $ 0.65 / one thousand passenger-km. Considering the technology lifetime of 40 years, and the required investment, the annual cost of investment is $ 2.5 million. *Operation and maintenance costs* Operation and maintenance costs include fuel consumption and increased management costs. It is assumed that costs will be 20-50% of the annual cost of investment (source: Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007). Accordingly, the costs will be $ 500,000 / year or $ 0.13 / one thousand passenger-km. *GHG reduction costs* **-** Taking into account the annual cost of $ 2.5 million investment + annual maintenance costs of 0.5 million in 2030 annual cost will be $ 3.0 million, reduction of 320 tons by 2030 with the cost of GHG reduction of $ 9.37 USD / ton CO2. *Technology lifetime* – 40 years. *Other* Source: http://climatetechwiki.org/technology/brt
4	**Direct Injection for internal combustion engines /**http://climatetechwiki.org/technology/ice_improvements/ *General description* Direct fuel injection is a technique that allows gasoline and diesel engines to run more fuel efficient, that is, to burn less fuel. Direct injection techniques are already commonly used in modern diesel engines and are becoming more and more established for gasoline engines. Direct injection engines can lower the CO_2 emission of the vehicle by about 15% with low extra costs compared to other techniques leading to similar CO_2 emission reduction. However, still two thirds of all gasoline powered internal combustion engine vehicles which are sold worldwide are equipped with an internal combustion engine with indirect injection. Direct injection in diesel engines leads to small reductions in NO_x and particulate matter emissions which affect local air quality. However, direct injection in gasoline engines can lead to a small, cca. 6% increase of NO_x and particulate emissions(Gable, 2008). Direct injection means injecting fuel, under high pressure, directly into the engine's cylinders (Leonhard, 2008). The direct injection process gives precise control over the timing and the amount of fuel which is injected. This precise control allows the motor management system to only inject relative large amounts of fuel when this is required, for example to accelerate the vehicle. Direct injection modifies the motor's fuel injection system, but does not require any additional changes in car design or transport infrastructure. Direct injection engines need more robust components, because they process fuel at significantly higher pressures than indirect injection systems. The injectors must be able to withstand the higher heat and pressure of combustion inside the cylinder. (source: climatetechwiki.org). *Implementation* Direct injection is fully developed for diesel engines, where it has been used for a considerable time (Bosch, 2004). For gasoline powered cars the technology is not yet widely implemented, although it is already being used in some vehicles. The abbreviation GDI, Gasoline Direct Injection, is commonly used. However, still two thirds of all gasoline powered internal combustion engine vehicles which are sold worldwide are equipped with an IC engine with indirect injection (Leonhard, 2008). It is assumed that by 2030 gasoline powered internal combustion engine will account for 100% of the total number of gasoline powered vehicles, with emissions in compliance with Euro-5 standards (1000 mg / km). *Implementation barriers*

	GHG emissions reduction (megaton CO_2 equivalent) – 177 thousand tons CO_2 in 2030. *Impact on development priorities:* *a) social* *b) economic* - increased energy security of the country; - improved balance of payments. *c) environmental* *d) other* *Investment* Direct injection engines are by about 5% more expensive than a conventional engine. The investments range of several hundreds of dollars, and contribute to reduction of CO_2 emission by up to 15% (Sharpe and Smokers, 2009). For the purpose of analysis an additional investment of $ 1,000 / vehicle was considered, the total purchase price of the car increasing from $ 20-21 thousand. Given the application of this technology to all gasoline powered cars, and given the estimated total number of cars by 2030 is 490,000, the total investment is estimated at $ 10.290 million. *Operation and maintenance costs* – were considered at 10% of the annual investment costs, or $ 300 / year, and given the total number of cars, the cost is $ 147 million. *GHG reduction cost* – 11.35 $/ton CO_2. *Technology lifetime* – 7 years. *Other* Source: http://climatetechwiki.org/technology/ice_improvements
5	**Compressed Natural Gas (CNG) in transport** /http://climatetechwiki.org/technology/cng/ *General description* The use of Compressed Natural Gas (CNG) as a transport fuel is a mature technology and widely used in some parts of the world. Although compressed natural gas is a fossil fuel, it is the cleanest burning fuel at the moment in terms of NO_x and soot (PM) emissions. CNG can be employed to power passenger cars and city busses. CNG passenger vehicles emit 5-10% less CO_2 than comparable gasoline powered passenger vehicles. Generally, there is no benefit over diesel powered cars in terms of CO_2 emission reduction. However, the NO_x and soot emissions of CNG powered vehicles are substantially lower than from diesel powered vehicles. Thus for city busses, often diesel powered, the benefits of CNG lay in the improvement of the local air quality and not in the CO_2 emission reduction. The introduction of CNG in the transport sector provides a good stimulus for biogas. Biogas has the potential to lower the CO_2 emissions by almost 75%. Technically, natural gas vehicles function very similarly to gasoline-powered vehicles with spark-ignited engines. It is possible to retrofit a gasoline powered vehicle with a natural gas tank. However, these vehicles are in general not as fuel efficient as original equipment manufacturer natural gas powered vehicles. In addition, retrofitted vehicles have higher emissions of NOx and soot. Compressed natural gas is also ideally suited for city busses. In Los Angeles, for example, 95% of the city busses employ CNG. *Implementation* Because of the relatively limited driving ranges, it is assumed that technology will be applied only to urban buses, which will enable transporting about 1.118 million passenger-km. *Implementation barriers* - lack of refueling infrastructure with sufficient national coverage. The low penetration of CNG refueling

	stations is caused by the fact that the investment costs for a natural gas refueling station are significantly higher than for liquid fuels. (Roeterdink et al, 2010). These high investment costs slow down the growth of a CNG vehicle park because owners of fuelling stations will only offer CNG when there is a sufficient demand. However, consumers will only purchase such a vehicle when there are sufficient CNG refueling stations. - a relatively short driving range, about ~ 50% shorter than vehicles powered by regular gasoline; *GHG emissions reduction (megatons CO_2 equivalent)* – 11 thousand tons CO_2 in 2030. *Impact on development priorities:* *a) social* *b) economic* *c) environmental* - improved local air quality due to with very low NO_x and soot emissions; *d) other* *Investments* The purchase price of natural gas powered vehicles is in general higher than the purchase price of comparable gasoline and diesel powered vehicles. Depending on the country the additional price ranges from 3 to 30% (International Gas Union, 2009). However, the lower price of CNG will compensate for the extra purchase cost. According to the statistics of the International Association for Natural Gas Vehicles (http://www.iangv.org/tools-resources/statistics.html) by the end of 2010 the Republic of Moldova had 5,000 CNG vehicles (0.95% of total number of vehicles) and 14 CNG stations. Worldwide average share of CNG vehicles is 0.99%, significantly higher rates being recorded in Pakistan (61.14%) and Armenia (32.13%), while Ukraine's share is 2.60 %. Given the implementation of CNG only for urban buses with a capacity of 1.118 million passenger-km, the annual capacity of one bus being 382,000 passenger bus-km, it will be necessary to purchase approx. 3000 CNG buses. The estimated cost of one CNG bus is $ 149,500, and the total investment - $ 448.5 million. *Operation and maintenance costs*– were estimated at 10% of the annual investment cost, which is 1.5 thousand $/year per one bus, or $4.5 million for the total number of 3 000 buses. *GHG reduction costs*– 4.771 $/ton CO_2. *Technology lifetime*– 10 years. *Other* Source: http://climatetechwiki.org/technology/cng
6	**Electronic Road Pricing** /http://climatetechwiki.org/technology/erp http://www.slocat.net/wp-content/uploads/2009/11/TRL-Jakarta-final-report.pdf/ *General description* Road pricing is an effective economic instrument to reduce congestion, and to limit the growth in private vehicle travel demand. It has been successfully implemented in cities such as Singapore and London, resulting in substantial improvements in the urban environment and transport system. The largest barrier for electronic road pricing (ERP) is public opposition by car users. However acceptance often increases after implementation. Important success factors are clear communication of the benefits to society and complementary policies regarding public transport and parking. Road pricing is an economic instrument that applies direct charges for the use of roads. It can serve three purposes: 1) as a tax to manage travel demand, 2) as an incentive to guide more efficient investment decisions, and 3) as a source of public revenues, e.g. to finance roads and public transport (Lindsay, 2009). Road pricing can be implemented in several ways, including (VTPI, 2010): • Road tolls: a (usually fixed) fee paid for driving on a particular road

- Congestion pricing: a variable fee depending on the level of congestion in a certain area
- Cordon fees: a fee applied to a certain area, e.g. an urban centre
- Distance-based fees: a vehicle fee based on the number of kilometers travelled

Toll booths or vehicle passes are common methods to collect the road fees, and have been used for decades in countries around the globe. A strong drawback is the inconvenience to the user, as the vehicle has to stop for paying the fee, possibly adding to congestion. Electronic road pricing (ERP) aims to minimize the inconvenience to the user, as well as providing flexibility as to the level of the charges. ERP methods include (VTPI, 2010):

- Electronic tolling, which bills a charges to users when passing a point on the road;
- Optical vehicle recognition, which uses an optical system to bill the user;
- GPS, which tracks the location of vehicles and bills based on the distance driven.

Implementation

Electronic road pricing, that uses electronic or optical tolling, is a mature technology. It has been successfully implemented in cities such as Singapore, London and Stockholm, and for highways, e.g. in Canada and the US (VPTI, 2010). Several countries in the developed and developing world, including Indonesia and the Netherlands, are considering ERP.

Implementation barriers

- The largest barrier for ERP is probably political and public acceptance, particularly before implementation (Gehlert et al, 2008);
- In general vehicle users are considering themselves worse off when charged for something previously perceived as being free of charge;
- In addition, there may be a general distrust in government agencies resulting in a fear that the instrument only serves to increase public revenues (VPTI, 2010);
- A referendum may be needed to decide about ERP application (for example, Stockholm, Harsman and Quigly, 2010);
- Lack of investments to implement ERP technology;
- Additional investments in public transport and non-motorized transport infrastructure are needed to absorb the increasing number of passengers (use of public ERP revenues for public and non-motorized transport);
- Implement a flexible and convenient payments collecting system.

GHG emissions reduction (megatons CO_2 equivalent) – 97 thousand tons CO_2 by 2030.

ERP contributes to reduction of traffic congestion by 13-30% and of GHG emissions by 15-20% (Source: Pike, E. (2010) Congestion pricing. Challenges and opportunities. The International Council for Clean Transportation. April 2010).

Impact on development priorities (Pike, 2010; VPTI, 2010):

a) Social

- congestion reduction, i.e. travel time savings;
- increased road safety due to less road accidents;

b) economic

- increased energy security of the country;
- improved balance of payments.

c) environmental

- improved air quality (CO, NOx, SOx and particulate matter)
- reduced noise.

d) other

In order to move to a more sustainable transport system, a combination of strategies is required, also called the Avoid-Shift-Improve approach, which 1) avoids or reduces the need for unnecessary travel (Transport Demand Management), 2) shifts private vehicle use to more sustainable modes, and 3) improves the environmental performance of modes. ERP is considered an important and effective instrument in the ‘Avoid’ strategy, i.e. limiting the growth in travel demand, while also contributing to a modal shift.

