MINISTRY OF ENVIRONMENT AND
PHYSICAL PLANNING

Evaluation of Technology Needs for GHG Abatement in the Energy Sector

Skopje, April 2004

MINISTRY OF ENVIRONMENT AND
PHYSICAL PLANNING

Evaluation of Technology Needs for GHG Abatement in the Energy Sector

SUMMARY

Skopje, April 2004

Published by:
Ministry of Environment and Physical Planning

Design:
Sandra Hegedus, Fonko Design Center

Printed by:
Fonko Design Center, Skopje

Printing run:
500 copies

This publication is made available thanks to the UNDP-GEF's financial support under the project " Expedited Financing of Climate Change Enabling Activities"

CONTENTS

PREFACE

In accordance with the Operational Guidelines for Expedited Financing of Climate Change Enabling Activities, and after submission of the First National Communication to the Conference of the Parties, the Government of Macedonia obtained additional funds to conduct follow-up enabling activities in the climate change area. These funds contributed to maintaining and enhancing the established capacities of Macedonia for preparation of future National Communications.

The country-specific process of the Technology Needs Assessment (TNA) is based upon the findings and recommendations from the First National Communication, where within the abatement analyses the power generation sector (supply side) was studied in details along with clearly defined and quantified measures for emissions reduction. The GHG abatement team from the Research Center for Energy, Informatics and Materials of the Macedonian Academy of Sciences and Arts (Jordan Pop-Jordanov, Tome Bosevski, Natasa Markovska, Mirko Todorovski) extended its research in the Abatement and mitigation analysis, both on the supply and demand side, and evaluated supplementary measures mainly related to energy efficient and energy saving technologies, as well as renewable energy technologies.

This report is a summary of the analysis conducted within the project "Expedited financing of climate change enabling activities", executed by the Ministry of Environment and Physical Planning, financially supported by UNDP-GEF. It summarizes the results of the abatement technologies evaluation and identifies some of the potential projects, which reflect the priorities in GHG abatement policy of the country.

1. The process of technology needs assessment

The transfer of technologies, defined as the flow of experience, know-how and equipment between and within countries, is among the priorities under the UNFCCC. The key elements, the technology transfer is based upon, are:

- Technology needs and needs assessment
- Technology information
- Enabling environments
- Capacity building
- Mechanisms for technology transfer

By decision 4/CP.4 the COP urges non-Annex I countries under the UNFCCC to assess and submit their prioritized technology needs, especially those related to key technologies for addressing the climate changes. From a climate change and developmental perspective, technology needs assessment entails the identification and evaluation of technologies, practices and reforms that might be implemented in different sectors of a country to reduce GHG emissions and climate vulnerability.

Many of the technologies and practices are well-suited to the needs of development in its broadest sense. Furthermore, many of the technologies being developed in response to the needs of mitigation, especially renewable energy and energy efficiency, are now proving to be economically important sources of supplying and utilizing energy efficiently. Thus, technology transfer is of high importance in the context of both the UNFCCC and country development activities.

An effort is made to extract some quantitative results for most of the technologies. At this stage, the notion is not to perform a detailed analysis but to demonstrate the way to go, since the uncertainties are so big that any detailed analysis would probably fail. In parallel to the TNA process, the other technology transfer related activities should be directed toward setting the necessary institutional arrangements, legislative and administrative tools, and engagement of stakeholders, whose list by function ideally includes:

- Government departments with responsibility for:
  - Relevant areas of policy – energy, environment and development
  - Regulation of relevant sectors – energy, agriculture, forestry etc
  - Promotion and development of industry and international trade
  - Finance
- Industries and/or public sector bodies responsible for provision of utility services (energy, water, etc)
- Companies, industry and financial institutions involved in the manufacture, import and sale of climate response technologies
- Households, small businesses and farmers using the technologies and practices in question, and/or who are experiencing consequences of climate change
- NGOs involved with the promotion of environmental and social objectives
- Institutions that provide technical and scientific support to both government and industry (academic organizations, industry research and development centers, consultants, forums)
- Labor unions
- Consumer groups
- International organizations and donors

The actions identified in TNA do not result in delivery of enhanced technology transfer without effective implementation. Stakeholders' support will be particularly important after the various packages and policies proposed have been put together, with substantial 'buy in' from the private sector.

