CLIMATE CHANGE MITIGATION

5. CLIMATE CHANGE MITIGATION

The main aim of Climate Change Mitigation Analyses is to assess the climate change mitigation potential of the country following the projected developmental lines of the national economy. This aim is realized through identification of appropriate measures/practices/projects/interventions in various sectors starting from electricity, heating, industry, transport through to waste and agriculture, which will be undertaken during the period 2008-2025. Then, to the greatest extent possible, the environmental effectiveness of the proposed measures was calculated, expressed in a reduced amount of GHG emissions in case the given measure/practice/project/intervention is implemented, as well as the economic effectiveness, estimating the price of GHG emission reduction (USD per tonne of CO_2-eq reduced). The optimum year of implementation for most of the measures was defined, imposing the maximum emission reduction and the minimum expenses as optimization criteria.

It should be noted that the mitigation analysis was constrained by the lack of sectoral developmental plans, relevant data (historical and present), as well as other relevant national studies. Still, this study is indicative concerning the country's mitigation potential, and should be permanently revised taking into account all the relevant occurrences in the national economy.

5.1. Sectoral analysis

5.1.1. Electric Power

a) Assumptions on input data

The planning of the development of the Electric Power Sector is based upon the performance data of the power system in the period from 1991 up and until today, as well as on the realistic assumptions about the possibilities for future expansions.

The Existing Power Generation

In the last two decades there has been a degree of stagnation in building new generating capacities in the country (with only the HPP Kozjak being built in 2004; and the existing thermal and hydropower units being revitalized). On the other hand, following the economic growth (with an annual rate of around 5%), there has been a considerable growth of energy needs. Over the years, this has certainly been an enhancing of the gap between electricity demand and supply. The shortage of electricity is covered by importation, which amounted to around 2,000 GWh in 2007, or almost 25% of the total needs. Therefore, it is necessary to start some very intensive activities towards building new thermal and hydroplants in Macedonia as a country which is expecting a rapid economical growth in the next period.

The thermal power units in Bitola and Oslomej, which cover over 60% of the total electricity needs, have been operating for almost 25 years, and are entering the second phase of their operating lives. One of the proposals in the Study for Expansion Planning of the Macedonian Power System is ensuring the fuel (lignite) supply for the existing thermal power plants until the end of their lifetime, which is the year 2025. The cumulative operating time of TPP Negotino is only a few years, which is very low compared to the age of the plant (built 30 years ago). The reasons behind this are the relatively low electricity consumption until the middle of the 1990s, when Negotino served as a cold reserve in the Macedonian Power System. In the last few years the price of oil has been constantly increasing which has resulted in the high price of the electricity output from Negotino. With a little reconstruction in the technological process, according to the electricity needs, TPP Negotino can operate in the base load as well as in the peak load. The hydropower potential contributes with 15% of the total electricity needs which is nearly the level of the technical losses in the power system in Macedonia.

Growth rate of the electricity consumption

The system for electricity generation in Macedonia has been operating with the same power plants over the last 30 years, but the electricity demand is continually increasing, and in the last few years the needs have exceeded the maximum capacity of the existing generating system.

The data for the first year (2006) in the developing scenarios are given according to real hour-by-hour consumption with a total electrical energy of 8,300 GWh. An annual growth rate of 3.5% in the first ten years is assumed and 3% in the second ten years of the analysed period until 2025. These assumptions are based on the forecast for the economic development of the country, which is around 5% annually. The power system as the basis for economic development for each country should follow the development dynamics with a slightly lower percentage of development compared to total economic and industrial development. The reason is that the recent economic development in Macedonia was based on the low energy efficiency technologies, which means more energy was spent for an output product compared to the advanced and sophisticated technologies in the most developed countries in the world.

The growth rate for the electricity consumption of around 6% in the last few years in Macedonia is a result of the restarting of the heavy industrial and electrometallurgical capacities such as FENI, SILMAK, the steel industry, etc. These capacities from 1991 until the period of their privatization at the beginning of this century had not been in operation, so their reactivation in the last few years is a big step with regard to the electricity needs in Macedonia. The last administrative changes in the energy sector with the liberalization of the electricity market in Macedonia, which were undertaken by the Government, resulted in new rules for the big industrial consumers, which means that ELEM and MEPSO as state-owned companies are not obligated for their electricity supply. From an environmental point of view it means that if the consumers import the electricity, the environmental impacts depend on the technologies for electricity production of the country from which the electricity was bought.

Prospects for new generation units

As a result of the stagnation of building new power plants, the obsolete existing capacities, and especially the effect of increased electricity demand in Macedonia, it is necessary to begin with an intensive investment activity in building new generating capacities. All the realistic options have been taken into consideration in the development scenarios for the Macedonian Power System. Macedonia, as a poor country regarding energy resources, has additional limitations in the transport of large amounts of energy resources (coal, oil, etc.), due to its geographical position. Taking into account all limitations and conditions, real options for energy development of Macedonia are the following:

- domestic lignite with limited capacities for fuel supply to the existing thermal power plants in Bitola and Oslomej until 2025;
- domestic lignite for new thermal power plant candidates Mariovo and Negotino;
- imported coal with high caloric value;
- using the natural gas of the gas pipeline with capacity of 800 million m^3 per year;
- crude oil for TPP Negotino (from the OKTA Refinery or imported);
- hydroelectric potential;
- renewable sources (small hydropower plants, wind power, etc.).

Based on these options three scenarios for power system expansion have been developed: baseline scenario, the first mitigation and the second mitigation scenarios.

Domestic lignite has a low caloric value and limited reserves. The open mines of Suvodol and Oslomej are already at the end of their reserves (maximum of up to five years of exploitation). The fuel supply for the existing thermal power plants in Bitola and Oslomej until 2025 can be ensured with the existing lignite mines and with opening new ones, as follows:

- opening the new mine in Brod Gneotino (for TPP Bitola);
- exploitation of underground lignite in Suvodol (for TPP Bitola);
- opening a new mine in Popovjani (for TPP Oslomej);
- importation of coal or lignite (Kosovo, Greece, ...) .

Mariovo and Negotino are locations near lignite mines, but their exploitation may be very expensive.

Imported coal with a high caloric value is the second option for fuel supply to the existing thermal power plants, but with limited capacities for continuous transport of large amounts of coal. Anyway, this possibility has been taken into consideration as the worst environmental scenario for development of Macedonia's power system.

Natural gas as an energy resource is the second option for fuel supply to the thermal power plants in Macedonia. The existing gas pipeline with a capacity of 800 million m^3 per year, and with the possibility of increasing the capacity up to 1,200 million m^3 per year is not being utilized by more than 15% (the gas consumption in Macedonia is up to 100 million m^3 per year). Therefore, the possibility for electricity generation from natural gas should be used in the next period. In the first and in the second mitigation scenarios, the building of the new thermal power plant candidates is based on gas-fired power plants, mainly with combined cycle (CC), and with combined heat and power production (CHP). These power plants have high efficiency and small heat rate, which can be more cost effective than the thermal power plants run on other fossil fuels. The first gas power plant in Macedonia is CHP Skopje which is under construction, and which is expected to start operating in 2009.

The operation of TPP Negotino is based on **crude oil,** which can be provided from the OKTA refinery or by importation. The infrastructure and the location of TPP Negotino enable its oil supply by rail transport.

Macedonia, as a poor country regarding fossil energy resources, should have maximum use of its **hydroelectric potential.** The new candidates for hydropower plants for which there is a good technical and hydrological foundation are mainly located in the western part of the country. Activities for their building have been initiated by tenders and by giving them under concession to foreign or domestic investors. All planned hydropower plants have been taken into consideration in the developing of the scenarios in the study.

Using the **renewable sources** for electricity generation is limited only to small hydropower plants, wind power plants, and solar power. Activities in building small hydropower plants have been initiated with the tender for the building of 60 small hydropower plants with a total installed power of around 43 MW.[1] The use of wind power is in an initial stage, of testing suitable locations in Macedonia. Solar power is still an expensive option for electricity production and lately there is a certain delay in the world compared to the wind power. Anyway, investments in small hydropower plants and in wind power plants are a more expensive option in comparison with the conventional thermal and hydropower plants. These solutions for using the renewable sources in electricity production can make a local contribution to the reduction of the electricity and energy needs.

Wind power is a cost effective if wind speed is over 8 m/s. This value of wind speed in Macedonia is on the mountains near the 2,000 m altitude above sea level, which can be an expensive technical solution for wind power. The best locations in Macedonia for wind power are Povardarie (around the river Vardar) and Ovce Pole (in the eastern part between the towns of Kocani and Stip). The greatest distribution of winds in Macedonia is those

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1 According to tender documentation from ELEM.

winds up to 4 m/s, so the wind potential in Macedonia as a continental country will be operated with a small capacity factor (below 10%). Some investors from Austria and Slovenia are interested in investments in wind power in Macedonia, but it is still far away from realization. The decision of the investors will follow after the measurements of the wind speed and the testing of the locations.

Solar power in Macedonia as a country with large a number of sun hours per year, can be used mainly in solar thermal systems for water heating because photovoltaics (PV) are still an expensive option for electricity production. It means that solar energy can be analysed from the energy efficiency point of view in households, residential, commercial, or industrial facilities, but mainly depends on the investment possibilities of the owners.

Geothermal energy in Macedonia is mostly used in locations near Kocani and Strumica. The thermal parameters of the water are low and insufficient for converting the geothermal energy into electrical energy. Geothermal energy in Macedonia can be used for recreation and for medical or tourist purposes (in spa centres), as well as for heating facilities and greenhouses. It means that geothermal energy in Macedonia can be taken into consideration locally, from the aspect of energy efficiency in the agricultural and industrial sectors, as well as for heating.

b) Scenarios for future expansion of the electricity generation system

The following three software tools: OPTIM, WASP, and LEAP have been used in the development of the system for electricity generation in Macedonia in the analysis of the study. The input data for hydropower plants as well as the technical characteristics for the water reservoirs and hydrological data have been processed with the OPTIM software tool. The electricity consumption in the first year (2006) was 8,300 GWh. The optimum solutions for a long-term expansion planning of the generating system in Macedonia have been processed with the WASP software tool. The output results from the WASP according to the input data give three different scenarios for planning the expansion generating as follows: the baseline scenario, the first mitigation scenario, and the second mitigation scenario. At the end of each development scenario analysis the LEAP software tool is used for evaluating the environmental impacts of each scenario.