	Vehicle use has been shown to be rather sensitive to tolls, with price elasticity from -0.1 to -0.4 for urban highways, i.e. a price increase of 10% results in a 1-4% automobile use reduction. The impact is however highly case specific, and may depend on many factors such as the type of toll, the availability of alternatives and on consumer preferences. Estimates for impacts of road pricing on vehicle trips vary widely, from 3% to 15% (VPTI, 2010; Dalkmann, 1010). However even if total travel demand was affected only to a limited extent, road pricing could significantly reduce congestion if only a small share of total traffic shifted from peak to off-peak hours with estimates for several cities in the range of 10% to more than 30% (VPTI, 2010; Pike, 2010). In Singapore, the ERP has decreased road traffic by 25,000 vehicles in peak hours, and increased average road speeds by 20%. Bus travel and car-pooling also increased. *Investment* The ERP payback time is less than 5 years (Dalkmann, H. (2010) Case study of a transport MRV NAMA: TDM Measures in Jakarta, Indonesia. Applicability of Post 2012 Climate Instruments to the Transport Sector (CITS) Project). According to research made, the investment in an ERP system are estimated at $ 130 million (Pike, E. (2010) Congestion pricing. Challenges and Opportunities. International Council for Clean Transportation). *Operation and maintenance costs*– operation and maintenance costs were estimated at 25% of the initial investment or $32.5 million /year (Pike, E. (2010) Congestion pricing. Challenges and opportunities. International Council for Clean Transportation). *GHG reduction costs*– 370 $/ton CO_2. *Technology lifetime*– 40 years. *Other* Source: http://climatetechwiki.org/technology/erp http://www.slocat.net/wp-content/uploads/2009/11/TRL-Jakarta-final-report.pdf
7	**Liquefied Petroleum Gas (LPG) in transport /**http://climatetechwiki.org/technology/lpg/ *General description* Liquefied Petrol Gas (LPG) is a widely used alternative fuel. It has substantial reserves due to its dual origins from natural gas processing and crude oil refining. Liquefied Petrol Gas (LPG) powered passenger cars have about 10% lower tailpipe CO_2 emission than comparable gasoline powered cars. When compared to a diesel car, there is no significant CO_2 emission reduction per km driven; however, LPG powered vehicles do have substantially lower NO_x emissions than diesel powered vehicles. Liquefied Petroleum Gas (LPG) is a liquefied mixture of propane and butane. It is an inevitable side product of the crude oil refining process and of natural gas processing. LPG can be used as an alternative fuel in vehicles, and may lead to lower vehicle maintenance costs, lower emissions, and fuel costs savings compared to conventional gasoline and diesel. An important difference between LPG and conventional vehicles is the method of fuel storage. LPG is gaseous at room temperature and a pressurized storage tank is required at the fuelling station as well as in the vehicle. In the vehicle, liquid LPG is converted to vapor in the vehicle’s engine. The vapor is then mixed with filtered air before it enters the combustion chamber where it is burned to produce the energy to propel the vehicle. There are also liquid propane injection engines, which do not depend on vaporizing the LPG, but instead burn the liquid fuel (US DOE, 2010). *Implementation* LPG can be used in dedicated LPG vehicles or in vehicles converted from gasoline use. The availability of dedicated LPG models is limited, and most LPG powered passenger vehicles have a modified combustion engine. Such converted vehicles normally operate in bi-fuel mode, using either LPG or regular gasoline. The advantage of a bi-fuel vehicle is that the car owner is less dependent on a LPG refueling infrastructure with

sufficient coverage. In areas, where LPG is not available, regular gasoline can be used. A drawback of the bi-fuel vehicle is that two fuelling tanks need to be available, lowering the available space in the vehicle. Usually, to save space in the trunk of the vehicle LPG tank is located where normally the spare tire is stored.

LPG also has a lower energy density than gasoline, and therefore requires more storage volume for an equivalent drive range.

The safety risks of LPG is higher than of other fuels, although LPG liquefies at moderate pressures In Europe, the number of accidents with LPG is very low, however, the effect of an accident may be large. In the past, most accidents have happened during the transport of LPG. These safety problems make it generally necessary to locate an LPG fuelling station well outside an urban location.

The use of LPG as a transport fuel is a well developed technology, and LPG is a widely used alternative fuel. According to an industry organization, the European LPG Association (AEGPL), there are more than 7 million LPG powered vehicles in Europe, and LPG accounts for about 2% of the fuel mix of passenger cars in Europe(AEGPL, 2009). AEGPL (2009) also estimates that LPG could account for 10% of Europe's passenger car fuel mix by 2020. The most developed LPG market is in South Korea, with more than 2 million LPG vehicles. In 2007, more than 13 million vehicles were powered by LPG worldwide (AEGPL, 2009s).

Implementation barriers

- Lack of a well developed LPG fuelling infrastructure.

GHG emissions reduction (megatons CO_2 equivalent) – 106 thousand tons CO_2 in 2030.

Impact on development priorities:

a) *social*

b) *economic*

- Lower maintenance costs and a longer engine life-time (the higher octane rating, the less pollution).
- Using LPG may also increase energy security as it diversifis the country's fossil fuel sources.

c) *environmental*

- Improved local air quality (lower NO_x emissions).

d) *other*

Investments

The initial infrastructure costs required to expand the sales of LPG in the transport sector, are mainly determined by the investment costs of the LPG refueling infrastructure.

In Europe the purchase cost for an LPG vehicle is estimated to be € 1.500 to € 2.500 higher than for a comparable fossil fuel powered car (Roeterdink et al, 2010). However, fuel costs are considerably lower . At present, the price of LPG in the country is 1.9 times lower than the price of gasoline or diesel oil. Much of this difference in fuel prices is due to lower taxes for LPG. Given the budgetary fiscal policy for 2012 of the Republic of Moldova, LPG will become less attractive, as the final price difference to petrol and diesel was reduced to 1.5 - 1.6 times.

Depending on the (road) tax regimes for LPG vehicles and on fuel prices, the financial breakeven point for the initial additional investment for an LPG vehicle mostly lies within several years.

An additional investment of \$ 2.025 thousand (1,500 Euro × 1.35 USD / Euro) was taken into account for calculations for LPG powered car, the total cost of such a vehicle amounting to \$ 22,000.

An additional investment of \$ 1,000 / vehicle was considered for analysis purposes, the total price of purchasing a car increasing from \$ 20 000 to 21 000. Given the application of this technology for all gasoline powered cars, by 2030 the estimated total number of cars will be 490,000, while the total investment is estimated at \$ 10,792,000.

Operation and maintenance costs–were considered at 10% of annual investment costs or \$ 315 / year and for the total number of cars these costs amount to \$ 154 million.

	GHG reduction costs– 18.275 $/ton CO_2. *Technology lifetime*– 7 years. *Other* Source: http://climatetechwiki.org/technology/lpg
8	**Modal shift in freight transport /**http://climatetechwiki.org/technology/modal/ *General description* The demand for freight transport is strongly coupled to economic activity, and in many countries growth of demand outstrips GPD growth (Essen, 2009). Freight can be transported by several modes, including road, rail, water, air, pipeline and non-motorised. In 2005, the freight transport sector was responsible for 2.8 GtCO2-eq including international shipping (IEA, 2009). Looking at modal shift between different modes of transport, one has to consider that, to a certain extent the different transportation modes serve different transport markets. The average distance for cargo travelling by ship is much larger than for road and rail, while the value per ton of cargo can be a order of magnitude lower (NTC, 2010; Mao, 2009). The preference for road transport for certain goods can also be explained by the need to be flexible and the trend towards 'delivery on demand'. However, due to the environmental and social benefits of rail and water-based transport compared to road, many countries are adopting policies to induce a modal shift. For example the EU is prioritizing 'motorways of the sea' and international freight rail connections (DG-TREN, 2009). *Implementation* The modal split in freight transport varies greatly by region. In North America, China, India and the former Soviet Union, large countries moving large amounts of raw materials, the majority of transport (measured in ton-kilometers) takes place by rail, while in most other regions its share is relatively modest (IEA, 2009). In the EU and Japan water-borne freight has a comparable share to road, (Larsson, 2009; Mao, 2009). *Implementation barriers* One of the basic barriers for a modal shift is the lack of direct access of companies to the railway network or to waterways. Thus, direct train or ship services are rare. Pre- and post-haulage by truck is needed to provide a door to door freight transport service. This is also called multi-modal or combined transport, and access to multimodal terminals and their connections to other terminals. Besides, the access to terminals, other supply side indicators like the trip duration, reliability, flexibility or transport prices are also relevant for the mode choice decision. In general a modal shift towards water borne - and railway transport gives rise to longer transport times and thus the necessity of bigger local stocks. In addition, the need for pre- and post-haulage for water borne- and railway transport can lower the environmental benefit of these transport modes, depending on the distance over which the road transport has to take place. In addition, freight rail can face a significant set of capacity problems and so rail has only a limited ability to expand market share. Another important financial barrier for modal shift is the high investment required for (rail) infrastructure and intermodal facilities (NTC, 2008). *GHG emissions reduction (megatons CO_2 equivalent)* Freight traffic modeling in Belgium revealed an energy consumption decrease of 23-25% (Belgium, SUA). *Impact on development priorities:*

	a) social - Improved traffic safety; - Reduced congestion; *b) economic* - Reduced expenditures for maintenance and repairs of road infrastructure (VTPI, 2010); - Increased energy security by decreasing dependence on fossil fuels import; - Improved balance of payments. *c) environmental* - Improved local air quality through lower emissions of NOx and particulate matter; - Reduce noise; - Conservation of biodiversity by reducing the land areas needed for road transport. *d) Other* *Investments* – no data available. Water and rail transport are often competitive with road-based transport and net benefits for society would accrue (VTIP, 2010; Walker et al., 1999). *Operation and maintenance costs*– no data available. *GHG reduction costs*- less than 100 $/ton CO_2 (Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007). *Technology lifetime*– no data available. *Other* Source: http://climatetechwiki.org/technology/modal
9	**Non-motorized Transport** /http://climatetechwiki.org/technology/nmt http://www.vtpi.org/tdm/tdm25.htm/ *General description* Non-motorized Transportation (also known as active transportation and human powered transportation) includes walking and bicycling, and variants such as small-wheeled transport (cycle rickshaws, skates, skateboards, push scooters and hand carts) and wheelchair travel. These modes provide both recreation and transportation (VTPI, 2010; gTKP, 2010), and are especially important for short trips up to 7 km, which take up the largest share of trips in urban areas (Witting et al., 2006). NMT can be stimulated by a policy package consisting of investments in facilities, awareness campaigns, smart urban planning, improved public transport and disincentives for the use of motorized private vehicles. Specific ways to improve non motorized transportation are, inter alia (VPTI, 2010; Litman, 2009): Improve sidewalks, crosswalks, paths, bicycle lanes and networks; public bicycle systems (automated bicycle rental systems designed to provide efficient mobility for short, utilitarian urban trips); develop pedestrian oriented land use and building design; increase road and path connectivity, with special non motorized shortcuts; traffic calming, streetscape improvements, traffic speed reductions, vehicle restrictions and road space reallocation; safety education, law enforcement and encouragement programs; bicycle parking; bicycle integration in transit systems (e.g. racks in metro or on bus); address security concerns of pedestrians and cyclists; congestion pricing; vehicle parking policies; fuel taxes. *Implementation* In many developing countries, NMT takes a larger share of trips than in developed countries. However the reverse is often true for the trends: modal shares of walking and cycling decreases in developing countries, and slowly rises in the developed world. Modal splits are highly country and city-specific, with NMT shares between 10% and 66% for different Western-European cities, and cycling in urban areas varying between 1% (USA) and 27% (The Netherlands) of total trips (VTPI, 2010).

NMT is mostly used for short-distance trips, with cycling particularly relevant up to 7.5 km, and walking up to 2.5 km. As up to 70% of cars trips cover less than 5 km, NMT has a large potential to replace car travel (IPCC, 2007). Several studies have shown that 5-10% of car trips can be replaced by NMT provided good policies are in place (Mackett 2000).

One of the key parameters is urban density. Most cities in developing countries are high-density and therefore very suitable for NMT-oriented policies.
However, the extent to which NMT is used has little to do with the welfare of the country and mostly depend on the country's further development direction (Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007). If the country is committed to promote walking and cycling, designing and developing urban areas accordingly, higher rates in the use of NMT can be achieved.

Given the density of population in Chisinau (54 persons / ha) and size of similar projects successfully implemented in European cities (for example, Amsterdam with density of population of 58 persons / ha and a certain share of non-motorized transport), such project has the implementation potential in the city with TNM area of cca.5 km long.

Implementation barriers

Increasing the modal share of NMT is possible in any country; however the successfulness depends on many country-specific factors, including climate, geography, culture, political commitment, public awareness, policy effort and consistency, long-term vision and the attractiveness of the alternatives.

The main barriers towards implementing a successful NMT policy are (based on ICE (2000):

- Private-vehicle-oriented transport and spatial planning, which is business-as-usual in most countries, particularly developing.;
- Public perception and status: walking, cycling and public transport is perceived as the transportation mode for the poor. The richer part of the population often has a disproportionate decision power, which makes NMT-focused policy risky.
- Safety: pedestrians and particularly cyclist are vulnerable, and therefore need separate road space, or at least be respected and taken note of by vehicle users. Lack of social safety, especially for females can also be a barrier. NMT users have a higher risk of being involved in accidents than car users, particularly in developing countries (IPCC, 2007);
- Lack of convenient public transport, which is required to make NMT a good option for multi-modal trip (i.e. the combination of cycling and rapid bus or rail systems);
- Chicken-and-egg problem: people don't start cycling if there are few cycle lanes, and planners don't build these when there is no interest in cycling;
- Lack of overall long-term, integrated vision and planning;
- High costs for bicycles, including taxes, in particular in developing countries.