Practical aspects of this process can be studied through direct use of the software tool GACMO (GHG costing model), which is used to evaluate the costs and benefits of a wide range of mitigation options, to calculate the GHG emissions reduction, as well as the average mitigation cost expressed in US$ per ton of CO_2 equivalent. It is able to combine the options in the form of an emissions reduction cost-curve, displaying the average cost of reducing GHG emissions for a number of different alternatives.

The basis for a mitigation analysis is a baseline or reference scenario for the development of the GHG emissions from the base year to the target year, which is chosen by the user. In a perfect baseline there is a total knowledge of the energy services supplied in the different energy consuming sectors i.e. the number of energy consuming units and the annual energy consumption by each unit. Ideally this information is needed to do a good mitigation study for a country.

The mitigation scenario combines the emissions from the reference scenario with the changes (i.e., reductions) in emissions introduced by the various mitigation options being evaluated. For each mitigation option, the technologies that deliver energy services in the reference option are changed. A mitigation unit of emissions from these new technologies offsets a unit of energy consumed in the reference scenario. A very important assumption that is made in this regard is that the level of energy service delivered by the reference option and the mitigation option does not affect the demand for the energy service. In other words, there is no change in the level of energy service demand when the new technology is introduced, e.g. the temperature in the room is kept constant, or the amount of person-km transported is the same.

The structure of the mitigation options in the different sectors varies a lot and it is impossible to describe them all in the same standard format. Therefore a flexible representation is used in GACMO for the options belonging to one of the following groups: energy efficiency, renewable resources and fuel replacement.

For each mitigation option, a unit measure for the new technology has to be defined, along with the penetration rate of the mitigation option in the country. For example, the units can be a refrigerator, a 1000 bulbs, one landfill, a MW, etc.

2. Selection of abatement technologies and collection of country-specific input data

For the energy sector, both on the supply and demand side, supplementary measures mainly related to energy efficient and energy saving technologies, as well as renewable energy technologies have been investigated. In Table 2.1 a list of selected abatement technologies and a base unit for each abatement option is given. These measures have been selected since they are most likely to be implemented in Macedonian conditions and there is data for constructing the mitigation options in previous relevant studies.

For each abatement option, all necessary input data in a form required by the GACMO software tool along with the data sources have been identified. In addition, underlying assumptions (fuel prices, electricity generation fuel mix, and emission factors) have been collected, providing the key-parameters for the abatement options evaluation.

3. Evaluation of the selected abatement technologies

Macedonia is a non-Annex I country under the UNFCCC, which means that, according to the Kyoto protocol, it has no a specific target for the reduction of GHG emissions in the period 2008-2012. Nevertheless, it has exhibited increased concern for the global problem of Climate Change.

3.1. General perspective on GHG emission reduction measures

In general, the Balkan countries face significant economic and social problems compared with the E.U. countries. It must be recognized that climate change issues are not of high priority in countries with economy in transition. Thus, GHG emission reduction policies can succeed only if they are integrated and implemented within the framework of these reforms. The main issues, in an effort to implement and enforce a GHG emission reduction policy, would be:

- **Institutional capacity building.** Effective administration and technical capacity are crucial points in adopting a realistic strategy, implementing and enforcing legislation and monitoring the results. It is noted that capacity building must be country-driven addressing the specific needs and conditions of each country.