- **The baseline scenario** assumes a maximum use of domestic lignite in the thermal power plants for covering the electricity needs in Macedonia, supposing there will be a fuel supply for the existing thermal power plants in Bitola (3×209 MW nett) and Oslomej (1×109 MW nett)[2] until 2025. Candidates on the list of thermal power plants are: TPP Mariovo with installed power of 209 MW[3] nett, the fourth unit of TPP Bitola with an installed power of the same size as the existing ones. Another lignite thermal power plant candidate is the TPP Negotino with installed power of 300 MW and with a mine near the location of the power plant. This scenario is mainly based on domestic lignite and it is the most destructive environmental scenario for the development of the Macedonian power system.
- **The first mitigation scenario** operates only with the existing thermal power plants in Macedonia. Apart from the candidates from the list of thermal power plants there are also two gas CHP power plants. One of them is the planned CHP Skopje with an installed power of 234 MW which is under construction, and the second one is CHP with an installed power of 300 MW, location still not defined. Therefore, the lignite-fired TPP Mariovo and TPP Negotino from the base scenario are not included in the first mitigation scenario.
- Additional assumption in **the second mitigation scenario** reduces the electricity consumption in the initial year of 2006 for the big industrial consumers (FENI, SILMAK, and the steel industry). Instead of the previous consumption of 8,300 GWh, the annual electricity needs in 2006 have been reduced to 6,700 GWh). The consumption is calculated according to hour-by-hour chronological values of loads in MW, and the distribution of the loads within the year is different with regard to the previous one, which can be noticed from the value of the load factor (for the reduced consumption it is 54% instead of 63% for the previous one). The reduced consumption refers only to distribution needs, and it is the effect of the liberalization of the electricity market for big industrial consumers, according to which they are obligated to provide energy supply for themselves on the market. The second different assumption involves renewable energy sources using small hydropower plants, wind power, and solar power. This is simulated by involving a small hydropower plant with aninstalled power of 25 MW and an annual electricity production of 45 GWh in the power system of Macedonia for every four years (2010, 2014, 2018, and 2022). By modelling such a small hydropower plant at every four years integrally, all renewable energy sources are taken into consideration. It means that at the end of the analysed period until 2025 the installed capacities from renewable energy sources will amount to 100 MW with a total annual electricity output of 180 GWh, which is a relatively optimistic forecast. The renewable energy sources should ease the development of new conventional power plants in Macedonian power system. The third assumption in this scenario is disconnecting the TPP Negotino from the Macedonian electricity system in 2009 by the activation of the new gas CHP in Skopje.

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[2] Nett power capacity is relevant for calculations of power needs planning, but the GHG emissions are calculated according the electrical production.

[3] According ELEM, TPP Mariovo is planning 300 MW. Two TPPs on domestic lignite are taken into consideration in the study (TPP Mariovo with 209 MW and TPP Negotino with 300 MW). These two options of lignite TPPs give possibilities for involving new lignite power plants in Macedonia, one with a 300 MW capacity as the planned one from ELEM, and the other with a capacity as the existing in Bitola.

Environmental impacts of the three scenarios

Detailed calculations for the GHG emission, as well as for other local emissions have been made for the three scenarios. The databases for the emission of the pollutants and the chemical content of different types of fuels according to the IPCC and Tier 2 are integrated in the software tool of LEAP (Long-range Energy Alternatives Planning System). The results from the calculations show the reducing of GHGs begins in 2009, when the CHP in Skopje starts operating according to the first mitigation scenario. (Fig. 5.1.1.1)

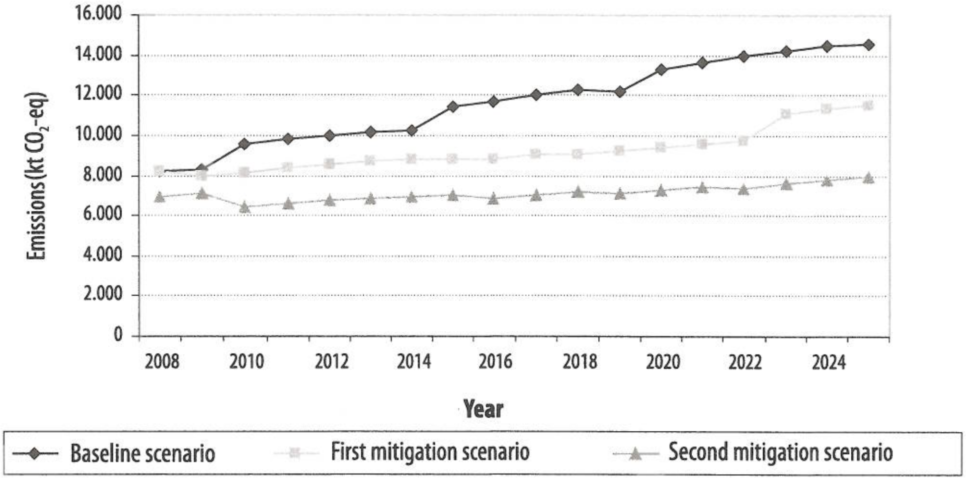

Figure 5.1.1.1 GHG emissions for the baseline scenario and for both mitigation scenarios [kt CO_2-eq]

The additional improving of the environmental impacts by reducing the GHG emission is due to the inclusion of the second CHP with an installed power of 300 MW in 2015. In the second mitigation scenario the additional environmental improvements are due to the reduced electricity production because of the reduced consumption. The final effect in the second mitigation scenario reduces the GHG emission by more than 6,000 kt of CO_2-eq in comparison with the baseline scenario.

5.1.2. Industrial Energy Transformations and Heating

Fossil fuels contribute with the largest share in the structure of the primary energy consumption for heating purposes in the industrial, residential, commercial and public sectors, agriculture, and other sectors in the country. According to the statistical data for the last few years, in this part of the energy sector, liquid fuels, mostly fuel oil and diesel oil, cover over a half of the primary energy for heat production. In the same period, the contribution of firewood is considerable, making about 20% of the total primary energy needs, used mostly in the households. In the liquid fuel supply, the Republic of Macedonia is completely dependent on the importation of crude oil. Domestic consumption of fuel oil products in the last few years ranges 700,000-1,000,000 t/year.

Further on, the contribution of firewood is significant, with about 20%, mostly in the residential sector, as well as the contribution of the solid fuels (lignite, hard coal, and coke), which participated with about 17.6% in 2005, mostly used as heat energy source in industry, agriculture, and other sectors. The share of natural gas (approximately 8% in 2005) and liquefied petrol gas (below 3% in the same year) is much smaller, while geothermal energy covers up to 1% of heat energy needs.

Regarding the final energy consumption, the distribution between various segments of the sector is relatively even, over the last few years. According to the energy balance for 2005, the final energy consumption in the industry amounts to 33.5%, the consumption in the households makes 29%, the transport sector 20.9%, and agriculture, commercial buildings, the public and administrative sector, and other areas contribute with 16.7% in the final consumption.

In developing of the **baseline scenario** for energy transformations in the industry sector and for heating, forecasts for annual growth rates of the economy activities, industrial production, energy needs and, in this framework, necessities for heat, etc., over the period 2006-2025, are assumed in accordance with relevant studies and publications that cover the mentioned period (annual growth rate of 3.5% during the first decade and of 3% during the second decade of the analysed period). The projections for the heat generation and for the consequent emissions of GHGs in the period 2006-2025 are derived by taking into account the following cases: the scenario without significant changes in relation to the actual practices, i.e. so-called "business as usual" scenario and the scenario that includes certain measures for reduction of GHG emission. Having in mind that the heat generation belongs to the wider energy sector, the analysis is done according to the same methodology and using the same emission factors as in the electricity generation sector. The analysis of the industrial energy transformations and heating, in the framework of the energy sector, is accomplished on a basis of the following division: (1) low-temperature heat consumers, that means, district heating systems, heat production and consumption for heating of buildings in the public and commercial sectors (hospitals, schools, administrative buildings, shopping centres, etc.), heat consumption in the residential sector, heat for agriculture and for other sectors; and (2) industrial heat consumers.

The main assumptions of the **mitigation scenario** regarding the GHG emissions originating from this part of the energy sector are:

- The same value of the growth rate of the overall energy needs is assumed as in the baseline scenario, although the optimistic prognoses regarding the expected economic development would lead to larger energy consumption; such necessity on the demand side would be compensated with measures of increased energy efficiency, energy saving, utilization of fewer energy-consuming technologies, etc.
- Certain redistribution regarding the used fuels is done, which is expected to be dictated partly by the market conditions and by the obligations for accomplishment of norms prescribed by the environmental legislation. In that sense, it is assumed that the growth rate of utilization of solid and liquid fuels will be lower, compared to the baseline scenario; a higher growth rate is assumed for biomass and the rest of the needs for thermal energy would be covered with gaseous fuels.
- In the energy transformation for heating purposes, the main point that should lead to mitigation of GHG emissions is introduction into operation of two combined heat and power plants run on natural gas, planned for commissioning in 2009 and 2015.
- Increasing of the share of the renewable energy sources in the country. In that sense, the energy potential of waste biomass of vegetative and animal origin, solar energy, and geothermal energy, in perspective, should get a more important place in the country's energy balance.

Comparison between the GHG emissions of the scenarios considered, presented as CO_2-eq, leads to a conclusion that the reduction of emission is relatively small. That is a result, most of all, of limited opportunities for fuels switching and transition towards energy resources with less potential for GHG production: limited capacity of a natural gas pipeline system, small probability for connection to other regional gas pipeline systems, limited potentials of the renewable energy sources, etc.