GHG emissions reduction (megatons CO_2 equivalent) – 4.2 thousand tons CO_2 in 2030.

Impact on development priorities:

a) social

- congestion reduction;
- health benefits due to exercise. For example, cycling for 30 minutes a day reduces the chance of cardiovascular diseases and diabetes by 50% (Witting et al., 2006);
- social equality and poverty reduction: cheap, fast and reliable transport opportunities, and public space development directed towards all segments of society (ICE, 2000);
- safety: increase in bicycle use is often accompanied by a reduction in cycling accidents and an increase in safety in public areas (Vanderbulcke et al., 2009; Witting et al., 2006);
- noise reduction.

	b) Economic - NMT, particularly cycling, is easy, flexible, cheap and fast - More attractive cities for tourists and residents, particularly if car-free zones are included - Reduced travel times due to improved traffic flow - Energy security due to lower vehicle energy use - Decreased demand for road space. *c) Environmental* - Air quality improvement - GHG emission reduction - By decreasing demand for road space and reducing the average travelling distance, cycling contributes to urban planning. *d) other* *Investments* The cost of bicycle paths, including construction, maintenance and awareness campaigns, has been estimated at being $ 200,000 per km (Wittink & Godefrooij, 2009). Implementing a 5 km bicycle lane project in the center of Chisinau would require an investment of $1 million. *Operation and maintenance costs* Such costs were estimated at 20% of the annual investment cost or $5 thousand /year. *GHG reduction cost* The costs for increasing bicycle modal share by 1-10% have been estimated at 14 $/tCO_2$, and a policy package covering bus rapid transit system, cycle lanes and pedestrian upgrades at 30 $/tCO_2$ (IPCC, 2007). *Technology lifetime*– 40 years. *Other* Source: http://climatetechwiki.org/technology/nmt http://www.vtpi.org/tdm/tdm25.htm

Medium and long term technologies

C. Small scale

#	Name and short description of technology
1	**Electric vehicles** /http://climatetechwiki.org/technology/electric-vehicles/ *General description* Electric vehicles are about 2.5 times more energy efficient than their counterparts which are powered solely by internal combustion engines. This high energy efficiency is the main reason why electric vehicles can contribute to lower the CO_2 emission and energy consumption of traffic substantially. Electric vehicles have zero tailpipe exhaust emissions and thus contribute substantially to a better air quality. Additionally, electric vehicles are inherently silent and can help to reduce the noise levels in cities. However, the market share of electric vehicles is currently still very small and consists mainly of small vehicles intended for urban transport. Purchase costs of electric vehicles are high compared to similar sized ICE vehicles. These high purchase costs are predominantly caused by the high costs of the battery pack needed in the vehicle. Moreover a recharging network with sufficient coverage is not yet available in most countries. Electric vehicles are propelled solely by electric motors. There are three main types of electric vehicles: • Battery electric vehicles • Series Hybrid vehicles (see also description of Hybrid Electric Vehicles) • Hydrogen Fuel cell vehicles. (see also description of fuel cells for mobile applications). The Battery Electric Vehicle does not have an internal generator to produce electricity, all the electricity has to be obtained from the power grid. Examples are the Citroen EVie, Mitsubishi iMiev and the Think (van Agt, 2010). The Chinese company BYD is planning to produce 100 electric cars in 2010, with the aim of using them as taxis in Shenzhen, where BYD is located. (Bloomberg News, 2010) The Series Hybrid vehicle can obtain its electricity from the power grid but has additionally a small internal combustion engine which serves as a generator to recharge the battery and offers an extended driving range. The combustion engine does not directly propel the vehicle. Examples are the Opel Ampera, GM Volt and the Volvo Recharge. The third group of electric vehicles are hydrogen fuel cell vehicles. These vehicles can also obtain their electricity from the power grid but in addition, the fuel cell can serve as a generator to recharge the battery, which also extends the driving range. Examples are the Honda Clarity and the Toyota FCHV. *Implementation* The market share of battery electric vehicles is still very limited and comprises mainly of small vehicles intended for urban transport (van Agt, 2010). Moreover, the purchase costs for electric vehicles are still relatively high due to the high costs of the required battery pack. To lower the purchase costs of the vehicle only relatively small battery packs are installed, limiting the driving range, which makes electric vehicles currently only suitable for urban transport. Nevertheless, the technology used in electric cars is largely proven and a breakthrough can be expected when the costs and weight of the battery pack are lowered sufficiently. Given the distances the electric vehicles can travel and use of electric vehicles for urban areas only the estimated market share for such transport can be 30% of the total number of cars, which by 2030will be cca.264, 6000 cars. *Implementation barriers* The main barriers for a wider user of electric vehicles are related to the batteries and to the recharging infrastructure: - batteries for use in electric cars are still expensive and have relatively limited driving ranges. Most existing EV need to be recharged after maximum 150 to 300 km.. - completely recharging the batteries may take 4 to 8 hours. (US Department of Energy, 2010b) - the widespread use of electric vehicles requires an extensive recharging infrastructure. The absence of

	this infrastructure may lead to reluctance to buy electric vehicles. - Lack of standards regarding the cords and connectors used for recharging (Markel, 2010). *GHG emissions reduction (megatons CO_2 equivalent)* - 396 thousand tons CO_2 in 2030. The energy efficiency of electric cars is about 2.5 times better than their fossil fuel counterparts, which is the main reason why electric cars can lower the greenhouse gas emissions of road traffic and reduce the demand for oil. The actual greenhouse gas emission associated with the use of battery electric vehicles depends largely on the way the required electricity has been produced. Employing coal fired electricity plants to generate the electricity will marginally lower the CO_2 emissions. However, using renewable electricity will lower the greenhouse gas emissions considerably. Electric vehicles might even provide a way to make the electricity sector more sustainable, if the batteries in the vehicles could be used to store the variable output of wind and solar-based power generation (Nieuwenhout et al, 2009). *Impact on development priorities:* *a) social* *b) economic* - improve energy security, as electric vehicles are more efficient; - improve balance of payments by reducing imports of fossil fuels. *c) environmental* - substantially improve local air quality, especially in urban areas, as electric vehicles have no tail-pipe emission of air pollutants such as NO_x and soot. The global improvement of the air quality however, is determined by the way the electricity used is produced; - reduce noise. *d) other* *Investments* The high cost of an electric vehicle over the conventional alternative is mainly determined by the costs of the lithium ion battery pack. Recent developments in lithium-ion batteries make it likely that these additional costs can be reduced from the current level of about €15,000 in prototypes to an expected level of around €3,000 in 2020. This requires the battery to be about €200-250 per kWh (Nieuwenhout et al, 2009). The 2007 prices for high energy batteries range from €800/kWh to €1000/kWh (Pesaran et al, 2009). The medium term cost goals of these batteries are €500/kWh in 2012 and €300/kWh in 2016. BYD's first commercial electric car, the E6 model, is expected to be available for sale in the US for 40'000 USD in 2010. (People's Daily Online, 2010) In addition, there is a need for investment into the recharging infrastructure. This infrastructure needs to be standardized in a way that every brand of electric vehicle can recharge at every recharging station. A simple recharging point at a private house or at an office site costs about $ 1800,-. However, a public recharging station, with the necessary electronics to make contact with the bank is estimated to cost about $ 18.000,-. (Roeterdink, 2010). Assuming the application of this technology for 30% of cars or cca.265 thousand units at a price of $ 40,000 per vehicle and construction of 50 public recharging stations, the total investment will be $ 10.6 million. *Operation and maintenance costs*– estimated at 10% of the annual investment cost of $ 1.1 million. *GHG reduction costs*– 6.825 $/ton CO_2. *Technology lifetime*– 7 years. *Other* Source: http://climatetechwiki.org/technology/electric-vehicles
2	**Fuel cells for mobile applications** /http://climatetechwiki.org/technology/mobile-fuel-cells/ *General description* Fuel cells are used to produce electricity. They are considered a promising technology to replace conventional

combustion engines in vehicles. Fuel cells may also replace batteries in portable electronic equipment. The most widely used types of fuel cells for mobile devices are Proton Exchange Membrane fuel cells (PEM FC). PEM fuel cells use hydrogen or certain alcohols such as methanol as fuel.

Fuel cells are used to produce electricity and are more advanced and energy-efficient technologies than combustion engines, which burn the fuel. Fuel cells operate according to the principle of electrochemical reactions and therefore they function completely different than combustion engines.

Implementation

Several car manufacturers were planning the deployment of PEMFC vehicle fleets planning to launch fuel cell vehicles in 2012-2020 (Crawley, 2006). However, as electric and hybrids vehicles have been receiving more attention in the last couple of years, it is possible that some of the PEMFC plans announced by car manufacturers have been postponed.

Implementation barriers

The main obstacle to widely implement fuel cell technology is high cost.

Infrastructure availability is another important prerequisite for the use of PEM fuel cells in transport applications. PEM fuel cells require high purity hydrogen which is not available everywhere.

GHG emissions reduction (megatons CO_2 equivalent) – data not available.

PEM fuel cells are more efficient than internal combustion engines. However, overall CO2 balance will depend depends largely on the way the required hydrogen has been produced.

Impact on development priorities:

a) social

b) economic

- increase energy security of the country;
- improve balance of payments by reducing imports of fossil fuels.

c) environmental

An important benefit of using PEM fuel cells in transport applications would be the fact that fuel cell powered vehicles do not emit any local air pollutants, such as NOx, CO or particulate matter. This would improve local air quality, especially in cities. PEMFCs also do not emit significant noise during operation.

d) other

Investments – data not available.

Investment costs per kW for PEMFC and DMFC systems are higher than for other types of fuel cells (Business Insights, 2009) – on average by 100 USD/kW.

One of the reasons is the expensive materials used in PEMFC and DMFC systems such as platinum and ruthenium. Moreover, transport applications and portable items require small systems, hence the fuel cell systems needs to be miniaturized. The latter leads to higher costs for the tubes, compressors, controllers, etc. which are used to connect the system with the fuel supply and exhaust gas tubes (Schoots et al. 2010).

The cost of fuel cell systems must be further reduced before fuel cells become competitive with conventional technologies (internal combustion engine costs about $25–$35/kW).

Operation and maintenance costs– data not available

GHG reduction costs– data not available.

Technology lifetime– data not available.