Table 2.1. Selected country-specific abatement technologies

	Technology	Base unit	Sector
	Energy supply options		
1	Introduction of liquid fuel in power generation	1 plant	Electricity production
2	New hydro power at Boskov Most	70 MW plant	Electricity production
3	Mini hydro power (4 plants of 1 MW)	4 MW plant	Electricity production
4	Wind power plants	1 MW	Electricity production
5	Landfill gas power plant	1 plant	Electricity production
6	Geothermal heating for greenhouses and hotels in Bansko	1 plant	Agriculture and public services
7	Biogas from sewage water and animal manure in small agricultural industries (milk and diary production)	1 plant	Industry, Agriculture
8	Grid-connected solar PVs	1 kW	Residential
	Energy demand options		
9	Solar heater replacing electricity consumption for hot water in individual houses	1 unit	Residential
10	Air conditioning	1 unit	Residential
11	Efficient refrigerators	1 unit	Residential
12	Large Solar heaters replace electricity consumption for hot water in hotels, hospitals, public buildings and industry	1 unit	Public services
13	Efficient office lighting	1000 bulbs	Commercial
14	Efficient motors	1 kW	Industry
15	Efficient boilers	1 boiler	Industry
16	Replacement of bus diesel motors	1 bus	Transport

- **Incorporate a GHG reduction strategy within other policies that are considered to be of higher priority.** Since the country has other problems that are considered to be of higher priority, the targets of a GHG emission reduction strategy could be better implemented if incorporated to those strategies. Especially, for the energy and industrial sectors it would be advisable to include GHG as a parameter in the country's energy policy rather that trying to implement an integrated GHG policy which includes provisions for the energy production and industrial development.
- **Attract foreign investment.** Since the country lacks the financial resources needed to rehabilitate the energy sector and since it is currently trying to privatize its industrial sector, direct foreign investments are considered to be crucial since they can be the sources of the capital needed to introduce new technologies and production processes.

The expected rising of living standard will enable the people to take steps towards a behavior that is more environment-friendly. Particularly, the car fleet is expected to gradually be renewed (decrease the average age of the cars) and thus to implement new technologies with less emissions. In the same context energy conservation attitudes will be gradually adopted by the population (more efficient electric appliances, central heating systems, energy efficient buildings, etc). Such changes can be accelerated by adopting the right strategies, raising public awareness, education and implementation of relevant legislation. Furthermore, institutional capacity building could help to isolate those country-specific changes that are considered to lead to better results and implement further measures to accelerate them. Such measures include implementations of taxation subsidiaries and participation in relevant research projects.

Each measure has been examined in relation to three criteria:

- **Effectiveness:** refers to the reduction that will be achieved if the measure is implemented
- **Cost:** refers to the cost of implementation. Depending on the type of measure the cost may lie to the state, the industry, the consumers or to a combination of those.
- **Difficulty of implementation:** in order to define the difficulty of implementation, a number of aspects are taken into account including the availability of technology and know-how in the country, availability of raw materials, etc.

An effort has been made to extract some quantitative results for most of the measures. In order to proceed to the development and evaluation of GHG emission reduction scenarios certain assumptions are made regarding the macroeconomic conditions in Macedonia. The assumptions made are:

- There will be stability in the country. It is assumed that there will be no more regional conflicts to influence the economy or to destroy the existing power generating plants.
- The country will have a steady GDP increase. It is assumed that during the next two decades there will be a positive GDP increase due to macroeconomic stability, foreign financial assistance and rehabilitation efforts.
- A legislative and administrative (capacity building) framework will be prepared that will allow the inflow of direct foreign investments.
- No major international economic crisis will arise.
- There will be no shock in energy prices. This includes all forms of energy (i.e. electricity, motor fuels, natural gas, coal, etc.).