5.1.3. Transport

The analyses accomplished in the framework of the inventory of greenhouse gases show that the contribution of the transport sector is 10.6 ÷ 13.4% in the total CO_2-eq emission from the energy sector in the period from 1990 until 2002, while in the total GHG emission in Macedonia, presented as CO_2-eq emission, its contribution is 6.9 ÷ 9.6%. Regarding the energy consumption, road transport dominates ahead of railway and air transport.

In the period of the 1990s passenger and freight transport faced a decline in activities, which has been followed by certain recovery over the last few years. By far the largest share in the GHG emissions in the framework of the transport sector comes from activities in road transport. In the structure of registered motor vehicles, passenger cars dominate (resulting in an average of 124 cars per 1,000 inhabitants), far ahead of road haulage, while a much smaller share belongs to buses. The age structure of the vehicle fleet in the country is not favourable, since a large number of vehicles, which are still in use, were produced ten or more years ago. The railway transport in the country has exhibited a tendency towards stagnation in the last decade, which is characterized by reductions of the number of passenger lines, as well as with the certain decrease of the capacity of available rolling stock (locomotives, passenger carriages, and freight cars). The general trend in the air transport in the Republic of Macedonia in the last few years, when it comes to the number of carried passengers, is characterized with moderate growth. On the other hand, the total quantity of departing and arriving goods shows a permanent decrease in the period after 2001.

The projections of the trend of consumption of various fuels and consequent GHG emissions coming from the transport sector are based on officially published statistical data from the last fifteen years. While developing the **baseline scenario** for this sector over the period until 2025, the following main assumptions are taken into account, which, regarding the fact that the Republic of Macedonia still does not have a document for long-term strategic planning of its goals and development policies in the transport sector, are mostly a result of expert judgment:

- The conditions in the sector are expected to improve steadily (age structure of the vehicles, quality of public transportation, technical characteristics of the equipment, etc.), but the general state of various segments of the sector stays without significant changes, regarding the infrastructure, fuel used, etc.
- It is assumed that the average annual growth rate of the number of motor vehicles in the country will be 2% over the period from 2006 until 2015, followed by a 3% growth rate over the period 2016-2025.
- The average annual growth rate of passenger kilometres in the road transport and railway transport is assumed to be 2%.
- The annual growth rate of carried goods is assumed to be 4%.
- The trend of activities in air transport is based on estimations for increasing of the economic activities in the country and the assumed growth rate is 4% in the case of carried passengers and number of operations. In the case of carried goods, it is foreseen that the trend of decreasing will be stopped in the first years over the considered period and then, followed by a steady growth of the total amount of carried goods.

In the **mitigation scenario**, the main strategic directions that should be followed for reduction of GHG emissions coming from the activities in the transport sector are directed towards the following objectives: improvement of the efficiency in the transport sector and energy efficiency of the vehicles, which means, reduction of the specific energy consumption, improvement of the public urban and inter-city transport and bringing the national legislation into accord with European Union regulations.

When it comes to the type of fuel used in the road motor vehicles, it is assumed that there will be a change in the fuels' correlation, expressed as a steady decreasing of contribution of petrol vehicles, stagnation or moderate increase of the number of diesel vehicles and steady increase of the contribution of vehicles run on other fuels, between which the dominating are LPG, CNG, and bio-diesel. Although the offer of hybrid petrol-electrical vehicles on the world market permanently increases, because of certain technological and economic reasons, it is very difficult to foresee the penetration of these vehicles onto the domestic market in the middle term and that is why they are not included in the scenarios.

In the mitigation scenario for railway transport, it is foreseen that in the beginning of the analysed period there will not be any significant changes in the railway infrastructure, meaning, mainly, the length and the technical characteristics of the railway tracks. Regarding the locomotives power system, it is assumed that the correlation between the number of electrically driven and diesel locomotives will steadily change, in favour of electric locomotives; that means both, an increased number of electric locomotives and their bigger contribution in transportation of passengers and goods.

Based on comparison of the GHG emission projections, obtained with the scenarios, expressed through CO_2-eq, a conclusion can be drawn that with the proposed measures the obtained reduction of GHG emissions is relatively small. More visible effects could be expected by application of certain qualitative systematic solutions, such as qualitative improvement of the public urban and inter-city transport, development of integrated transport system, spreading, reconditioning, and better maintenance of the road infrastructure, qualitative improvement of the overall railway infrastructure, more intensive use of the railway transport and other measures, which, basically, are the way towards the development of an efficient public transport system.

5.1.4. Waste

GHG emissions in this sector comprise methane (CH_4) and nitrous oxide (N_2O) released during the waste decomposition in anaerobic conditions. According to the GHG emission inventory, the contribution of the waste sector is 5.5 ÷ 7% of the total CO_2-eq emissions. The waste sector includes the following three sub-sectors:

- Municipal Solid Waste (MSW);
- Wastewater handling (domestic and industrial wastewater);
- Human sewage.

Considering that the major part of the emissions comes from the solid waste disposal sites, the mitigation analyses will be made mainly for this sub-sector.

In order to reduce the GHG emissions from the waste decay, a technology for methane collection and flaring was adopted, thus converting the methane content of LFG into CO_2. In this sector following scenarios are considered:

- **Baseline scenario** which assumes that no changes will be made, and the GHG emissions will increase according to the demographic growth rate;
- **Mitigation scenario** which proposes implementation of systems for methane collection and flaring at nine landfills in Macedonia. The selection of these nine landfills is based on the preliminary analyses made for the purpose of the portfolio of potential CDM projects[4], developed under the established climate change related collaboration between the respective Macedonian and the Italian ministries of the environment.

The selected technology applied at the specified landfills, has been evaluated using the GACMO2 model.[5] This option has been compared to the baseline/reference scenario which assumes that the content of the disposed MSW and other organic matter are left to decay at the landfill, so that in the absence of the collection system methane will be emitted into the atmosphere. The mitigation scenario, in fact is a time schedule for implementation of the selected mitigation technology at the considered sites. The criteria for definition of the time schedule mainly involve the potential for emission reduction, geographical distribution of the sites, financial and technical capacities of the corresponding municipalities, etc. One possible mitigation scenario is presented in Table 5.1.4.1.

Table 5.1.4.1 Schedule for the implementation of the GHG mitigation technology in the waste sector (mitigation scenario)

	Landfill	Annual Emission Reductions [t CO_2-eq]	Annual Costs [USD]	Total Investment [USD]	Year of Implementation
1.	Skopje ('Drisla')	77,760	221,333	1,800,000	2009
2.	Veles ('Bunar Dere')	9,694	27,593	224,400	2010
3.	Gostivar ('Sibnica')	5,081	14,461	117,606	2010
4.	Kumanovo ('Krasta')	18,921	43,086	438,000	2011
5.	Bitola ('Meglenci')	15,137	43,086	350,400	2012
6.	Strumica ('Sapkar')	12,856	36,594	297,600	2013
7.	Stip ('Trestena Skala')	15,034	42,791	348,000	2014
8.	Kocani ('Belski Pat')	4,095	11,657	94,800	2014
9.	Vinica ('Leski')	3,888	11,067	90,000	2014

[4] "Assessment of the projects' potential in the fields of renewable energy sources, energy efficiency and forestry management, in the framework of Clean Development Mechanism of the Kyoto Protocol for the Republic of Macedonia", Italian Ministry for the Environment, Land and Sea, May 2007.

[5] Fenham, J., 'Introduction to the GACMO Mitigation Model' in: *Economics of Greenhouse Gas Limitations*. Handbook reports, UNEP, Riso National Laboratory, Denmark, 1999 ISBN: 87-550-2574-9.

As per the assumed mitigation scenario, after the year 2014 about 162 kt CO_2-eq can be reduced annually. That corresponds to 18% of total CO_2-eq of the waste sector. But it is worth mentioning that the selected technology in this study also recognizes non-GHG-related environmental benefits, such as reduced explosion or poison risks from uncontrolled migration of LFG and odour prevention from the landfill site.

5.1.5. Agriculture

The GHG emissions from the agricultural sector account for 8-15% of the total emissions and comprise methane (CH_4) and nitrous oxide (N_2O), originating from the following sources:

- Enteric fermentation (CH_4 emissions);
- Manure management (CH_4 and N_2O emissions);
- Rice cultivation (CH_4 emissions);
- Agricultural soils (N_2O emissions).

A considerable amount of waste is produced by the agricultural sector (around 530,000 tonnes of straw, from which 370,000 tonnes are used for stock-breeding, around 190,000 tonnes of cuttings from winegrowing and orcharding, and also a certain amount of animal waste from livestock breeding); the absence of the collection systems (with the exception of the systems of some individual farms) leads to the significant amount of GHG emissions. The current waste management practices are different, whereupon the waste from the cattle-breeding farms is stacked, burned, and used as a fertilizer; the waste from pig farms is released into the rivers or accumulated in lagoons (which are not properly managed). The crop residues are used as food or as mat for cattle and the pruning residues are burned or used for heating. Livestock breeding and agricultural activities such as crop production generate the largest part of the agricultural waste, therefore are associated with a major negative impact on the local environment.

Several projects related to the improvement of the Animal Waste Management System (AWMS) have been identified in the Republic of Macedonia that will reduce the uncontrolled release of GHG from manure. These projects are based on the technology for biogas collection and combustion at pig-breeding farms. This technology includes installation of covered lagoons creating negative pressure and anaerobic digesters, instead of current anaerobic open lagoons. The system will also include an efficient enclosed flare to combust the digester biogas, converting its methane content to CO_2 and thereby achieving significant GHG reduction. After anaerobic digestion, the solid sludge can be separated and stored for sale to the local farmers for land application as fertilizer.