Other

Source: http://climatetechwiki.org/technology/mobile-fuel-cells

D. Large scale

#	Name and short description of technology
1	**Plug in Hybrid Electric Vehicles /**http://climatetechwiki.org/technology/phev/ *General description* A plug in hybrid electric vehicle (PHEV) is a hybrid electric vehicle with the ability to recharge its energy storage with electricity from an off-board power source such as a grid. (Pesaran et.al, 2009) The PHEV can run either on its Internal Combustion Engine (ICE) or on its battery. A full electric vehicle uses its energy far more efficiently than a vehicle with an Internal Combustion Engine (ICE) and can drive about 2.5 times further with the same energy. For this reason it is expected that the electric vehicle will replace the ICE vehicle in the long run. However, in the coming 20 years or so vehicles will probably still be equipped with IC engines, possibly in combination with electric engines, because per unit of weight an ICE vehicle can still drive about 40 times further. In this 20 year period the IC engine is expected to improve substantially (Sharpe et al. 2009). The key advantage of PHEV technology relative to full Battery Electric Vehicles (BEV) is the fuel flexibility. PHEVs have no limitation of the driving range and if the recharging infrastructure is spatially or temporally unavailable, it doesn't restrict the use of the vehicle. A possible drawback of the PHEV is that it contains two systems to propel the vehicle, making it more costly to build than a BEV. However, the car manufacturing industry expects that PHEVs will be introduced to the market first, and that the switch to BEV could be made when the PHEVs are found to be economically and technological viable. (Gilijamse,2009). *Implementation* Plug-in hybrid vehicles (PHEVs) have the potential to displace a significant amount of fuel in the next 10 to 20 years. The main barriers to the commercialization of PHEVs are the cost, weight, safety, volume and lifespan of the batteries. It is expected that more and more car manufactures will bring plug in vehicles to the market in the coming years. *Implementation barriers* - high costs of the vehicles; - lack of recharging infrastructure; - lack of standards for vehicles recharging equipment; *GHG emissions reduction (megatons CO_2 equivalent)* – 428 thousand tons CO_2 in 2030. Studies estimate that a PHEV with usable electrical energy storage equivalent to 30 kilometers of electric travel would reduce fuel consumption by 36 - 45% relative to that of a comparable combustion engine vehicle assuming that the PHEV drives in full electric mode in the city and as a hybrid on rural roads and on the highway (Pesaran et al. 2009, CalCars, 2009). The final CO_2 emission reduction depends strongly on the source of the electricity used. *Impact on development priorities:* *a) social* *b) economic* - increase energy security of the country; - improve balance of payments by reducing imports of fossil fuels. *c) environmental* - improve local air quality due to low NOx emissions and particulate matter; - reduce noise. *d) other* *Investments* The hybridization of the vehicle adds about US$ 4000 to the manufacturer's cost. (Sharpe, 2009) Additionally

	PHEVs require a bigger battery which adds extra to the costs. The price of the battery system price is about $1700 for a 15 kilometer battery and about $3400 for a 60 kilometer battery. This brings the additional cost of a PHEV to $ 5700 to $ 7400 compared to a conventional vehicle with an internal combustion engine. However, the costs of the lithium ion battery are expected to decrease in the near future by 1/3 by 2016. A big advantage of VEHC is that fuel costs compared are lower compared to internal combustion vehicles. In addition, there is a need for investment into the recharging infrastructure. This infrastructure needs to be standardized in a way that every brand of Plug-in Hybrid Electric Vehicle can recharge at every recharging station. A simple recharging point at a private house or at an office costs about $ 1800. However, a public recharging station, with the necessary electronics to make contact with the bank costs about $ 18.000. (Roeterdink, 2010). Given the cost of a traditional internal combustion vehicle of $ 20,000 and additional costs of cca. $6, 5000 related to a VEHC vehicle, the total cost of a VEHC vehicle amounts to 26,500 $. *Operation and maintenance costs*– estimated at 10% of the annual purchasing cost of a VEHC vehicle, or $2700 / year. *GHG reduction costs*– 5.132 $/ton CO_2. *Technology lifetime*– 7 years *Other* Source: http://climatetechwiki.org/technology/phev
2	**Transport management systems** /http://climatetechwiki.org/technology/transport-management/ *General description* Intelligent Transport Systems (ITS) apply information and communication technologies to vehicles and to transport infrastructure. This may increase the reliability, safety, efficiency and quality of transport systems. ITS has a supporting role for the successful implementation of transport emission reduction strategies such as low-carbon fuels, energy efficient vehicles, public and non-motorized transport, mostly by supporting a more efficient organization of the transport system. ITS can be applied to both passenger and freight transport and all modes. Examples of ITS include electronic road pricing, online travel information, vehicle-to-vehicle communication, computerized traffic signaling and automatic and eco-driver assistance. Automatic driver assistance could for example inform the driver about the ideal speed to pass the next green traffic light, whilst eco-driving systems inform the driver whether he is driving in the most fuel-efficient manner and how he can improve his driving style. *Implementation* The UK Department for Transport strategy includes the following objectives for ITS (DfT, 2005): • Improving road network management, including road pricing. • Improving road safety, by reducing collisions, casualties and deaths. • Better travel and traveler information, helping to match supply and demand by providing better information so that travelers can make informed choices on when and how to travel. • Better public transport on the roads, supporting more reliable, more accessible, safer and more efficient services. • Supporting the efficiency of the road freight industry. • Reducing negative environmental impacts. • Supporting security, crime reduction and emergency planning measures. *Implementation barriers* • High initial investments and chicken-and-egg problem, i.e. decision makers only recognize the need for investments once they experience the benefits of a fully functional ITS system.

	• Complex implementation process due to roll-out to large numbers of end-users • Technological complexity • Uncertainty regarding costs, benefits and public acceptance • Protection of privacy, security and legal issues • High data requirement for ITS operations *GHG emissions reduction (megatons CO_2 equivalent)* – data not available. A recent study has shown that several in-vehicle or infrastructure ICT applications can lead to significant reductions in CO_2 emissions (Klunder et al., 2009), *Impact on development priorities:* *a) Social* - Reduce traveling times; - Congestion relief; - Road safety improvement. *b) Economic* - Increased transport efficiency; - Increased energy security; - improved balance of payments. *c) environmental* - Efficient use of lands; - Improved local air quality. *d) other* *Investments*– data not available. Costs for the various ITS applications may include: • Investments in infrastructure, e.g. toll gantries, traffic detectors, road-side information displays and communication systems • Investments in vehicles, such as on-board electronic meters, GPS systems • Investments in travel time information systems • Policy implementation, including awareness campaigns • Operation and maintenance of the systems *Operation and maintenance costs*– data not available. *GHG reduction costs*– data not available. *Technology lifetime*– data not available. *Other* Source: http://climatetechwiki.org/technology/transport-management
3	**Hydrogen technologies** /http://climatetechwiki.org/technology/hydrogen/ *General description* Hydrogen is considered an important fuel for future use in transportation, central and distributed electric power, portable power and combined heat and power for industrial development. The plethora of sources for hydrogen

production, along with the variety of methods to extract it, makes hydrogen a very promising fuel. The introduction of hydrogen can be feasible in both industrialized and developing countries.

Chemically bound hydrogen is found everywhere on Earth: in water, fossil fuels and all living things. Yet, it rarely exists free floating in nature. Instead, it has to be extracted from water or from hydrocarbons. Hydrogen can mainly be produced from water or fossil fuels.

Today, nearly half the hydrogen produced in the world is derived from natural gas via a steam reforming process. The natural gas reacts with steam in a catalytic converter. The process strips away the hydrogen atoms, leaving carbon dioxide as the byproduct (and, unfortunately, releasing it to the atmosphere as a global warming gas). Coal can also be reformed through gasification to produce hydrogen, but this is more expensive than using natural gas. Hydrogen can mainly be produced from water through electrolysis or from fossil fuels through the process of reforming, whereby water (H_2O) is dissolved into oxygen (O) and hydrogen (H). The hydrogen can be stored and transported and used as energy source elsewhere and/or at a later time. The energy required for these processes can be obtained from various sources, such as fossil fuels, nuclear energy and renewable energy sources, including bio-fuels.

Hydrogen can be used in transport –buses, trucks, passenger vehicles, aircrafts, and trains, with technologies being developed to use hydrogen in both fuel cells and internal combustion engines, including methanol systems. Almost all major carmakers have a hydrogen-fuelled vehicle demonstration program. Hydrogen-fuelled, internal-combustion engine vehicles are viewed by some as a near-term, lower-cost option that could assist in the development of hydrogen infrastructure and hydrogen storage technology (Sapru et al., 2002). A key advantage of this option is that hydrogen-fuelled internal-combustion engines vehicles can be made in larger numbers. Since the early 1990s, several car makers (BMW, Daimler-Benz, Mazda) have developed and tested prototype hydrogen-powered passenger cars with internal combustion engines. In addition, first fuel-cell hydrogen passenger cars are under development (e.g. Renault/Volvo - France/Sweden). To date, first city bus prototypes are under development.

Implementation –data not available.

Hydrogen is not yet commercially used in transports industry. (Technologies for Climate Change Mitigation: Transport Sector, March 2011)

Implementation barriers

- Public acceptance: creating confidence in hydrogen safe application;
- Technological and technical challenges: to develop durable, storage and use systems; to develop the infrastructure, to reduce the costs of hydrogen production (National Academy of Engineering 2004);
- Lack of the main infrastructural components are pipelines, compression, liquefaction, tube trailers, liquid and gaseous tanks, geologic storage, separation/purification, dispensers, carriers and carrier charging and discharging (Freedom Car Fuel Partnership 2005);
- Safety challenges and requirements: Safety will be a major issue for commercialization of hydrogen applications and this requires an early discussion of safety policy goals with stakeholder groups, continuing work with standards development organizations, the inclusion of safety in systems analysis, a physical testing program to resolve safety issues, and public education focusing on hydrogen safety.
- Regulatory issues: In the special case of hydrogen, existing codes and regulations usually do not include or reflect hydrogen as a product itself. For a successful and efficient planning and design process for a new technology or concept to be applied on a worldwide basis as well as for a successful marketing, an extension of such codes to the technology or concept in question is needed.

GHG emissions reduction (megatons CO_2 equivalent) – data not available.

Impact on development priorities:

a) Social

- Create jobs;
- Reduce health risks.

b) Economic

- Substantial increase of energy security;
- Improved balance of payments.

c) environmental

- Improve local air quality.

	d) other *Investment* – data not available. The costs of hydrogen technologies refer mainly to the processes necessary to produce, distribute, and dispense the hydrogen. The major factors that will affect the cost of delivered hydrogen are the following: • The feedstock and/or the major energy source with which the hydrogen is produced, • The size of the facility at which the hydrogen is produced and the transportation requirements to deliver it to the customer, • The state of the technology used and future improvements, and • Whether or not the CO_2 by-product is sequestered when hydrogen is produced using fossil fuel. However, it should be noted that there remains significant uncertainty about the actual costs of the technologies under current conditions. Considering all costs (production, storage, distribution), depending on the electric power source, indicative costs vary from 3.7 (large scale hydropower plant) to 17.5 (solar parabolic trough plants) Euro per kWh H_2. *Operation and maintenance costs*– data not available. *GHG reduction costs*– data not available. *Technology lifetime*– data not available. *Other* Source: http://climatetechwiki.org/technology/hydrogen

Agricultural Soils

Sector	**Agricultural Soils**
Technology name	**The classic tillage (plowing 20-35cm deep with moldboard plow (Annex 1), with cutting and turning within a crop rotation with 50% weeding crops) without application of organic fertilizers** Neonila Nicolaev, B. Boincean. Agrotehnica. Bălţi, 2006. P. 225-230.
CO_2 Emissions in „Agricultural Soils" sector, tons CO_2	**Year 2010 – 3 000 787 t or 2.07 t/ha** (sown area – 1 451 500 ha, fallow lands= 1 820 510-1 451 500 = 369 010 ha; on fallow lands the emissions were well balanced or slightly positive)
General description of the technology	At present classical (conventional) tillage is the most commonly used both in Moldova and worldwide. It implies as a must the moldboard plowing (Annex 1) by cutting and turning the furrow. Plowing regulates the water, air, nutrients and heat regime. Advantages of this technology are: *common tillage habits; total incorporation vegetal waste, weeds and their seeds*; *reliability due to simple construction of the plow; soil loosening effect (intensive mobilization of soil fertility, etc.* **Disadvantages:** *Damage of the soil's natural structure and catastrophic decrease of the topsoil's resistance to compaction; strong compaction of the post-arable layer situated under the recently plowed layer; considerable dehumification of the topsoil ; increased erosion on slopes ; high costs of plowing; negatively marked balance of carbon in soil; large CO_2 emissions from soil.*
How the technology will be implemented and disseminated across the sector?	However, the total abandonment of the classical soil cultivation system with moldboard plow is impossible as some crops require mandatory plowing (beets, potatoes, vegetables). Such crops require areas of about 200 000 ha. Such areas, if cultivated in conformity with classical system, allow for application of manure that pollute the countryside, which would reduce CO_2 emissions from agricultural soils and improve the environment in rural settlements.
Implementation barriers	Do not exist. In terms of application of manure on plowed areas, the barriers are the following. Currently there are no large farms and cattle herd is concentrated in rural households. In order to use manure as fertilizer municipalities need to organize the collection, depositing, fermentation and storage of manure on special platforms (Annex 2). Processing technologies and introduction of manure in the soil are provided in specially developed recommendations (Organic Fertilizers User Guidebook. Ch Pontos, 2012.115p). Realistically, the manure reserves do not exceed **2 - 3 million tons**, which would be sufficient to fertilize annually only 200 thousand ha of agricultural land, if collected (unfortunately, much less is actually collected).
CO_2 reduction as a result of technology implementation , tons CO_2	There are no CO_2 reductions as a result of technology implementation. To ensure CO_2 balanced emissions from plowed agricultural soils, it necessary to introduce about 10 t / ha of manure with bedding yearly.
Impact – Impact of the technology on the country development priorities ii	
Impact of the technology on the country social priorities	Ensures minimal welfare of rural population
Impact of the technology on the country economic priorities	Largely ensures food security of the country and provides for the agricultural products export needs.
Impact of the technology on the country environmental priorities	The technology leads to intensification of topsoil degradation processes, wasteful use of reserves of water in the soil and increases the risk of pedologic drought in the topsoil during dry years.
Other impact	Technology creates prerequisites for efficient use of manure that accumulates in rural settlements and pollutes the environment and groundwater. For this purpose it is

	necessary to build at least 40-50 inter-communal platforms for collection, processing and storage of manure from farms (Annex 2).
Costs	
Investment costs	For 1ha **- $ 222 once in 10 years or $ 22.2 / ha / year**. For 200 000 ha **- $44.4 million** once in 10 years **or $ 4.44mln / year** (for purchasing of the necessary equipment, Annex 3, tab. 2-3).
Operation and maintenance costs	For 1 ha **- $390 / ha / year. For 200 000ha = $79.2 million / year**. (Annex 3, tab. 2-3).
CO_2 reduction cost	No reductions
Technology lifetime	In Moldova on cca 200 000 ha this technology will last forever. At present classical tillage is used on cca 0.8-1 mln ha.
Other	The yield od grain ensured by this technology is cca 3t/ha/year. Cost of grain produced on 1 ha = 3t/ha/year. $250 **= $750 /ha/year.** Total annual costs = 22+396 = 418 **$/ha/year. Total benefit = 750-418 = $332 /ha/year or $66.4 mln /year** on 200 000 ha allocated for classical tillage. **This technology will be used as standard for the purpose of comparing other technologies used on whole profile soils (not eroded soils).**