3.2. CO_2 abatement cost curve

Based on the characteristics of the selected abatement measures and county-specific input data (Table 3.1.), a comparative analysis of the measures can be performed resulting in chart for the cost effectiveness of each GHG abatement measure in terms of \$/t CO_{2-eq} (Figure 3.1.). It is evident that about half of the examined measures are "win-win"* or "no regret" measures in the long run, which means that they are beneficial even from a financial point of view. This is partially explained by the high energy intensity in the economy which has high potential for improvement. Most of the proposed measures are energy efficiency measures associated with beneficial environmental results. The measures in the power generation sector have negative costs for the hydro projects, while the others (introduction of liquid fuel in power generation and wind) have a positive specific cost although it is considered as low. The most cost effective measures appear to be replacement of old bus diesel motors with more efficient ones, probably due to very low characteristics of the old diesel motors, and application of geothermal energy in greenhouses and hotels which has moderate costs. At the other hand, PVs connected to electric grid is by far the most expensive measure due to the high investment costs.

Furthermore, the GHG abatement potential of the measures for the year 2010 can be also charted (Figure 3.2.). As it was expected, the introduction of liquid fuel in power generation (reduces 1.24 Mt CO_{2-eq}) along with industrial boiler improvement (reduces 1.48 Mt CO_{2-eq}) are the greater contributors to the overall GHG abatement (in total for these two measures about 2.72 Mt CO_{2-eq}), while all other options accumulate to 0.83 Mt CO_{2-eq}. If all the measures are implemented, the reduction in 2010 is estimated to be 3.55 Mt CO_{2-eq}, which is 19.74% of the baseline GHG emissions (approximately 18 Mt CO_{2-eq}).

* Measures in which the cost difference between reduction and reference option are negative, meaning that they are cost saving measures. In these measures initial investments are required, but they will be returned to the investors by itself in certain period generating profit afterwards. Even if climate changes were not an issue, there would still be a strong case for implementing these measures on the grounds of their efficiency benefits alone.

The combination of the two charts is a curve which is called CO_2 abatement cost curve or marginal cost abatement curve (Figure 3.3.), with the CO_2 abatement in 2010 (kt CO_{2-eq}) in the horizontal axis and the specific cost of each measure in \$/t CO_{2-eq} in the vertical axis. The measures are introduced in the marginal cost abatement curve according to their cost-effectiveness (most cost effective measures are introduced first in the left side of the curve). It must be emphasized that it is only an approximate curve as all the measures are introduced additively. The synergies and interactions between the measures are not taken into account. For example if the measures in the power generation sector are implemented then the power generation mix will be changed and a new emission factor for power generation must be calculated and applied in the subsequent measures related to electricity. Nevertheless, although this curve is an approximation, it serves well as an illustrative tool for recognizing priorities in GHG abatement policy. For example, in the present case with "win-win" measures (Geothermal district heating, Replacement of bus diesel motors, Efficient public office lighting, Efficient refrigerators, Hydro power plant Boskov Most, Efficient motors and Landfill gas power plant) GHG emissions in 2010 can be reduced by 0.49 Mt CO_{2-eq} (2.7%).

Table 3.1. Main characteristics of the selected abatement options

Reduction option	US\$/t CO_2	Unit type	Emission reduction t CO_2/unit	Units penetrating in 2010	Emission reduction in 2010		
					Per option Mt/year	Cumulative	
						Mt/year	%
Geothermal district heating	-187.15	1 unit	2,269.34	1	0.0023	0.0023	0.01%
Replacement of bus diesel motors	-171.49	1 bus	22.75	2,000	0.0455	0.0478	0.27%
Efficient public office lighting	-24.98	1000 bulbs	87.60	200	0.0175	0.0653	0.36%
Efficient refrigerators	-8.63	1 refrigerator	0.58	150,000	0.0876	0.1529	0.85%
Hydro power plant (Boskov Most)	-4.09	1 plant	202,195.87	1	0.2022	0.3551	1.97%
Efficient motors	-3.22	1 kW	0.78	25,000	0.0194	0.3745	2.08%
Landfill gas power	-2.85	1 plant	112,232.58	1	0.1122	0.4868	2.70%
Wind turbines	4.16	1 MW	2,872.98	50	0.1436	0.6304	3.50%
Minihydro power	7.21	4 MW plant	12,423.71	1	0.0124	0.6428	3.57%
Large Solar Heater	11.70	1 unit	62.16	200	0.0124	0.6553	3.64%
Residental solar water heating	19.35	1 unit	1.32	100,000	0.1320	0.7873	4.37%
Liquid fuel in power generation	22.71	1 plant	1,238,139.75	1	1.2381	2.0254	11.25%
Biogas from agro-ind. sewage water	43.21	1 digester	11,699.89	3	0.0351	2.0605	11.45%
Efficient industrial boilers	63.93	2 tones of steam	29,652.40	50	1.4826	3.5431	19.68%
Air Conditioners (residential)	70.51	1 air conditioner	0.16	60,000	0.0094	3.5525	19.74%
PVs connected to electric grid	398.22	1 kW	1.10	500	0.0006	3.5531	19.74%