In this analysis, the following scenarios were developed for the agricultural sector:

- **Baseline scenario** which does not assume introduction of any changes and the GHG emissions will increase in accordance with the growth rate of the number of animals, as well as the arable area in the country and the input of the nitrogen fertilizers;
- **The mitigation scenario** where the main activities are focussed on implementation of systems for biogas collection and combustion at six pig farms in Macedonia.

The implemented systems at the selected farms have been evaluated using the GACMO2 model and the calculated values, as well as the time schedule of the implementation are given in Table 5.1.5.1.

Table 5.1.5.1 Schedule for implementation of the GHG mitigation technology in the agricultural sector (Mitigation scenario)

	Pig farm	Annual Emission Reductions [t CO_2-eq]	Annual Costs [USD]	Total Investment [USD]	Year of implementation
1.	Veles ('Agria group')	6,240	41,802	390,000	2010
2.	Stip ('Tarinci')	2,870	19,229	179,400	2011
3.	Vinica ('Vineam')	1,560	10,450	97,500	2011
4.	Sveti Nikole ('Sveti Nikola')	1,654	11,078	103,350	2011
5.	Berovo ('Zito Males')	1,487	9,963	92,950	2011
6.	Tetovo ('Edinstvo')	3,744	25,081	234,000	2012

According to the mitigation scenario, the total possible GHG emission reduction in the agricultural sector, after 2012, is 17.55 kt CO_2-eq.

There are available technologies for reduction of GHG emissions in agriculture that can be used in Macedonia, but they are mostly related to increased production by unit area/unit head, managing of animal diet, better utilization of fertilizer and water, etc. These technologies should be further analysed and researchers should develop technologies that can be implemented in various regions in the country.

Production of bio-diesel as well as bio-ethanol and their use as energy sources can reduce emission from fossil fuels. There is potential for using of crop residues (straw, pruning residues, etc.) as an energy source. These options should be investigated and serious research should be conducted in order to maintain sustainability of agriculture (to produce energy without disturbing food production, and maintain soil and water quality).

Within this chapter the estimated GHG emissions by each sector have been integrated in order to project the total national GHG emissions over the period 2008-2025, following the three assumed scenarios: baseline (Business As Usual – BAU), first mitigation scenario, and second mitigation scenario. Worth mentioning is that the first mitigation and second mitigation scenarios differ only in the electricity sector, whereby the second mitigation scenario incorporates additional abatement measures, which, as will be shown later, will have a considerable contribution to the overall reduction of GHG emissions. The main figures for all scenarios are summarized in Table 5.2.1. Table 5.2.2 (and Figure 5.2.1), Table 5.2.3 (and Figure 5.2.2), and Table 5.2.4 (and Figure 5.2.3) show the GHG emissions by sector and total emissions, for each year of the analysed period and for each scenario, respectively.

Table 5.2.1. Key values for all three scenarios

	2008-total GHG emissions [kt CO_2-eq]	2025 – total GHG emissions [kt CO_2-eq]
BAU scenario	14,040	23,947
First Mitigation scenario	13,904	20,348
Second Mitigation scenario	12,645	16,713

Table 5.2.2. Projections of the total GHG emissions [kt CO_2-eq] – baseline scenario

	Power System	Heating	Industry	Transport	Waste	Agriculture	Total
2008	8,196	1,328	906	1,390	844	1,376	14,040
2009	8,268	1,375	937	1,432	847	1,517	14,376
2010	9,584	1,423	970	1,475	850	1,553	15,855
2011	9,836	1,472	1,004	1,520	853	1,595	16,280
2012	10,025	1,524	1,039	1,566	856	1,637	16,647
2013	10,154	1,577	1,076	1,614	859	1,679	16,959
2014	10,246	1,632	1,113	1,664	862	1,722	17,239
2015	11,388	1,690	1,152	1,715	865	1,764	18,574
2016	11,719	1,740	1,187	1,775	868	1,807	19,096
2017	12,006	1,792	1,222	1,838	871	1,851	19,580
2018	12,261	1,846	1,259	1,902	875	1,894	20,037
2019	12,199	1,902	1,297	1,970	878	1,937	20,183
2020	13,260	1,959	1,336	2,039	881	1,981	21,456
2021	13,628	2,017	1,376	2,112	884	2,025	22,042
2022	13,954	2,078	1,417	2,186	887	2,070	22,592
2023	14,241	2,140	1,459	2,264	891	2,114	23,109
2024	14,463	2,205	1,503	2,344	894	2,159	23,568
2025	14,600	2,271	1,548	2,427	897	2,204	23,947

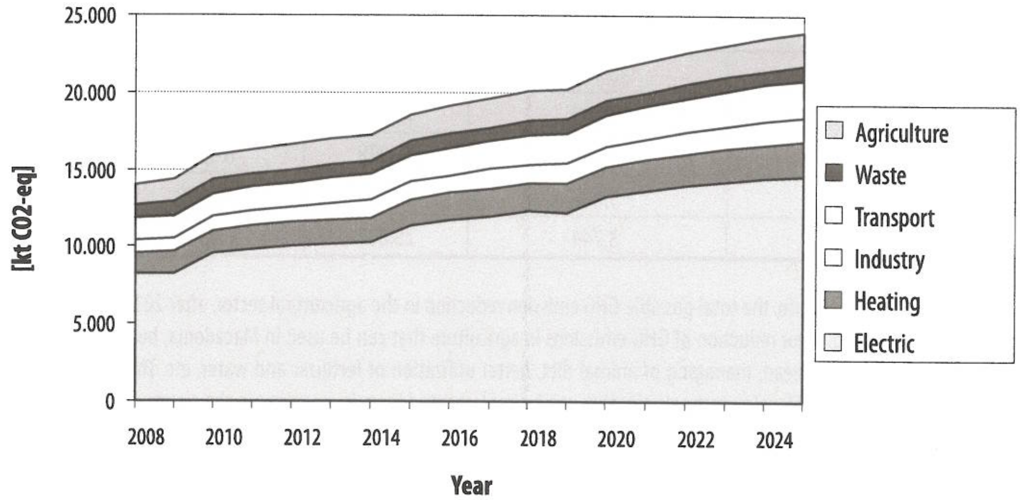

Figure 5.2.1. Projections of the total GHG emissions [kt CO_2-eq] – baseline scenario

Table 5.2.3. Projections of the total GHG emissions [kt CO_2-eq] – first mitigation scenario

	Power System	Heating	Industry	Transport	Waste	Agriculture	Total
2008	8,196	1,328	902	1,258	844	1,376	13,904
2009	7,922	1,353	931	1,296	769	1,517	13,788
2010	8,093	1,401	961	1,335	757	1,512	14,059
2011	8,354	1,451	993	1,375	741	1,546	14,460
2012	8,575	1,502	1,025	1,416	729	1,588	14,835
2013	8,719	1,556	1,059	1,458	720	1,630	15,142
2014	8,831	1,611	1,094	1,502	700	1,673	15,411
2015	8,784	1,647	1,130	1,547	703	1,715	15,526
2016	8,827	1,697	1,163	1,601	706	1,757	15,751
2017	9,071	1,749	1,196	1,656	709	1,800	16,181
2018	9,055	1,803	1,231	1,714	712	1,844	16,359
2019	9,262	1,859	1,267	1,773	715	1,887	16,763
2020	9,428	1,916	1,304	1,834	718	1,930	17,130
2021	9,580	1,975	1,342	1,897	722	1,974	17,490
2022	9,700	2,035	1,381	1,963	725	2,018	17,822
2023	11,131	2,097	1,422	2,031	728	2,063	19,472
2024	11,367	2,162	1,463	2,101	731	2,107	19,931
2025	11,553	2,228	1,506	2,174	735	2,152	20,348

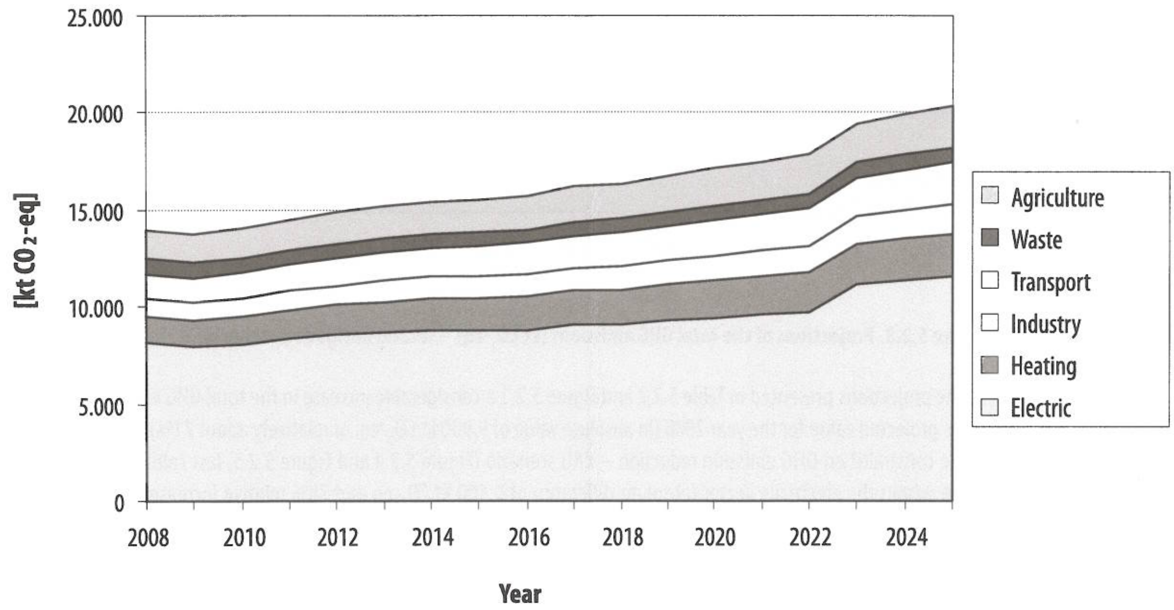

Figure 5.2.2. Projections of the total GHG emissions [kt CO_2-eq] – first mitigation scenario