Sector	**Agricultural Soils**
Technology name	**Replacing the moldboard plow with harrow with heavy discs (Annex 3) for tillage up to 20cm deep without application of organic fertilizers** Gheorghe Budoi, Aurelian Penescu. Agrotehnica. Bucureşti: Cereş, 1996. P. 306-308.
CO_2 Emissions in „Agricultural Soils" sector, tons CO_2	**Year2010 – 3 000 787 t or 2.07 t/ha** (sown area – 1 451 500 ha, fallow land = 1 820 510-1 451 500 = 369 010 ha; on fallow lands the emissions were well balanced or slightly positive)
General description of the technology	As a substitute for moldboard plow harrows with heavy discs are used (Annex 4). Their active parts are equipped with concave-shaped discs, placed obliquely towards forwarding direction and inclined to the vertical plane. Penetrate into the soil up to 18-20 cm, cut and crush the soil, turning it partially. The disks contribute greatly to the soil structure damage, so, it should not be used excessively, however, when needed it should be used at the time of optimal humidity. As a result of disc tillage only, the soil gets considerably weeds infested, in particular because the weeds propagate by rhizomes and these are fragmented during tillage.
How the technology will be implemented and disseminated across the sector?	There are no problems in implementation and dissemination of this technology in the sector. The technology can be implemented on approximately 200 000 ha in alternation with plowing. Tillage with heavy discs harrow in alternation with plowing is advantageous in terms of fuel economy and obtaining yields practically equal to those obtained as a result of classical technology.
Implementation barriers	Do not exist. As long as this technology contributes to soil structure deterioration (Annex 6), it is recommended to be implemented on areas not larger than 200 000 ha in alternation with other tillage systems protecting the soil.
CO_2 reduction as a result of technology implementation , tons CO_2	According to researchers Boaghii I., Bulat L., 2003, cited by B. Boincean in the paper – Soil Tillage – Trends and Perspectives. In: Akademos Magazine, nr. 3(22), 2011, p.64, over 20 years of tillage with heavy disks harrowing carbon losses from the 0-40cm layer of soil have reduced by 2.7 t/ha or 0,13t/ha annually in comparison with classical tillage of soil by plowing (Annex 5). This reduced amount of carbon (0,13t/ha/year) equals to CO_2 emissions annual reduction by 0.45t/ha/year (0.13t/ha/year x 3.5).
Impact – Impact of the technology on the country development priorities	

Impact of the technology on the country social priorities	Ensures minimal welfare of rural population
Impact of the technology on the country economic priorities	Largely ensures food security of the country and provides for the agricultural products export needs.
Impact of the technology on the country environmental priorities	Leads to a very small reduction of CO2 emissions from agricultural soils however largely contributes to the deterioration of the soil's natural structure as compared to classical basic tillage of the soil.
Other impact	Intensive destruction of the topsoil natural structure entails to smaller resistance to secondary compaction, high risk of weed infestation.
Costs	
Investment costs	For 1ha – **$194 once in 10 years or $19.4 ha/year.** For 200 000 ha **- $38.8 mln** once in 10 years or **$ 3. 88 mln /year** (for purchasing of the necessary equipment, Annex 3, tab. 4-5)
Operation and maintenance costs	For 1 ha – **$348 /ha/year. For 200 000ha = $69,6 mln /year** **(Annex 3, tab. 4-5)**
CO_2 reduction cost	CO2 reduction **– 0.45 t/ha**, on cca 200 000ha where the technology is used– 0.45 t/ha 200 000 = **90 thousand tons.** CO2 reduction cost = 90 000 tx 30 $/t **= $2,7 mln /year**
Technology lifetime	In Moldova this technology exists on cca 200 000 ha and will exist permanently because of fragmentation of farmlands, poverty and cost of this technology which is 2-3 times lower than plowing.
Other	Annual yield of grain ensured by this technology is cca 3t/ha. The cost of grain harvested from 1ha = 3t/ha. $250 **= $750 /ha/year.** Total annual costs = 19+365 = $384 **/year. Total benefit = 750-384 =** **366 $/ha/year.**

Sector	**Agricultural Soils**
Technology name	**Classic tillage on slopes with more than 5 ° gradient, in a crop rotation with participation of field seeded crops only (spiked cereals, annual legumes, perennial herbaceous).** Neonila Nicolaev, B. Boincean. Agrotehnica. Bălti, 2006. P. 225-230. Complex Program of degraded lands reclamation and increasing soils fertility. Part I. Ch.: Pontos, 2004. P. 85.
CO2 Emissions in „Agricultural Soils" sector, tons CO2	**Year 2010 – 3 000 787 t or 2,07 t/ha** (sown area – 1 451 500 ha, fallow land = 1 820 510-1 451 500 = 369 010 ha; on fallow lands the emissions were well balanced or slightly positive)
General description of the technology	Erosion is the main soil degradation factor (Annex 7). Aim of technology –antierosion protection of arable lands on slopes with more than 5 ° gradient. The technology is based on the principle of differentiated protection ensured by the foliage and variable density of the crops, which by protection degree can be divided into following groups: ***Very well protecting crops -*** perennial grasses and legumes after the first year of use, provide 90-95 percent protection; ***Well protecting crops*** -cereal grains, legumes and perennial grasses in the first year of vegetation, annual fodder plants with high density, provide 70-90 percent protection; ***Medium protecting crops -*** annual legumes, provide 50-70 percent protection; ***Poorly protecting crops*** – weeding crops with low density (maize, sun-flower, beets,

	vegetables), provide 20-50 percent protection. Anti-erosion effect is achieved by alternating strips of very well and well protecting crops with medium and poorly protecting crops, on the slopes. Implementing rotation of crops forming the first three groups only on slopes with more than 5 ° gradient provides 80% anti-erosion effect.
How the technology will be implemented and disseminated across the sector?	The technology can be implemented without restrictions by farms with areas of cca 200 thousand ha of arable lands on slopes with more than 5 ° gradient. The crop rotation should include cereal grains (50-60%), annual legumes (20-30 %), perennial herbs (20 %). The technology will have a positive effect on the environment: solid and liquid leaks from slopes will stop by 80 %; the fields at the foot of the slopes and in valleys, water basins and rivers, roads, hydraulic engineering installations, etc. housing will be protected.
Implementation barriers	Lack of a state anti-erosion system and management of farmland on slopes.
CO_2 reduction as a result of technology implementation , tons CO_2	On cca 200 000 ha CO_2 emissions will be reduced by circa 70%. Annually, on 1ha of slope with a 5° gradient CO_2 emissions will reduce by 2.07 x 0.7 = **1.5 t/ha.** In total, on the entire area of 200thousand ha reductions will amount to 200 000 x 1.5 = **300 thousand t/year.**
Impact – Impact of the technology on the country development priorities	
Impact of the technology on the country social priorities	Soils will be protected from erosion, welfare of rural population will improve in the long term, migration of population will be reduced, it will become possible to develop and implement different social projects.
Impact of the technology on the country economic priorities	Yields on eroded arable lands on slopes with more than 5° gradient (cca 200 thousand ha) will increase by 2 q/year, or 40 thousand t/year grain units . The benefit will be **cca $50 /ha/year or $10 mln / year** on the entire area of 200 thousand ha. Solid leaks (fertile soil) will decrease by 10 t/ha/year or 2 mln t/year on the entire area. The cost of **1 t** of black earth washed away from the slopes is **cca 10 dollars.** The costul of soil protected from washing away from the slopes is **$100 /ha/year or $20 mln / year on the area of 200 thousand ha**.
Impact of the technology on the country environmental priorities	Solid and liquid leaks from the slopes will decrease by **80 percent**, degradation of soils through erosion will stop, water regime, as well as other regimes will improve. The fields at the foot of the slopes and in valleys, water basins and rivers, roads, hydraulic engineering installations, etc. housing will be protected
Other impact	The slopes will acquire a more stable and productive agricultural landscape.
Costs	
Investment costs	The investment costs are the same as for grain crops (Annex 3, Table 3). For 1ha – **$213 once in 10 years or $21.3 ha/year.** For 200 000 ha **- $42.6 mln** once in 10 years or **$**4. 26 mln **/year** (for purchasing of the necessary equipment).
Operation and maintenance costs	For 1 ha – **$416 /ha/year. For 200 000 ha = $83.2 mln /year**
CO_2 reduction cost	Cost of reduction on 200 000 ha = 300 000 t x $30 **/t = $9 mln /year**
Technology lifetime	This technology will be used permanently on 200 000 ha. Only the basic soil tillage methods will change, as a combination of these methods can be used under this technology.
Other	The cost of soils protected from washing on the 200 000 ha of slopes is **$20 mln / year**.

Sector	**Agricultural Soils**

Technology name	**Classic tillage. Including a vetch field (two yields per year –autumn and spring), as a „green fertilizer field" into a 5 fields crop rotation (two crops of vetch incorporated in soil as green fertilizer on each field once in 5 years).** Neonila Nicolaev, B. Boincean. Agrotehnica. Bălţi, 2006. P. 225-230. Mihai Rusu. Tratat de Agrochimie. Îngrăşăminte verzi. Bucureşti: Cereş, 2005, p. 487-488.
CO_2 Emissions in „Agricultural Soils" sector, tons CO_2	**Year 2010 – 3 000 787 t or 2.07 t/ha** (sown area – 1 451 500 ha, fallow land= 1 820 510-1 451 500 = 369 010 ha; on fallow lands the emissions were well balanced or slightly positive).
General description of the technology	Because of some specifics of certain crops cultivation (sugar beets and fodder beets, vegetables etc.), the classic soil tillage system can be replaced by a tillage system contributing to soil conservation only on 80 % of arable lands. Keeping this in mind, it is suggested to use a crop rotation with five fields with „one field of vetch used as green fertilizer" on the 20% of lands remaining under the classic soil tillage system (Annex 8). One crop of vetch provides 6 t/ha of dry mass of airy parts with a 4% nitrogen content and 4 t/ha of dry mass of roots with a2% nitrogen content. Cca 10 t/ha of organic matter is accumulated in soil and provides for the synthesis of 2.5 t/ha of humus containing cca 200kg of nitrogen. Two crops of vetch (autumn and spring) per one agricultural year accumulate cca **20 t/ha** of dry organic matter in soil ensuring synthesis and accumulation of **5 t/ha** of humus (or **2.9 t/ha** of carbon equivalent to CO_2 emissions reduced during 5 years of **10.15 t/ha** or 2,03 t/ha/year). This amount of humus is sufficient to create a positive balance of carbon and nitrogen in soil over 5 years. The topsoil becomes structured, loose, providing for the favorable air, water and nutrients regime for plants.
How the technology will be implemented and disseminated across the sector?	The technology can be successfully implemented on cca 20-25 percent (cca 400thousand ha) o farmlands which, for various reasons, can not be used for implementing **land conservation tillage systems.** The vetch should be sown on the „occupied field", and incorporated in soil twice a year (cca 20t/ha of organic matter that maintains a good balance nitrogen and carbon over the next 4 years when the field is used for cultivation of main crops). In order to implement this complex technology, it is necessary to create a vetch seeds production facility. Autumn vetch should be sown in late August or early September, while spring vetch – late April or early May.
Implementation barriers	1. Rural population mentality about everything that is grown should be used and just incorporated in soil. 2. Lack of vetch seeds production facility. 3. Lack of economic incentives system to encourage agricultural producers to use green fertilizer which protect the quality and fertility of soils in the long term (in Canada farms who use green fertilizers are subsidized with 100-150 dollars/ ha/year). 4. Lack of a state, financially secured program in this sense.
CO_2 reduction as a result of technology implementation , tons CO_2	The technology provides for reduction of 2.03 t/ha/year or **812 thousand tons** of CO_2 on the area of 400 000 ha planned to be used for implementation of this technology.
Impact – **Impact of the technology on the country development priorities**	
Impact of the technology on the country social priorities	Improves the welfare of the rural population, makes it possible to implement various social projects. It ensures a long term maintenance of soils fertility – the main production means of the country, protects the farmlands from desertification which leads to impoverishment of population and migration, provides economic prerequisites for replacement of the existing subsistence agriculture with sustainable agriculture based primarily on employment of natural processes, biological and renewable resources, and only secondarily, purchased resources.
Impact of the technology on the country economic priorities	The total increase in yields over the entire period of action of the vetch green mass (4 years after incorporation in soil) is **4t/ha** grain units, which in monetary terms is –**$ 1000 /ha** or **$200 /ha/year.**