Table 5.2.4. Projections of the total GHG emissions [kt CO_2-eq] – second mitigation scenario

	Power System	Heating	Industry	Transport	Waste	Agriculture	Total
2008	6,937	1,328	902	1,258	844	1,376	12,645
2009	7,082	1,353	931	1,296	769	1,517	12,948
2010	6,430	1,401	961	1,335	757	1,512	12,396
2011	6,613	1,451	993	1,375	741	1,546	12,719
2012	6,765	1,502	1,025	1,416	729	1,588	13,025
2013	6,881	1,556	1,059	1,458	720	1,630	13,304
2014	6,973	1,611	1,094	1,502	700	1,673	13,553
2015	6,990	1,647	1,130	1,547	703	1,715	13,732
2016	6,878	1,697	1,163	1,601	706	1,757	13,802
2017	7,042	1,749	1,196	1,656	709	1,800	14,152
2018	7,180	1,803	1,231	1,714	712	1,844	14,484
2019	7,143	1,859	1,267	1,773	715	1,887	14,644
2020	7,290	1,916	1,304	1,834	718	1,930	14,992
2021	7,415	1,975	1,342	1,897	722	1,974	15,325
2022	7,398	2,035	1,381	1,963	725	2,018	15,520
2023	7,586	2,097	1,422	2,031	728	2,063	15,927
2024	7,756	2,162	1,463	2,101	731	2,107	16,320
2025	7,918	2,228	1,506	2,174	735	2,152	16,713

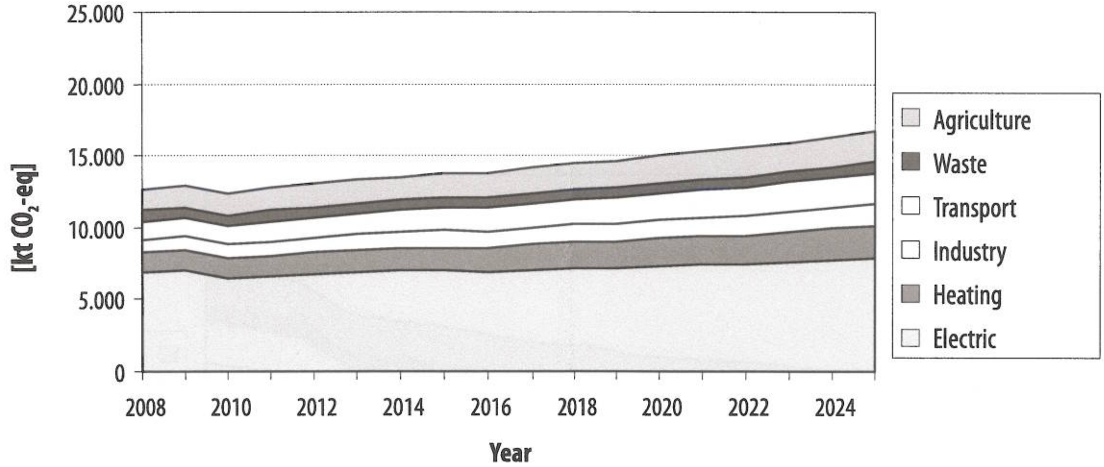

Figure 5.2.3. Projections of the total GHG emissions [kt CO_2-eq] – second mitigation scenario

BAU analyses: as per the projections presented in Table 5.2.2 and Figure 5.2.1 a considerable increase in the total GHG emissions by the year 2025 will occur compared to the projected value for the year 2008 (in absolute value of 9,900 kt CO_2-eq, or relatively about 71%) if the usual practice is applied without imposing the constraint on GHG emission reduction – BAU scenario (Figure 5.2.4 and Figure 5.2.5, last column). This increase is mainly related to the major rise within the electricity sector (absolute difference of 6,400 kt CO_2-eq and 78% relative increase to the 2008 value), which reflects the so-called black, lignite-based development scenario for the national power sector (Figure 5.2.4 and Figure 5.2.5, first column). The other sectors also exhibit significant rise in GHG emissions, as the 2025 values compared to the 2008 values are 75% (transport), 71% (heating and industry), 60% (agriculture), and 6% (waste) higher (Figure 5.2.4 and Figure 5.2.5).

Mitigation scenarios analyses: the situation can be improved if the developmental paths integrate practices/measures leading to GHG emission reductions. Hence, the first mitigation scenario (as defined in the sectoral analyses) leads to a 46% increase of the 2025 value of the total emissions compared to the 2008 total emissions or absolute difference of 6,400 kt CO_2-eq. (Table 5.2.3 and Figure 5.2.2; also Figure 5.2.4 and Figure 5.2.5, last column). This increase in the total emissions is further reduced to 32% (absolute difference of 4,000 kt CO_2-eq) if the developmental paths follow the second mitigation scenario (Table 5.2.4 and Figure 5.2.3; also Figure 5.2.4 and Figure 5.2.5, last column).

With regards to the sectoral projections for the three scenarios, the comparison between 2025 and 2008 emissions points to the largest achievement in the electricity sector. Namely, within this sector, the BAU relative increase of 78% is reduced to 41% by the first mitigation scenario (the first one in 2009 and the second one in 2015). Relative increase is reduced to 14% by the second mitigation scenario as a result of reduction of the electricity consumption for the value of the large consumers, introduction of renewable energy sources, and the disengagement of the TPP

Negotino when the CHP plant will start with operation (Figure 5.2.4 and Figure 5.2.5, last column). As to the other sectors, the effect of the waste sector is noticeable where the 6% BAU relative increase is turned into a negative relative increase (-13%) according to both mitigations scenarios, meaning that in the case of mitigation scenarios the 2025 waste emissions will be 13% lower than the corresponding 2008 values (Figure 5.4 and Figure 5.5, fifth column). The remaining sectors contribute slightly to the overall emission reduction, given the fact that the difference between BAU and mitigation scenarios ranges from 2% to 4%, (Figure 5.2.5).

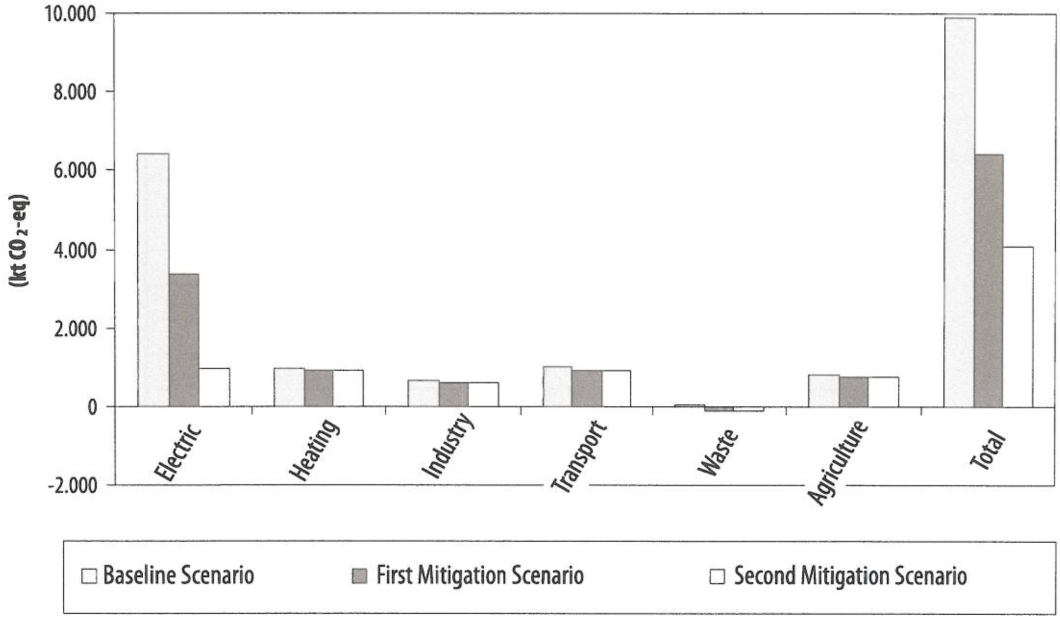

Figure 5.2.4. The effectiveness of the three scenarios expressed as an absolute increase of the 2025 emissions to the 2008 emissions [difference: 2025 emissions minus 2008 emissions in kt CO2-eq]

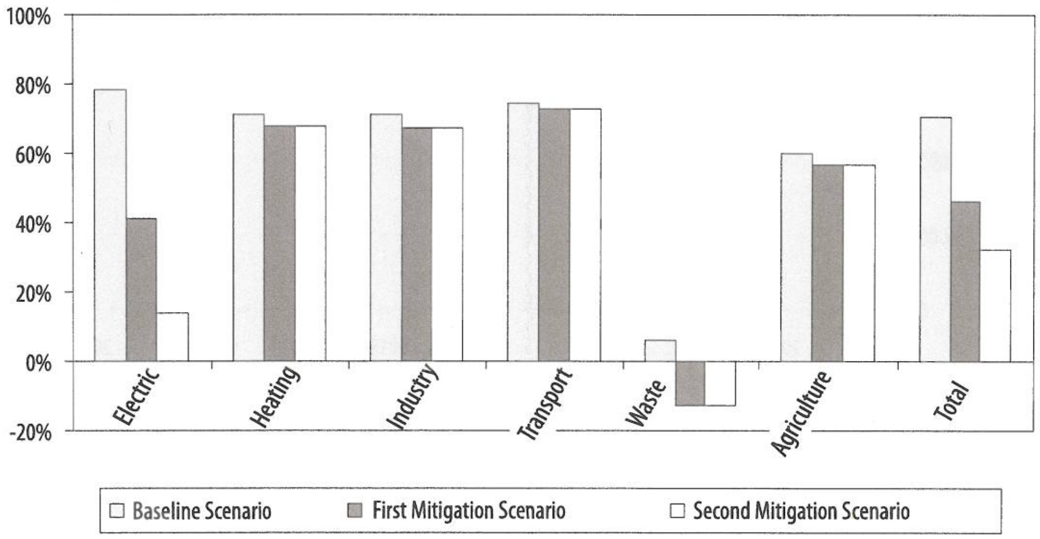

Figure 5.2.5. The effectiveness of the three scenarios expressed as relative increase of the 2025 emissions to the 2008 emissions

Finally, the overview of the projections of total GHG emissions for each year over the analysed period, according to the adopted scenarios is presented in Table 5.2.5 and Figure 5.2.6.