Impact of the technology on the country environmental priorities	The process of land degradation is stopped, humus and carbon balance in soil improves, as well as the soil biota status, the soil's resistance to pollution and drought increases. The ecological status of farmlands improves.
Other impact	Agricultural products production process becomes more environmentally friendly, the internal, conserved resources: the soil, water, biodiversity, etc. of the farm are used in a more rational manner.
Costs	
Investment costs	Investment costs are the same as the cost in conventional agriculture (Annex 3, tab. 2-3) – **$222 once in 10 years or $22,2 / ha/year.** For areas of 200 000 ha **- $44.4 mln** once in 10 years or $4.44 mln **/year** (for purchasing of the necessary equipment).
Operation and maintenance costs	Operation and maintenance costs for 1 ha in 5 years are**: (4 years x $390 /ha/year) + (1ha x $128 /ha/year x 2crops) = $1816.** For 1ha/year the costs are: **$1816 : 5 = $363 /ha/year** or **$145.2 mln.** for 400 000 ha farmlands planned to be used for implementation of this technology.
CO2 reduction cost	CO2 emissions reduction **- 812 thousand tons** on 400 000 ha. The cost of CO2 reduction = 812000 t X $ 30 = $24.36 mln /year. Emissions reduction cost per 1ha = 2.03 t x $30 = $60.9 /ha/year
Technology lifetime	The proposed technology (field occupied with vetch as green fertilizer) can be used under any soil tillage systems.
Other	The annual crop of grain ensured by this technology is cca 4t/ha over 4 years. The cost of grain on 1ha over 4 years = 4t/ha x 4 x $250 **= $4000 /ha.** Total annual costs = 22+396+ 51 = **$469 /ha/year. Total annual benefit = ($4000 /ha : 5 years) – $469 /ha/year = $800 /ha/year - $469 /ha/year = $331 /ha/year.**

Sector	**Agricultural Soils**
Technology name	**Mini-Till soil cultivation system with application of preponderantly mineral fertilizer.** Budoi G., Penescu A. Agrotehnica. Sistemul minim de lucrare a solului. Bucureşti: Cereş, 1996, p. 330-332.
CO2 Emissions in „Agricultural Soils" sector, tons CO2	In 2010 – 3 000 787 t or 2.07 t/ha (sown areas – 1 451 500 ha, fallow land = 1 820 510-1 451 500 = 369 010 ha; on fallow lands the emissions were well balanced or slightly positive)
General description of the technology	The classical soil cultivation system generated the phenomena of soil features degradation. Excessive plowing favored dehumification, damage of the soil structure, increased compaction, danger of erosion. It became necessary to develop new tillage systems known as" soil conservation works systems, SCWS". Mini-till and No-Till systems turned out to be the most effective.
How the technology will be implemented and disseminated across the sector?	This technology can be successfully implemented by all farm businesses on cca 20-25 percent of agricultural lands (cca 200 000 ha), primarily for cultivation of grain crops. Implementation of this technology will require a combined drill tillage with light discs and a common sowing machine, or combined tillage and sowing machine (Annex 10).
Implementation barriers	There are no barriers to technology implementation. Compared with the basic soil cultivation technology with heavy discs harrows, the proposed technology is less expensive as it excludes stubble plowing and leveling, however, it has its negative moments. Being used without application of organic fertilizers this technology leads to: strong compaction of the post-arable layer 10-35 cm and decreasing of the physiologically active soil layer thickness, increasing the danger of pedological drought in 0-30cm layer, increasing the risk of temporary excess of humidity in soil in years with abundant rainfall. The compact layer can be periodically loosened by using a chisel type

	loosener or Pinocchio type aggregate (Annex 9).
CO_2 reduction as a result of technology implementation , tons CO_2	According to the research Institute "Selectia" in Balti (Annex 5), over the 20 years period of use of minimum soil cultivation techniques, the soil carbon losses from 0-40cm soil layer decreased by 6.7 t / ha / year or 0. 34t/ha/year compared to traditional tillage (Annex 5). This small amount of carbon (0.34 t / ha / year) is equivalent to annual reduction of CO_2 emissions by 1.19 t / ha / year (0.34 t / ha / year x 3.5), or 238 000 tons from recently cultivated areas according to this technology.
Impact – Impact of the technology on the country development priorities	
Impact of the technology on the country social priorities	The technology ensures yield equal or 5-10 percent lower than those obtained under classical tillage system. The welfare of population remains at subsistence level.
Impact of the technology on the country economic priorities	Compared to classic tillage, the cost of mechanized work is reduced by cca **70$/ha/year**. At present, given the poverty of rural population, this less costly technology, is the one being used in farmlands cultivation. However, the way it is used now (without application of organic fertilizers) this technology is not very efficient as it leads to soils degradation.
Impact of the technology on the country environmental priorities	Contributes to partial reduction of CO_2emissions from agricultural soils.
Other impact	The advantages of this technology are: Reduction of amount of fuel used for field works by practically 2 times; Reduction of humidity losses from the topsoil occurring during tillage with harrow with heavy disks; Reduction by cca 50 percent of humus and soil carbon losses.
Costs	
Investment costs	Machinery wearing cost is by 2 dollars smaller than in case of traditional tillage with harrow with heavy disks and amounts to $192 /ha in 10 years or $19.2 /ha/year. For an area of 200 000ha the investment costs amount to$ 38.4 mln once in 10 years.
Operation and maintenance costs	Operation and maintenance costs are by **28$/ha/year** smaller than in case of traditional tillage with harrow with heavy disks and amounts to **$320 /ha/year.**
CO_2 reduction cost	CO_2 emissions reduction **- 238 thousand tons** from 200000 ha recently cultivated according to this technology. CO_2 reduction cost - 238 000 t x $30 = $**7.14 mln** per year.
Technology lifetime	Gradually this technology will be improved by employment of methods allowing to increase the inflow of organic matter in soil.
Other	The yields of grain ensured by this technology amounts to cca 3t/ha/year. Cost of grain production from 1 ha = 2.7 t/ha/year. $250 **= $675 /ha/year.** Total annual costs amount to **-** $339 **/ha/year. Total benefit = 675 -339 = $336 /ha/year** or **$6.72 mln /year** on 200 000 ha.

Sector	**Agricultural Soils**
Technology name	**Mini-Till soil cultivation system with use mineral fertilizers and of vegetal waste (straw, cobs, etc.) as fertilizer** Budoi G., Penescu A. Agrotehnica. Sistemul minim de lucrare a solului. Bucureşti: Cereş, 1996, p. 330-332.

	Resturile Vegetale de la Culturi. Bucureşti: Cereş, 2005, p. 485-487.
CO_2 Emissions in „Agricultural Soils" sector, tons CO_2	**In 2010 – 3 000 787 t or 2,07 t/ha** (sown areas – 1 451 500 ha, fallow lands = 1 820 510-1 451 500 = 369 010 ha; on fallow lands the emissions were well balanced or slightly positive)
General description of the technology	According to the Banaru A. paper "Method of determining the carbon balance in agricultural soils of Moldova to assess CO2emissions" (Ch., 2000), 1q of dry mass of the crop provides 1. 0q/ha of vegetal waste during straw evacuation, 43q/ha during straw incorporation in the soil. So, the incorporation of straw into the soil provides for additional 0.43 q/ha of vegetal waste containing 40-45% carbon and 0.05 - 0.08% nitrogen (Mihai Rusu. Agrochemistry Treaty, tab 5100, p.485.) Humification coefficient of the straw incorporated into the soil is 0.11. So, the result of using straw as fertilizer after harvesting - standard 3t/ha of the main crop, is accumulation in the soil of 1.3 t / ha of vegetal waste which will synthesize 1.4 q of humus and remove 83 kg of carbon, which help reduce additional CO_2 emissions from agricultural soils by about 3q/ha or 0.3 t / ha.
How the technology will be implemented and disseminated across the sector?	This technology can be successfully implemented by all farm businesses on cca 20-25 percent of agricultural lands (cca 200 000 ha), primarily for cultivation of grain crops. Implementation of this technology will require a combined drill tillage with light discs and a common sowing machine, or combined tillage and sowing machine (Annex 10).
Implementation barriers	Machinery that would chop and uniformly distribute the vegetal waste on the soil's surface are needed; The compact layer can be periodically (once in 2-3 years) loosened by using a chisel type loosener or Pinocchio type aggregate (Annex 9).
CO_2 reduction as a result of technology implementation , tons CO_2	The technology may be applied on cca 200 thousand ha of areas sown with grain crops, what will lead to reduction of CO_2 emissions by cu 0.3 t/ha x 200 000 ha = 60thousand tons CO_2.
Impact – Impact of the technology on the country development priorities	
Impact of the technology on the country social priorities	As a result of using straw as fertilizer, the yields will increase by 1q/ha/year grain units**, thus somewhat reducing the rural population poverty**.
Impact of the technology on the country economic priorities	Increase of yields by 1q/ha/year grain units will ensure o benefit of **$25/ha/year** or **$5 mln/year on the potential area of 200 000 ha.**
Impact of the technology on the country environmental priorities	Annually, the straw from 200 000 ha of land are burned. This operation damages the soil and its biota. Using straw as fertilizer would displace this negative practice.
Other impact	Carbon emissions will reduce, the soil structure will improve.
Costs	
Investment costs	Investment costs for 1ha – **$222 once in 10 years or $22.2 / ha/ year.** For 200 000 ha - **$44.4 mln** once in 10 years or **$4.44 mln /year**
Operation and maintenance costs	Operation and maintenance costs amount to **$320 /ha/year or $64 mln /year for 200 000 ha.**
CO_2 reduction cost	CO_2 emissions will be reduced by **60 thousand tons** on the area of 200000 ha cultivated according to this technology. CO_2 reduction cost - 60 000 t x $30 = $**1.8 mln** per year.
Technology lifetime	Gradually this technology will be improved by employment of methods allowing to increase the inflow of organic matter in soil.
Other	Benefits will increase by **$25/ha/year or by $5mln for 200 thousand ha.**