Table 5.2.5 Projections of the total GHG emissions for all three scenarios [kt CO2-eq]

Year	Baseline scenario	First mitigation scenario	Second mitigation scenario
2008	8,196	8,196	6,937
2009	8,268	7,922	7,082
2010	9,584	8,093	6,430
2011	9,836	8,354	6,613
2012	10,025	8,575	6,765
2013	10,154	8,719	6,881
2014	10,246	8,831	6,973
2015	11,388	8,784	6,990
2016	11,719	8,827	6,878
2017	12,006	9,071	7,042
2018	12,261	9,055	7,180
2019	12,199	9,262	7,143
2020	13,260	9,428	7,290
2021	13,628	9,580	7,415
2022	13,954	9,700	7,398
2023	14,241	11,131	7,586
2024	14,463	11,367	7,756
2025	14,600	11,553	7,918

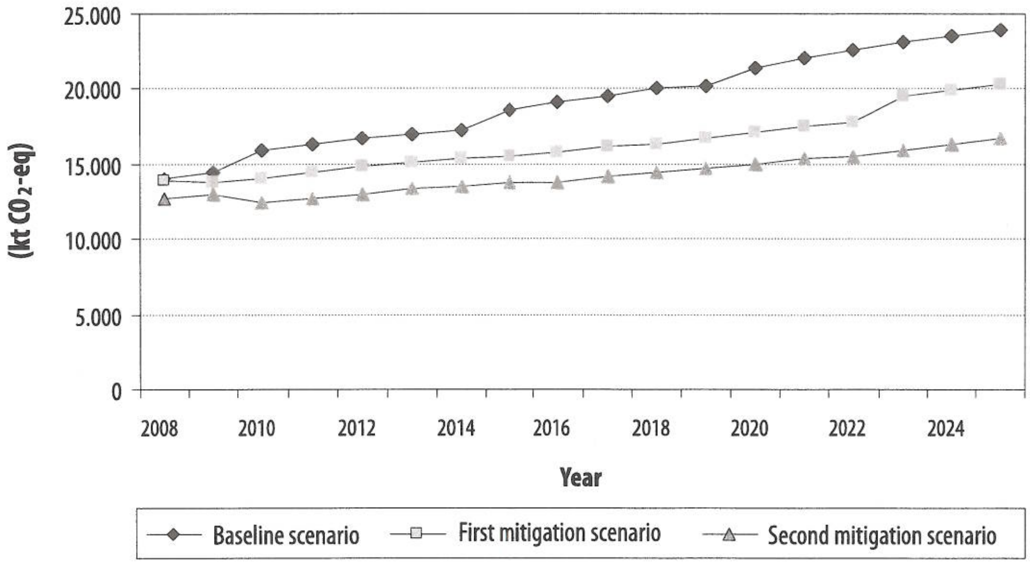

Figure 5.2.6. Projection of the total GHG emissions for all three scenarios [kt CO_2-eq]

In terms of carbon intensity (kt CO_2-eq per capita), Macedonia remains among the countries with relatively high per capita emissions mainly due to predominant use of fossil fuels for electricity generation. This parameter progressively decreases as the gas is introduced under the mitigation scenarios. This parameter is calculated for the three scenarios and presented in Table 5.2.6.

Table 5.2.6. Carbon intensity of Macedonia (GHG emissions per capita – t CO_2-eq per capita)

Year	Projections of the Population (1,000 persons)	BAU scenario	First Mitigation scenario	Second Mitigation scenario
2008	2,055	6.83	6.76	6.15
2012	2,080	8.00	7.13	6.26
2020	2,131	10.07	8.04	7.04
2025	2,163	11.07	9.41	7.73

5.3.1 Electric Power

According to the development scenarios for the Macedonian power system, some general directions for future activities in building new generating capacities can be given. Table 5.3.1.1 gives the overview of the dynamic activities in building new power plants for the period until 2025. For each of the three scenarios new thermal and hydropower capacities have been identified, as well as the year of the start of their operation. The table is actually a result of the optimization process in the WASP software tool, where the optimization is based on fully satisfying the needs for electric power, with minimum emissions related to electric power production and with minimum total costs (investments, fuel, and O&M costs).

Table 5.3.2.1. Dynamic of building new capacities for electricity production for the three scenarios

	BASELINE SCENARIO		**FIRST MITIGATION SCENARIO**		**SECOND MITIGATION SCENARIO**	
Year	Candidate	P (MW)	Candidate	P (MW)	Candidate	P (MW)
2008						
2009			Gas CC (CHP Skopje)	*234*		
2010	HPP Boskov Most	66	HPP Boskov Most	66	HPP Boskov Most	*66*
	TPP Bitola 4	209			Gas CC (CHP Skopje) 25MW (REN)	234
2011						
2012						
2013						
2014					25MW (REN)	
2015	HPP Galiste	194	Gas CC	*300*	HPP Galiste	194
	TPP Negotino coal	300				
2016			HPP Galiste	194	Gas CC	*234*
2017						
2018			HPP Cebren	280	25MW (REN)	
2019	HPP Cebren	280			HPP Cebren	280
2020	TPP Mariovo	209				
2021						
2022					Gas CC 25MW (REN)	*300*
2023			TPP Bitola 4	209		

According to the table, some proposals can be drawn as follows:

Using natural gas as a resource for electric power production. The maximum possibilities of the existing gas pipelines for electricity production are up to 4,000 GWh per year, or for building of two or three gas power plants with a total installed power of 700 MW. CHP Skopje which is under construction is the first one to start operating in 2009. The others should be built every five years in the following period, or in 2015 and around 2020.[6] With such a maximum utilization of the gas system the price of the natural gas can be reasonable for economical operation of the gas power plants.

The environmental effects of gas power plants are much more favourable compared to the environmental impacts from coal or oil-fired thermal power plants. The next table shows the GHG emission from thermal power plants in Macedonia compared to the gas CC power plants.

TPP Bitola	TPP Oslomej	TPP Negotino	Gas CC
(kg CO_2-eq / kWh)			
1,276	1,239	0,776	0,421

GHG emission from gas CC power plants is three times less than the same ones from TPP Bitola and TPP Oslomej, and around two times less than GHG emissions from oil-fired TPP Negotino. These environmental advantages of natural gas compared to lignite and oil without doubt should be the main attribute in favour of gas as a resource for electricity generation and for development of the electric power system in Macedonia.

[6] Two possibilities for the next gas power plants in Macedonia are taken into account: one of 234 MW installed power as the CHP in Skopje and the other one is 300 MW installed power, and both with no specific location. The tender documentation of ELEM is beyond the timeframe of the study, and the deadline of tender procedure is 2 July 2008.

Maximum use of the hydroelectric potential. All three scenarios take into consideration the maximum use of the hydroelectric potential in Macedonia. HPP Boskov Most[7] is the first hydropower plant which should start operating in 2010. The next ones, HPP Galiste and HPP Cebren[8], are planned to start operating after 2015.

Benefits of renewable sources. Renewable sources should be incorporated in the energy system continually without technical, social, or other limitations. In order to have a better implementation of the renewable sources some administrative and tax relief from legal aspects should be implemented, as well as ensuring the electricity output with guaranteed economic cost effective prices. Small hydropower plants and wind power plants should be based on private initiatives and investments which will be continually incorporated according to the locations and the interest of the market. The electricity production of small HPPs and of wind power plants strongly depends on hydrological and meteorological conditions and has a relatively small capacity factor of up to 20%. The low capacity factor cannot be a basis for energy planning, but it can contribute to reducing the operation of the conventional thermal and hydropower plants, and their effect is mainly at local level.

Energy efficiency as a strategy for energy saving. Energy efficiency is one of the main strategies for energy saving in developed countries and should become an imperative for Macedonia and for other developing countries. Energy efficiency is strongly related to the economic possibilities of the country as well as of the people. The technologically developed countries have significantly higher GDP and higher energy consumption per capita compared to Macedonia. It means that the developed countries have reached a high technological and economic level and can invest additional funds in reducing energy consumption.

Investments in energy efficiency projects require great funds, which mean that it may not be cost effective for old technologies or capacities. Energy efficiency by the consumer can be implemented mainly in the heating sector, industry (through energy saving with zero-cost, reducing the temperature in the premises, etc.). In the electricity sector, the contribution to energy efficiency can be made by reducing the electricity consumption by investing in more efficient electrical appliances as well as by replacing the old light bulbs with better ones. An additional imbalance of energy resources used for heating can be made with economically reasonable prices of fuels, in order that the consumers have a choice between different energy resources.

Nowadays, energy efficiency as a strategy is based on private initiatives and individual decision making by the consumers, and cannot be a general and obligatory requirement for all consumers, because it depends on the economic possibilities.

The measures which can contribute to GHG emission reduction in the electric power sector in Macedonia are listed in Table 5.3.1.2.

[7] The planning period for Boskov Most according ELEM is 2012 because of delaying of tender documentation.

[8] According to the development plan of ELEM HPP Cebren and HPP Galiste are being planned for 2014 and 2015 respectively, and in this study they are planned for operation after 2015. This is correct, real, and acceptable when taking into consideration the real possibilities and the uncertainties in hydro-planning (tender and technical documentations, building delay of such projects, financial and technical problems, etc.).

Table 5.3.1.3 Measures for GHG emission reduction in electric power sector

	Target	Objects / Investment	Type	Involved subjects	Timeframe	Finances	Environmental effects	Comments
1	Finalizing the law frame in the energy sector	Opening an electricity market for big consumers	Administrative	Government of RM, Ministry of Economy	In parliamentary procedure			Incorporation of renewable sources in the energy sector in accordance with EU regulations
2	Ensuring stability in energy supply with continual coal (lignite) supply to the existing thermal power plants in Bitola and Oslomej		Technical Energy, Economic	Government of RM, Ministry of Economy, ELEM				
		Brod Gneotino			Activities have started	€100 million		Especially important for continual fuel supply to TPP Bitola
		Underground mines of Suvodol			Middle term up to 10 years			Especially important for continual fuel supply of TPP Bitola
		Popovjani mine			Short-middle term up to five years			Especially important for continual fuel supply of TPP Oslomej
		Mariovo mine			Middle term up to ten years			Considering the possibility of building a new TPP Mariovo
		Importation of coal (lignite)			Activities have started	€30 /tonne	Possibility for more energy efficient and environmentally more suitable resource	- Ensuring fuel supply for the existing TPP Bitola and Oslomej. - Transport limitations for big amounts.
3	Ensuring stability in energy supply with investment activities for building new big hydropower plants		Technical Energy, Economic	Government of RM, Ministry of Economy, ELEM			No GHG emission ; Obligatory EIA	Big investments in capital projects with serious financial investors
		HPP Boskov Most		Concession, Private investors	Short-middle term up to five years; - Tender procedure in progress	€70 million		
		HPP Galiste		Concession, Private investors	Middle term up to ten years; - Tender procedure	€200 million		
		HPP Cebren		Concession, Private investors	Middle term up to ten years; - Tender procedure	€320 million		

	Target	Objects / Investment	Type	Involved subjects	Timeframe	Finances	Environmental effects	Comments
4	Ensuring stability in energy supply with investment activities for building new thermal power plants run on gas		Technical Energy, Economic	Government of RM, Ministry of Economy, ELEM	Short-middle term		Reducing the GHG emission with gradual introduction of gas in the thermal power plants	- Ensuring enough amounts of gas for two or three gas power plants with total installed power from 500 to 700 MW, for which 600 million Nm^3 gas annually are necessary - Strategic and long-term contract with gas suppliers for continual supply are necessary
		CHP Skopje 230 MW		AD Toplifikacija Skopje	Under construction	€135 million		The necessary amounts of natural gas have been provided
		CC gas (200-300 MW)		Government of RM, Ministry of Economy, ELEM	Middle term up to ten years	€250 million		Strategic and long-term contract with gas suppliers for continual supply are necessary
5	Increasing the share of renewable sources in the energy sector		Technical, Energy, Stimulating for sustainable development	Government of RM, Ministry of Economy, Local self-government	Short-middle term		No GHG emission	- Attracting foreign and domestic potential investors. Animation of the interested subjects with favourable legal regulations and other relief. There have already been tariffs introduced for guaranteed and economically suitable disposal of the produced electricity from small HPPs, wind power plants, and biomass. - Possible financial mechanisms: carbon financing and credits through the Programme for Sustainable Energy Development
		Small hydropower plants		Concession, Private investors	Continual construction process	€1500 /kW		The tender procedure for 60 small HPPs has already been finished. There are expectations for building small HPPs in the next few years with total installed power of 43 MW.

	Target	Objects / Investment	Type	Involved subjects	Timeframe	Finances	Environmental effects	Comments
		Wind power plants		Concession, Private investors	Continual construction process			Pilot projects and initial activities of measurements for wind speed in some locations have been started. The results of the decision for investments are expected in a few years.
		Solar thermal and PV panels		Private investors and initiatives, Stimulations from the Government	Continual construction process			- Governmental stimulation in financial support for thermal solar collectors. Other similar initial financial supports for private investments are necessary. - Reduced VAT
6	Improvement of the energy efficiency		Economic, Energy, Stimulating for sustainable development	Enterprises, Institutions, Households	Middle-long term		Saving energy and reduced GHG emission	- Building plants for production of combined heat and electrical energy (CHP). - Measures for reducing the losses in transmission and distribution of electricity. - Measures by the electricity consumers by introducing more efficient light bulbs, more efficient electrical appliances, etc. - Animation of the interested investors with favourable legal regulations and tax relief.

5.3.2. Industrial Energy Transformations and Heating

There are a series of measures identified in the segments of industrial energy transformations and heating, which would contribute to energy savings or would improve the energy efficiency, and, as an ultimate result, a certain reduction of the GHG emission would be achieved. The measures are classified according to the objectives that should be achieved in order to make reduction of the GHG emissions from the sector of industrial energy transformations and heating: reduction of the use of carbon intensive fuels, improvement of the energy efficiency and energy saving, increasing of the contribution of renewable energy sources in the country's energy balance, introduction of economically viable prices of electricity, and raising the awareness of the final consumers. Some of the measures that would give visible results are presented in Table 5.3.2.1.

Table 5.3.2.1 Measures for GHG emission reduction in the industrial energy transformations and heating sector

	Goal	Action	Type	Involved subjects	Timeframe	Financing	Comments
1	Reduction of the use of carbon intensive fuels	Replacement of coal with liquid or gaseous fuels; replacement of liquid fuels with gaseous fuels	Technical, economic, regulatory	MOEPP, ULSG, Industrial subjects, Subjects in the public sector	Short-middle term	Possibility for carbon financing and loans through the Programme for renewable energy	Issuing permits for adjustment of the installation in line with operational plans and integrated environmental permits.
2	Improvement of the energy efficiency and energy saving	- Improvement of the energy efficiency of the boiler plants with permanent maintenance; - Replacement of old equipment in boiler rooms, with regular reconditioning work; - Installation of measurement-regulation equipment and automatic control systems; - Better insulation, maintaining clean heat exchanging surfaces; - Utilization of heat content in flue gases; - Reduction of losses in systems for transportation of fluids; - Heat insulation of pipelines for transport of water, steam, fuels, etc.; - Reduction of specific consumption of energy in the industry by introduction of up-to-date technologies and processes; - Improvements of the performances of thermal cycle; - Improvement of the standards for construction of buildings, better insulation, use of high quality materials	Technical, economic, regulatory	MOE, Energy Agency, MOEPP, MOTC, ULSG, Industrial subjects, Heating plants	Short-middle term	Possibility for carbon financing and loans through the Programme for Renewable Energy; programmes with support of donors community	Investments are favourable, also, from the economic aspect. There is significant potential for GHG emission reduction in this segment.

	Goal	Action	Type	Involved subjects	Timeframe	Financing	Comments
3	Increasing of the contribution of renewable energy sources in the country's energy balance	- Utilization of waste biomass as an energy source and as a raw material for production of briquettes and pellets; - Installation of tens of boiler units on waste biomass in the agro-industry complex, industry sector, and in households; - Rehabilitation, and expanding of the geothermal system Geoterma-Kocani; - Revitalization of other systems on geothermal energy; - Introduction of solar energy systems for heating and hot water supply (in hotels, hospitals, schools, public buildings, health resorts, etc.)	Technical, economic, organizational	MOE, Energy Agency, MOEPP, MOTC, ULSG, Industrial subjects, Public enterprises, Households	Short-middle term	Possibility for carbon financing and loans through the Programme for Renewable Energy	Substitution of firewood with waste biomass, which will contribute to an increased sequestration
4	Introduction of economically viable prices of electricity	- Harmonization of the prices between different kinds of energy	Regulatory	Regulatory commission for energy	Middle term		
5	Awareness raising of the final consumers	- Reduction of electrical energy consumption in the households with measures of energy saving (home electrical appliances) and/or with replacement of electrical energy use with fuels or alternative energy sources; - Introduction of measurement equipment and charging in accordance with the consumption	Organizational	MOEPP, MOE, Energy Agency, NGOs, Media	Continuous	National budget	

5.3.3. Transport

There are a series of measures of a technical-technological, financial, and institutional character, which would result with certain reduction of the GHG emissions from the activities in the transport sector. The measures are classified in accordance with the planned objectives: improvement of the overall efficiency in the transport sector and energy efficiency of the vehicles, improvement of the public urban and inter-city transport and harmonization of the national legislative, regarding the transport sector, with European Union legislation. Some of the measures, which are, more-or-less, appropriate to the circumstances in Macedonia, are listed in Table 5.3.3.1.

Table 5.3.3.1 Measures for GHG emission reduction in the transport

	Goal	Action	Type	Involved subjects	Timeframe	Financing	Comments
1	Improvement of the overall efficiency in the transport sector and energy efficiency of the vehicles	- Revitalization, extension, and better maintenance of the road and railway infrastructure; - Extension-spreading of the electrification of the railway network; - Modernization of the vehicle fleet; - Motivation for wider use of alternative fuels and other power systems (LPG, CNG, bio-diesel, hybrid vehicles, etc.)	Technical, economic, legislative	MOTC, MOE, MOEPP, Institutions, Public and private enterprises, Citizens	Middle term, continuously	- National budget; - Budget of the municipalities; - Finances from the enterprises; - Foreign donations	Application of relevant European standards
2	Improvement of the public urban and inter-city transportation	- Improvement in the planning, organization and control of the traffic; - Measures for regulation of the traffic in central urban areas; - Modernization of the transport equipment for the public traffic; - Synchronization of the road signalization in the towns; - Introduction of electronic pay toll charging; - Introduction of electrically driven types of transport, i.e. tramway; - Railway transport – electrification of the railway network	Technical, economic, regulatory	Fund for national and regional roads, MOTC, MOE, MOEPP	Middle and long term	- National budget; - Budget of the municipalities; - Finances from the enterprises (public and private); - Foreign donations	Improvement of the public urban and inter-city transportation system is a basic condition for decreased use of cars in the urban and other areas, which is the main precondition for achievement of significant reduction of GHG emission from this sector
3	Harmonization of the national legislative, regarding the transport sector, with European Union directives	- Regulation on fuels quality in accordance with European Union norms	Legislation	MOE, MOTC, MOEPP, Legislative institutions, Other institutions	Short-middle term		Besides the necessity in the process of approximation towards EU integration, these measures contribute to the mitigation of GHG emission

5.3.4. Waste

This study takes into account current situation, conditions, and indicators comprised within the National Waste Management Plan. The improvements that will follow the adaptation of the Solid Waste Management Strategy for the Republic of Macedonia are not considered. This strategy is expected to provide a sustainable management concept that will also introduce measures for waste selection and recycling, composting, and reduction of the deposited waste. In the absence of this strategy the GHG emissions can be estimated according to current situations and management practices at the landfills. The mismanagement of the landfills and the lack of technical interventions and protection often are the cause of firing and self-incineration of the landfill sites which will result in uncontrolled burning, generation of dioxins, furans, nitrous oxide, reduction of the methane collection, and will increase the risk of explosions. Selected landfills are not technically structured to deposit a higher layer of waste, which should be well compressed in order to enable better conditions for LFG generation.