Sector	**Agricultural Soils**

Technology name	**The No-Till soil cultivation system with preliminary positive recovery of the post-arable layer and use of vetch as intermediary crop for green fertilizer** Budoi G., Penescu A. Agrotehnica. Sistemul „Fără Lucrări” (Semănat Direct). Bucureşti: Cereş, 1996, p. 335-336. Mihai Rusu. Tratat de Agrochimie. Îngrăşăminte verzi. Bucureşti: Cereş, 2005, p. 487-488.
CO2 Emissions in „Agricultural Soils” sector, tons CO2	**In 2010 – 3 000 787 t or 2.07 t/ha** (sown area – 1 451 500 ha, fallow lands = 1 820 510-1 451 500 = 369 010 ha; on fallow lands the emissions were well balanced or slightly positive)
General description of the technology	The existing soil cultivation systems entail intensive physical, chemical and biological degradation of soil. The classical soil cultivation system generated the phenomena of soil features degradation. Excessive plowing favored dehumification, damage of the soil structure, increased compaction, danger of erosion. It became necessary to develop new tillage systems known as "soil conservation works systems, SCWS". Mini-till and No-Till systems turned out to be the most effective. It is proposed to improve these two systems by including vetch as successive crop for green fertilizer. A crop of vetch (about 6 t / ha of dry weight containing 4% of nitrogen), and roots (about 4t/ha dry weight containing 2% of nitrogen) accumulates about 10 tons of organic matter in soil, which ensures synthesis of about 2.5 t / ha of humus containing about 200kg of nitrogen. This amount of humus is sufficient to create a positive carbon and nitrogen balance in soil during 2 years. The No-till soil cultivation system means that the sowing is done directly on the stubble field or field containing vegetal waste of the previous crop. The main mechanism for No-Till is the sowing machine. The main element of the sowing machine is the cutter. Recently, the cutters are combined with corrugated disc type blades in combination with chisel type blades. Gradually, the topsoil will become biogenic, well structured, loose, will contribute to a favorable air-fluid and nutrients regime and will increase the plants resistance to drought.
How the technology will be implemented and disseminated across the sector?	No - Till soil cultivation system can be implemented, primarily on cca 200 thousand ha arable lands in the South of Moldova. These lands feature a more favorable texture for this technology. Before implementing the No-Till technology, it is recommended to implement the preliminary positive recovery of the arable layer structure on the area planned to be used for this technology. For this purpose, the field should be used as occupied field, sown with autumn and spring vetch. Two harvests of this crop incorporated in soil as green fertilizer will cardinally recover the physical, chemical and biological condition of the arable layer of the soil and ensure successful implementation of the technology. No-Till is an agricultural technology which protects the soil and improves the ecologic condition of agricultural ecosystems. Being used in combination with a successive crop as green fertilizer (vetch), it provides for a well balanced or positive content of carbon in soil.
Implementation barriers	The main implementation barriers for the No-Till land cultivation system are: mentality of population; the initial unfavorable condition of the arable layer of the soil; the high cost of the No-Till sewer; the need to strictly stick to the technological process, what is not in the habit of Moldovan farmers.
CO2 reduction as a result of technology implementation , tons CO2	No- Till system used in combination with vetch as successive crop for green fertilizer (10t/ha of dry mass forming cca 2.5 t/ha of humus and stocks cca 1.45 t/ha carbon in soil) reduces CO2 emissions by **5.08 t/ha**, ensures a positive carbon balance in soil over 2 years, reduces annual CO2 emissions from soil by **2.54 t/ha**.
Impact – Impact of the technology on the country development priorities	
Impact of the technology on the country social priorities	Harvests of 4-5 t/ha grain units ensure the welfare of population, decrease migration, create prerequisites for implementation of various social projects.
Impact of the technology on the country economic priorities	The technology ensures crops of 4-5 t/ha grain units **(on average 4.5 t/ha)**, at a cost of **1125 dollars**. It provides for the food security of the country and agricultural products export needs.

Impact of the technology on the country environmental priorities	It ensures a long term maintenance of soils fertility – the main production means of the country, protects the farmlands from desertification which leads to impoverishment of population and migration, provides economic prerequisites for replacement of the existing subsistence agriculture with sustainable agriculture based primarily on employment of natural processes, biological and renewable resources, and only secondarily, purchased resources.
Other impact	Other impact are : Reduction of amount of fuel used for field works by practically 2 times; • Gradual restoration of the humus content, favorable structure and fertility of the soil arable layer; • Decrease of non-productive losses of water from soil due to mulching which contributes to combating pedological drought; • Partial or total stop of the soil erosion (the stubble field and mulching favor reduction of leaks and accumulation of water from precipitations in the soil); • Establishment of a positive balance of humus and carbon in soil, total reduction of GHG emissions from agricultural soils. • Increase of soils productivity by 30-40 percent.
Costs	
Investment costs	Minimal investment costs for an area of 400ha agricultural lands is cca **340 thousand dollars** (V. Cerbari. No-Till – soil protecting land cultivation system. In the magazine Moldova's Agriculture, nr. 8-9, 2011, p. 9-14.) for 10 years, or **34 thousand dollars** for one year, or $**85**/ha/year.
Operation and maintenance costs	Annual operation and maintenance costs for 400ha are $225 thousand / year or $**560** /ha/year (V. Cerbari. No-Till – soil protecting land cultivation system. In the magazine Moldova's Agriculture, nr. 8-9, 2011, p. 9-14.).
CO2 reduction cost	Reduction of 2.54 t/ha/year. Cost of CO2reduction = 2.54 t/ha/year x 30$ = $76,2/ha/year or $15.24 mln / year on the area of 200000 ha.
Technology lifetime	Technology lifetime is not limited. No-Till system can not be alternated with other mechanical soil cultivation system in the following.
Other	No-Till soil cultivation system is cost efficient for large agricultural enterprises. For a crop of 4.5t/ha/year grain units the cost of production is $**1125** /ha/year, expenditures are – 560+85= 645 $/ha/year. Profit =1125-645 = **$480/ha/year**

Sector	**Agricultural Soils**
Technology name	**Mini-Till soil cultivation system with preliminary positive recovery of the post-arable layer and use of vetch as intermediary crop for green fertilizer.** Budoi G., Penescu A. Agrotehnica. **Mini-Till soil cutivation system**. Bucureşti: Cereş, 1996, p. 330-332. Mihai Rusu. Tratat de Agrochimie. Green Fertilizers. Bucureşti: Cereş, 2005, p. 487-488.
CO2 Emissions in „Agricultural Soils" sector, tons CO2	**Anul 2010 – 3 000 787 t sau 2,07 t/ha** (sown areas – 1 451 500 ha, fallow land= 1 820 510-1 451 500 = 369 010 ha; on fallow lands the emissions were well balanced or slightly positive)
General description of the technology	Mini-Till soil cultivation system further became a version of soil conservation system based on the agro technical, economic and energy, ecologic principles. This system implies returning the crop residues back into the soil, partial preservation of vegetal waste as mulching, as the source of energy material for the living beings living in sol, on the surface of the soil, maintaining biodiversity and balance in ecosystems. Use of this system is conditioned by certain appropriate measures allowing combined (concurrent) implementation of a number of operations related to use of insecticides, fungicides and herbicides, fertilizers and use of mechanisms for their application or incorporation in soil,

	knowledge of specific features of crops and local pedoclimatic conditions, types of soils and hybrids adapted to conditions created by this technology. It is proposed to improve this system by using vetch as successive crop as green fertilizer. A vetch crop accumulates cca 10 tons of organic matter in soil, which ensures synthesis of 2.5 t/ha of humus containing cca 200kg of nitrogen. Cca 1,45 t/ha/year of carbon is stocked in soil. It reduces CO2 emissions by **5.08 t/ha**, ensures a positive carbon balance in soil over 2 years, reduces annual CO2 emissions from soil by **2.54 t/ha**.
How the technology will be implemented and disseminated across the sector?	This technology can be successfully implemented by all farm businesses on cca 20-25 percent of agricultural lands (cca 200 000 ha), primarily for cultivation of grain crops. Implementation of this technology will require a combined drill tillage with light discs and a common sowing machine, or combined tillage and sowing machine (Annex 10).
Implementation barriers	Do not exist. It is necessary to create a vetch seeds operation.
CO2 reduction as a result of technology implementation , tons CO2	Mini-Till system used in combination with vetch as successive crop for green fertilizer (10t/ha of dry mass forming cca 2.5 t/ha of humus and stocks cca 1.45 t/ha carbon in soil) reduces CO2 emissions by **5.08 t/ha**, ensures a positive carbon balance in soil over 2 years, reduces annual CO2 emissions from soil by **2.54 t/ha**.
Impact – Impact of the technology on the country development priorities	
Impact of the technology on the country social priorities	Harvests of 4-5 t/ha grain units ensure the welfare of population, decrease migration, create prerequisites for implementation of various social projects.
Impact of the technology on the country economic priorities	The technology ensures crops of 4-5 t/ha grain units **(on average 4.5 t/ha)**, at a cost of **1125 dollars**. It provides for the food security of the country and agricultural products export needs.
Impact of the technology on the country environmental priorities	The technology assures a positive balance of humus, carbon and nitrogen in soil, decreases soil degradation and fertility, radically decreases CO2emissions from soil.
Other impact	It creates prerequisites for implementation of ecologically safe agriculture. Advantages are the same as for the first No-Till technology, however, more prominent. Soil protection against natural disasters is less ensured.
Costs	
Investment costs	Investment costs for 1ha – **$230** once in 10 years or **$23 / ha/year.** For 200 000 ha **- $46 mln** once in 10 years or **$4.6 mln /year.**
Operation and maintenance costs	Operation and maintenance costs amount to $384 /ha/year or $ 77 mln /year on the area of 200 000 ha.
CO2 reduction cost	CO2 emissions reduction by **2.54 t/ha/year**. CO2 reduction cost = 2.54 t/ha/year x $30 = **$76.2/ha/year or $15.24 mln / year** on the area of 200000 ha.
Technology lifetime	Technology lifetime is unlimited
Other	For a crop of **4,5t/ha/year** grain units the cost of production is **$1125 /ha/year**, costs – 384+23= **$407 /ha/year**. Profit =1125-407 = **718 $/ha/year.**

Annex 2. Technology Performance Matrix

No.	Tehnology	Main production parametres		Costs		GHG Reduction
		Capacity to implement the technology by year 2030	How long the technoloy will be used during the year (in 2030)	Investment	Operation and maintenance costs plus other costs (including the fuel)	GHG reduction in 2030
		kW, Gcal/h,	hours	$/kW, $/m2, $/hectar, $/other capacity measuring unit	$/kWh, $/Gcal, $/tons of yield, $/other product unit	tons CO2
		C	T	I	E	R
1	Tehnology 1	10000	5000	1000	0.17	100,000
2	Tehnology 2	5000	4500	350	0.15	50,000
3	Tehnology 3	150000	5700	1500	0.14	300,000
4	Tehnology 4	300000	7000	1200	0.14	150,000
5	Tehnology 5	150000	6000	3000	0.15	200,000
6	Tehnology 6	150000	7000	2500	0.13	70,000
7	Tehnology 7	300000	7000	2000	0.12	20,000
8	Tehnology 8	150000	6300	650	0.12	120,000
9	Tehnology 9	100000	7500	1200	0.04	80,000
	Guidance on how to fill in					
	I. As mentioned in "Guidelines", each sub-sector has to be covered by 4 sets of technologies:					
		1. Small scale short term technology				
		2. Small scale long term technology				
		3. Large scale short term technology				
		4. Large scale long term technology				
	II. For each set above it is necessary to fill in the yellow cells in the table above , following the recommendations given below.					
	1. Capacity to implement the technology by year 2030					
	The expert shall assess approximately the maximum extent to which the technology can be used by 2030. For example, provided the technical potential of wind energy use is 600MW, by year 2030 only as much as 250 MW will be actually used. Consequently, the implementation capacity of the windmills will be 250MW.					
	2. How long the technoloy will be used during the year (in 2030)					
	Shall be filled in as time of the technology maximal capacity use over the whole year. For example, a windmill with a capacity of 250MW, mentioned in Item 1, does not operate 8760 hours per year, but only cca. 2600 hours, given the fact that the wind does not have a constant speed. So, the corresponding cell in the table will have to be filled in with only 2600 hours.					
	3. Investment					

	The value that has to be filled in the corresponding cell is the value of the specific investment for this technology. So, if for example, the power of a generator is 100kW, and the investment necessary to purchase, construct and put into operation is 100000 $, then the specific investment will be 1000$/kW.
	4. Operation and maintenance costs plus other costs (including the fuel)
	The value shall correspond to the total costs related to production of one unit of the corresponding product or service. So, if a generator produces 100000 kWh per year, and operation and maintenance costs plus cost of fuel for the entire year amount to 100000$, then the needed value is 1$/kWh
	The information from pp. 1-4 is needed to calculate the total updated costs and other financial parameters that will further be used to finally choose the performant technologies. The respective parameters will be calculated automatically.
	5.GHG reduction in 2030
	Having the prognosis for the respective technology implementation by 2030, the amount of fossil fuel (or electric power, or number of hectare cultivated) saved by application of this new technology. Given the emissions factor for the saved fuel, or CO_2 emissions under the old and new technology, it becomes possible to calculate CO_2 emissions reduction in 2030. Emission factors for fossil fuels, as well as the emission factor for the energy saved are attached.