The most important measures for GHG mitigation in the waste sector are summarized in Table 5.3.4.1.

Table 5.3.4.1 Measures for GHG emission reduction in the waste sector

	Goal	Action	Type	Stakeholders	Timeframe	Financing	Comments
1	GHG emission reduction at the existing landfills	- Technical improvement of the existing landfills - Installation of methane recovery and flaring systems at selected landfills	Technical	Public enterprises Local authorities	Short-medium term	Municipal budgets, carbon financing (CDM)	Technical improvement is necessary in order to set up methane collection systems. This refers to the larger landfills where the LFG collection is viable
2	Improvement of the possibilities for efficient methane collection	- Construction of regional solid waste disposal sites	Technical	Local authorities	Short-medium term	National budget Municipal budgets Foreign investments	The regional SWDS will assure concentrating the waste at single places, which will enable efficient methane collection.
3	Reduction of the nitrous oxide (N_2O) emissions.	Introduction and realization of legal measures for restriction of the economic activities that include uncontrolled burning of the waste	Legislation Regulation	MOEPP Local authorities	Short term		Restriction of the waste exploitation activities
4	Reduction of the methane emissions from the wastewater	Expansion of the wastewater treatment plant network	Technical	MOEPP Local authorities	Short-medium term	National budget Municipal budgets Foreign investments	This will slightly affect the GHG emission reduction. But it will provide protection of the surface water thus protecting the water flora and fauna.
5	Raising public awareness for restriction of the uncontrolled burning of the waste	- Realization of public campaigns - Enhancement of the inspection and implementation of penalties/ provisions	Public awareness	MOEPP Local authorities Non-governmental sector Media	Continuous	National budget Donations	Involvement of the public (media, NGO, units of the local authorities) is essential for increasing the awareness of the damage caused by uncontrolled burning of the waste.

5.3.5. Agriculture

In the Republic of Macedonia there are scarce analyses for the GHG emission reduction in the agricultural sector. According to the previous analysis, there is a potential for emission reduction, but mobilization of the scientific and research stuff is necessary to identify the possible solutions.

This report provides a partial solution for manure management at animal farms (particularly pig farms).

As for emissions from other sources in the agricultural sector, several solutions are recommended for their reduction, which will target the future research analyses in this sector.

For example, methane emission from enteric fermentation can be reduced by increasing production by animal head, manipulation of dietary composition to minimize bacterial activity in the rumen, then with feed additives, antibiotics, vaccines, etc.

As additional measures that can be suggested in order to reduce the emissions of CH_4 and N_2O from manure management are: adjustment of the diet of animals to increase the amount of N_2O excreted in the manure at the cost of the urine, proper storage, manure combustion, utilization of the animal manure in the winter, etc.

Agriculture also has a great potential to answer the problem of CO_2 emissions from transport by growing oil crops for bio-diesel production and crops for bio-ethanol production.

Table 5.3.5.1 summarizes the main measures for mitigation of the GHG emissions in agriculture.

Table 5.3.5.1 Measures for GHG emission reduction in the agricultural sector

	Goal	Action	Type	Stakeholders	Timeframe	Financing	Comments
1	Enabling favourable pre-conditions for GHG emission reduction (laws, bylaws, institutional measures, support measures)	Approximation of legislation in agricultural sector with EU CAP	Policy Legislation	MOAFWE	Short term	National budget Foreign donations	Better access to EU funds and agricultural products more marketable
		Completion of institutional and legal reforms in irrigation sector	Policy Legislation	MOAFWE	Short term	National budget Foreign donations	Water communities and water management organizations fully operational.
		Increasing of the institutional and individual capacities for application of the available EU funds	Capacity building	MOAFWE	Short term	National budget Foreign donations	IPARD programme is adopted and there is a risk that the means will not be realized due to the lack of capacity
		Development of legislation and system for application of Good Agricultural Practices in the country	Policy Legislation	MOAFWE	Short term	National budget Foreign donations	Good Agricultural Practices can be a useful tool for reduction of GHG emission on the farm level
		Financial support for motivating the farmers to use mitigation technologies	Financial incentives	MOAFWE	Short-medium term	National budget Foreign donations	Farmers use mitigation technologies with economic benefit
2	Introduction/ development of GHG mitigation technologies in agriculture	Installation of methane recovery and flaring systems at selected farms	Technical	MOEPP MOAFWE Public enterprises Local authorities Farms	Short-medium term	Foreign investments Municipal budgets Agriculture support mechanism Carbon financing	Application of this technology will have significant effect on reduction of GHGs
		Research support programme for development of new mitigation technologies and transfer of the existing ones	Research	MOES MOAFWE MOEPP Foresting donation Research community	Short-medium term	National budget Foreign donations EU Research programmes	Allocated budget and developed system for support of projects that develop or upgrade mitigation technologies
		Programme for introduction of practices that use agriculture's potential for renewable energy and carbon sequestration, Programmatic CDM projects	Development	MOAFWE MOEPP MOE	Short term	National budget Foreign donations Private investments Carbon financing	Possibility for implementation of mechanisms for carbon emission reduction
3	Strengthening the national and local capacities for carbon financing	Training for CDM potential in agriculture Training for preparation of CDM documentation		MOEPP NGOs	Medium term	Foreign donation Bilateral projects	

4	Education (of experts/farmers/ decision makers) for application of mitigation measures/ technologies in agriculture	Current curricula and syllabuses upgraded with CC mitigation issues	Education	MOES Universities Vocational schools	Short-medium term	National budget Foreign donations	Students informed about CC mitigation issues and trained to scope problems
		Training of farmers for adopting new technologies	Education	MOAFWE Agency for development of agriculture Educational institutions	Short-medium term	National budget Foreign donations	A training system for farmers is planned through the Strategy for Agriculture and Rural Development 2007-2013
		Familiarization of public and institutions with the problem of CC mitigation	Public awareness	MOAFWE MOEPP NGOs Relevant scientific and educational institutions	Short-medium term	National budget Foreign donations	Public, especially the decision makers and agricultural producers, are not familiar enough with climate change issues

5.3.6. Forestry

Forestry is the only sector that acts like a carbon sink. Therefore, one of the measures for GHG emission reduction in this sector is afforestation. The Ministry of Agriculture, Forestry, and Water Economy has an approved budget of 160,000,000 MKD (€260,000) for 2008 to finance: afforestation of bare lands and coppicing; afforestation of bare land and erosive soils and melioration of degraded forests and coppice; sanitation of burned forest areas and prevention of mass oak forest dieback process; care; preventive protection from insect calamities and diseases and providing seedlings for forestation.

Forest fires are one of the most negative current factors in both Europe and the World, reducing forest areas and their health condition. Motivated by catastrophic national forest fires in 2007, several mass forestation national events have been organized in the last couple of years (on 12 March 2008, more than two million seedlings, equalling the number of citizens in the Republic of Macedonia, were planted in one day).

According to development plans of the Ministry of Agriculture, Forestry, and Water Economy, measures for GHG emission abatement are presented in Table 5.3.6.1.

Table 5.3.6.1 Measures for GHG emission reduction in the forestry sector

	Goal	Action	Type	Stakeholders	Timeframe	Financing	Comments
1	Implementation of the National Strategy for Sustainable Forestry Management	Encouraging afforestation	Policy Technical	MOAFWE PE Macedonian Forests	Continuous	National budget Foreign donations	Prospects for carbon financing
		Fire prevention measures	Policy Legislation Public Awareness	MOAFWE PE Macedonian Forests Inspectorate	Continuous	National budget	
		Measures for prevention of illegal logging	Legislation Public Awareness	MOAFWE PE Macedonian Forests Inspectorate	Continuous		Strengthening of penalties

5.3.7. Prospects for Implementation

The proposed measures/practices/projects/interventions in each of the sectors can be treated as the National Action Plan for climate change mitigation from a technical point of view (technical actions). However, in the wider sense, the National Action Plan also defines country-specific instruments, which will enable implementation of the proposed direct measures (economic and fiscal instruments; regulations and standards; voluntary agreements; information and public awareness; research and development).

One positive example from the national legislation is the Law on Environment, which includes commitment for preparation of national inventories of GHG emissions, as well as an action plan on measures and activities to abate the increase of GHG emissions. Furthermore, as a strategic document of primary importance, there is the National Strategy for Clean Development Mechanism (CDM) for the first commitment period of the Kyoto Protocol 2008-2012. The goal of the National CDM Strategy is to facilitate transfer of investment and technologies through CDM for implementation of projects that reduce GHG emissions and contribute to Macedonia's national sustainable development priorities.

Principally, the "non-technical" actions of the national climate change mitigation action plan, in fact, provide linkages and diffusion of the climate change mitigation objectives into all the other relevant national policies (energy, industry, transport, agriculture, forestry, environment, waste management, etc.). This will certainly enable implementation of the technical measures/practices/projects/interventions proposed under the mitigation scenarios developed within this study.