Annex 3. Guidance on how to select 2-3 priority technologies from a series of 4 or more technologies

1. As mentioned in "Guidelines", each sub-sector has to be covered by 4 sets of technologies:

   1. Small scale short term technology
   2. Small scale long term technology
   3. Large scale short term technology
   4. Large scale long term technology

2. Each set shall include a long list of technologies with description of each technology in conformity with the Technology Fact Sheet (TFS), attached to the "Guidelines".

3. The expert shall familiarize with "13.National Priorities" and "14.Priority Sectors " prezented below.

4. For each set above it is necessary to select 2-3 technologies for further consideration and description in the Report, as indicated in "Guidelines". There are three Steps that need to be done for this purpose :

Step 1

5. In the Table below , column 1 should list the technologies from the long list of technologies drafted for this particular set

6.6. Columns 2, 3,4 (grey background) of the same table should contain data from the already filled in Performance Matrix. Data for column 4, i.e. price of one kWh, or price of one m2, or one kg of agricultural product, etc. has to be calculated by using the following formula: P=(I*C)/(A*C*T)+E, where A- is the technology’s lifetime (years), while C, T, I, R,E correspond to the same from the Performance Matrix page (are marked in red). Prices can be drawn from bibliographic sources rather than calculated. Choosing investments and price as cost criteria has not been done randomly. The R. of Moldova does not have the capacity to invest, and consumers and the economy can not afford high prices because of poverty. The country is the poorest in Europe.

7.7. Each technology should be rated from 0 to 100 for each of the six criteria listed in columns 5-10 (cells colored in blue and pink). The worst technology is rated with "0", the best technology - with"100" for each of the six criteria. For other technologies the rating should range from 0 to 100. Criteria from columns 8-10 (cells colored in pink) should be rated by experts depending on how well the technology meets the objectives of the respective criterion. At this stage of rating, the National priorities stated in page "3. National Priorities" should be taken into account. As for the rating of criteria from columns 5-7 (cells colored in blue) it can not be assigned as the expert wishes, but has to be automatically calculated, depending on the technologies assigned with maximal (100) and minimal (0) rating, as well as the value of the assessed technology parameters (Price reduction, Specific Investment or Price from the grey cells). In order to see how the rating is calculated, it is sufficient to activate a cell with the browser. The upper part of the screen will display the formula used. For example, if cell G41 is pressed, the screen will display: =100*(E42-E41)/(E42-E39), meaning that figures from column E were calculated, where E42, E39 represent the biggest (3000) investment, and the smallest (350) investment, rated "0" and, respectively, "100" in column G of the "Investments" criterion. Cell E41 with the value 1200 represents the assessed investment for Technology 4. When the expert will be introducing the technologies with the respective performances the same formula will have to be used , with the exception that instead of cells E42, E39 he will have to write in the cells corresponding to "0" and "100" , respectively. It should be noted that one formula applies for columns 5 and 6 and a different formula applies to column 7, given the fact that for columns 5 and 6 the larger is the investment of price, the lower is the rating, while for column 7 – the bigger is emissions reduction, the higher is the rating.

8. Cells colored in yellow of the Table "Step 1" are filled. This time, the rating corresponds to the rating of criteria used for evaluation of technologies, which also range from 0 to 100.

Step 2

9. After filling in items 7 and 8, in the Table, "Step 2" and page " Cost-Benefit Analysis", automatically one gets the following : a) rating of each technology (total and separate related to benefit), as well as b) position of each of the technologies in the coordinates "Investments"-"Benefit". Priority of each of the technologies in Table " Step 2" shall be established by the expert based on the accumulated rating points. The higher is the technology’s rating, the more priority it has. The needed 2-3 technologies will be selected from the range of technologies needing the smallest investments, and the highest benefit . In the case under consideration, these would correspond to the ones within the dotted circle in the diagram from the " Cost-Benefit Analysis" page.

Step 3

10. A sensibility study will be done for the 2-3 technologies selected, which will evaluate the change of these technologies position in "Investments"-"Benefit" coordinates if the rating or performance parameters for criteria with the highest uncertainty, from the expert’s point of view, change. It is enough to select 2-3 such criteria. So, other values for criteria with the highest uncertainty shall be established, assigning respective points (for costs and emissions reduction values shall be indicated in columns 2,3,4) in Table "Step 1", watching how the technology moves within the graph "Investments"-"Benefit", and drawing relevant conclusions.

11. While evaluating Cost-Benefit, the Expert can use prices instead of investments. In this case, column D of the Table "Step 3" shall contain prices rather than investments. Results will be obtained automatically , with no need to make other modifications.												
12. Results will be described in the Report, in conformity with "Guidelines"												
	Multicriteria decision analysis											
	Step 1 (Data filling out)	**Performances**			**Criteria**						**TOTAL**	
	Tehnologies	**GHG ReductionReducerea de GES**	**Specific investments**	**Price**	**Costs**		**Benefits**					
		tone CO2	**$/kW, $/m2, $/he, $/other units**	**$/kWh, $/Gcal, $/m2, etc.**	**Investments**	**Price**	**GHG reduction**	**Social**	**Economic**	**Environment**	**Applied to all criteria**	**Applied to benefits criteria**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
	Tehnology 1	100,000	1000	1.1	75	64	29	60	100	5	333	194
	Tehnology 2	50,000	350	1.5	100	36	11	50	20	60	276	141
	Tehnology 3	300,000	1500	0.7	57	93	100	100	30	90	469	320
	Tehnology 4	150,000	1200	1.2	68	57	46	50	40	20	281	156
	Tehnology 5	200,000	3000	0.8	0	86	64	40	50	100	340	254
	Tehnology 6	70,000	2500	2	19	0	18	0	60	40	137	118
	Tehnology 7	20,000	2000	0.9	38	79	0	30	0	60	206	90
	Tehnology 8	120,000	650	0.6	89	100	36	60	70	20	374	186
	Tehnology 9	80,000	1200	1	68	71	21	30	80	0	271	131
	Weighting criteria				100	90	70	60	100	50	470	
					0.213	**0.191**	**0.149**	**0.128**	**0.213**	**0.106**	1.000	
	Step 2 (automatic calculation)											
	Tehnologies				**Criteria**						**TOTAL**	
					Costs		**Benefits**					
					Investments	**Price**	**GHG reduction**	**Social**	**Economic**	**Environment**	**Applied to all criteria**	**Applied to benefits criteria**
1	Tehnology 1				16.1	12.3	4.3	7.7	21.3	0.5	62.1	33.7
2	Tehnology 2				21.3	6.8	1.6	6.4	4.3	6.4	46.7	18.6
3	Tehnology 3				12.0	17.8	14.9	12.8	6.4	9.6	73.4	43.6
4	Tehnology 4				14.5	10.9	6.9	6.4	8.5	2.1	49.3	23.9
5	Tehnology 5				0.0	16.4	9.6	5.1	10.6	10.6	52.4	36.0
6	Tehnology 6				4.0	0.0	2.7	0.0	12.8	4.3	23.7	19.7
7	Tehnology 7				8.0	15.0	0.0	3.8	0.0	6.4	33.3	10.2
8	Tehnology 8				18.9	19.1	5.3	7.7	14.9	2.1	68.0	30.0
9	Tehnology 9				14.5	13.7	3.2	3.8	17.0	0.0	52.2	24.0

Annex 4. National Priorities

Environmental Development Priorities	
Reduced soil degradation	Soil is continuing to degraded due to unsustainable harvesting
Extended forest area	The eco-protective function of forests is manifested more strongly only if the degree of the country afforestation exceeds 15% of a country's territory. For this reason, the forested area of the Republic of Moldova should be extended by around 150 000 hectares
Improved management of the water supply and sewerage sector	The current management of the water supply and sewerage sector is not adequate to today requirements
Economic Development Priorities	
Reduced the absolute poverty rate	Moldova is the poorest country in Europe[1]. 26,3% of population is below poverty line (2009) [2].
Increased energy security	Lack of own natural fossil fuel reserves is obliging the country to import more than 96% of energy resources needed. 70% of electricity demand is covered by import. All natural gas is coming from GAZPROM
Improved urban and rural roads	According to World Economic Forum[3] the quality of the Republic of Moldova roads accumulate 1,6 point from a maximum of 7.
Establishment of an integrated and stable agricultural system	The vegetable crop production and animal breeding is not one integrated by each agricultural soil/climate zone
Improved employment	This holds for both quantity of jobs and human capital transfer
Social Development Priorities	
Access of rural child to well equipped school	During the last 10-15 years in the many of the villages the number of child has decreased significantly and that has leaded to both lack of tutors and necessary equipment for qualitative teaching
Ensured medical assistance to rural population	Lately many of the villages have lost the capacity to maintain the appropriate medical stuff.
Political Priority	
Re-integrate the country	Because of Transnistria secessionism, starting with 1992 Moldova territory located at left bank of river Nistru is not controlled by country recognized authorities
[1] http://www.ruralpovertyportal.org/web/guest/country/home/tags/moldova	
[2] http://www.indexmundi.com/moldova/population_below_poverty_line.html	
[3] http://www.constructor.md/News/3260/ro.html	

Annex 5. Priority Sectors

Sectors	**Subsectors**	**GHG emissions**	
		Gg CO2eq	**% from total with LULUCF**
1. Energy	1. Energy Industries	2990	30
	2. Manufacturing Industries and Construct.	397	4
	3. Transport	1655	17
	4. Other Sectors	1911	19
	5. Other (other works and needs in energy)	119	1
	6. Oil and Natural Gas (Fugitive Emissions from Fuels)	654	7
2. Agriculture	A. Enteric Fermentation	793	8
	B. Manure Management	636	6
	D. Agricultural Soils	699	7
TOTAL		**9853**	**100**

Sectors	**Subsectors**	**GHG emissions**	
		Gg CO2eq	**% from total country GHG emissions with LULUCF**
1. Energy	Energy industries	2990	**83**
	Transport	1655	
	Other Sectors	1911	
2. Agriculture	Eneric Fermentation	793	
	Manue Management	636	
	Agricultural Soils	699	
TOTAL		**8684**	

Annex 6. List of stakeholders involved and their contacts

1. Ministry of Environment (Maria Nagornii, Chief of Department for Analysis, Monitoring and Evaluation of politics, tel 373-22-204520)
2. Ministry of Economy (Cristina Guriev, Deputy Chief, Department of Thermoenergetics, tel 373-22- 23-32-67
3. Ministry of Agriculture and Food Industry (Iurie Senic, Chief of Department Ecological Agriculture, Renewable resources and irrigation, tel 373-22-233427)
4. National Agency for Energy Regulation (Andrei Sula, the senior specialist ,Department Regulation and Licensing, ANRE, tel 373-22-852 934)
5. National Agency for Energy Efficiency (Mihai Stratan; Director, tel +373-788 85 505)
6. Climate Change Office, Ministry of Environment (Marius Taranu, National Inventory Team Leader, tel. 373-22-232247)
7. Institute of Power Engineering of the Academy of Sciences of Moldova (Sergiu Robu, tel 373-22-727040)
8. Institute of Ecology and Geography of the Academy of Sciences of Moldova (Maria Sandu, Deputy Director, tel 373-22-211134)
9. Technical State University (Petru Todos, Deputy Rector, tel 373-22- 235400)
10. State Agrarian University of Moldova (Ion Bacean , associate professor, tel 373-22-432258)
11. RED Union Fenosa S.A. (Sergiu Codreanu, Regulation specialist tel 373-22-431441)
12. State Hydrometeorological Service (Elina Plesca, Deputy Director, tel 373-22-773511)
13. National Agency for Energy Regulation (Anatolie Boscaneanu, senior specialist, Direction Regulation and Licensing, tel 373-22-544936).
14. NGO “Ecospectr” (Alexandru Teleuta, Director, tel 373-22-523898)
15. NGO “Energie Plus” (Vice-Director Anderi Chiciuc, tel 373-22237619)