Total baseline emission in 2010: 18 Mt $CO_{2-eq.}$ *

* Taken from the Macedonia's First National Communication Under the United Nations Framework Conventions on Climate Change, 2003.

Figure 3.1. Specific cost of measures for GHG emissions abatement

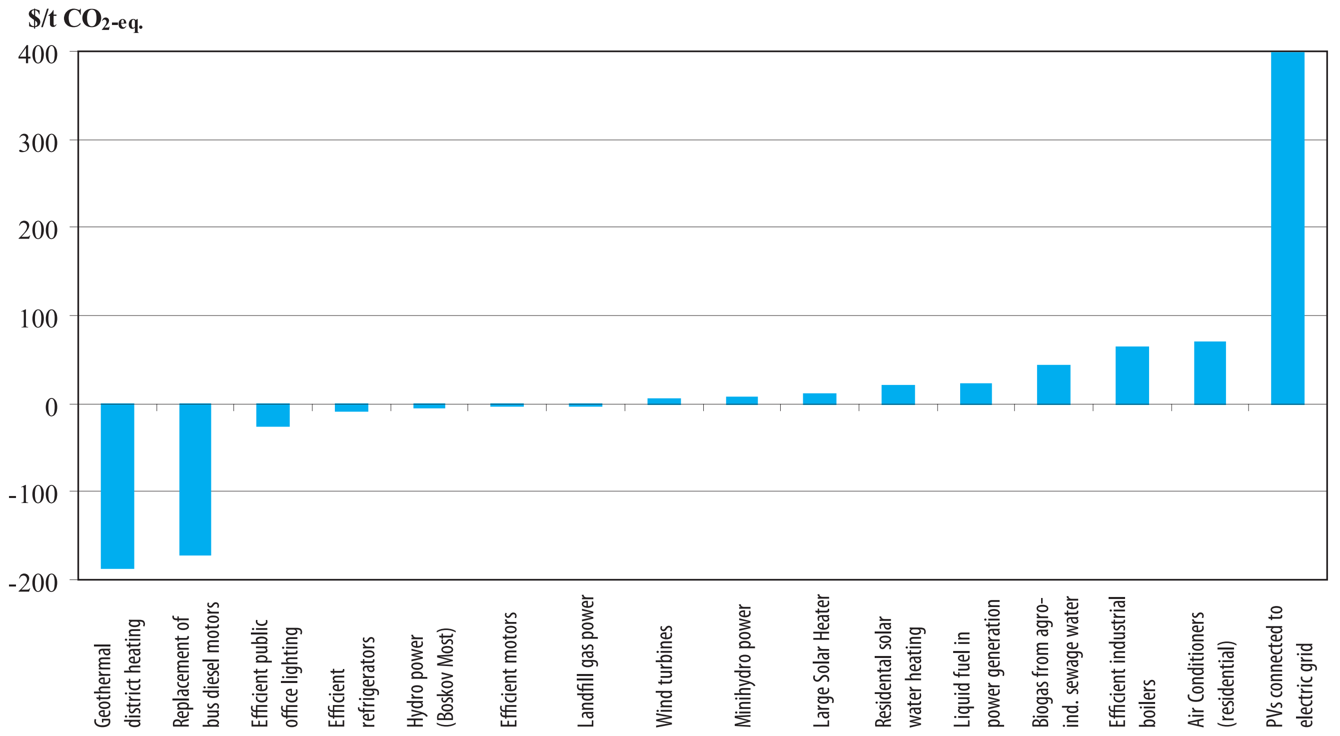


Figure 3.2. GHG abatement potential of measures in the year 2010

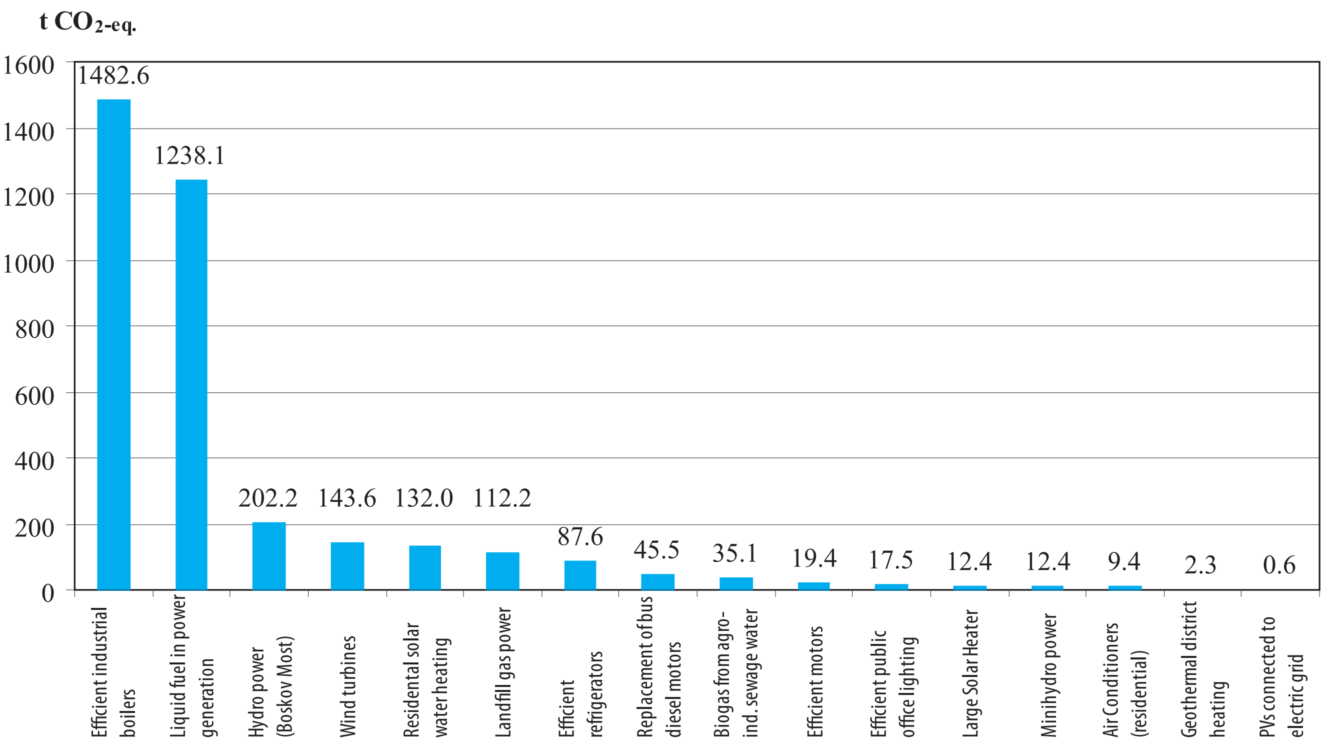
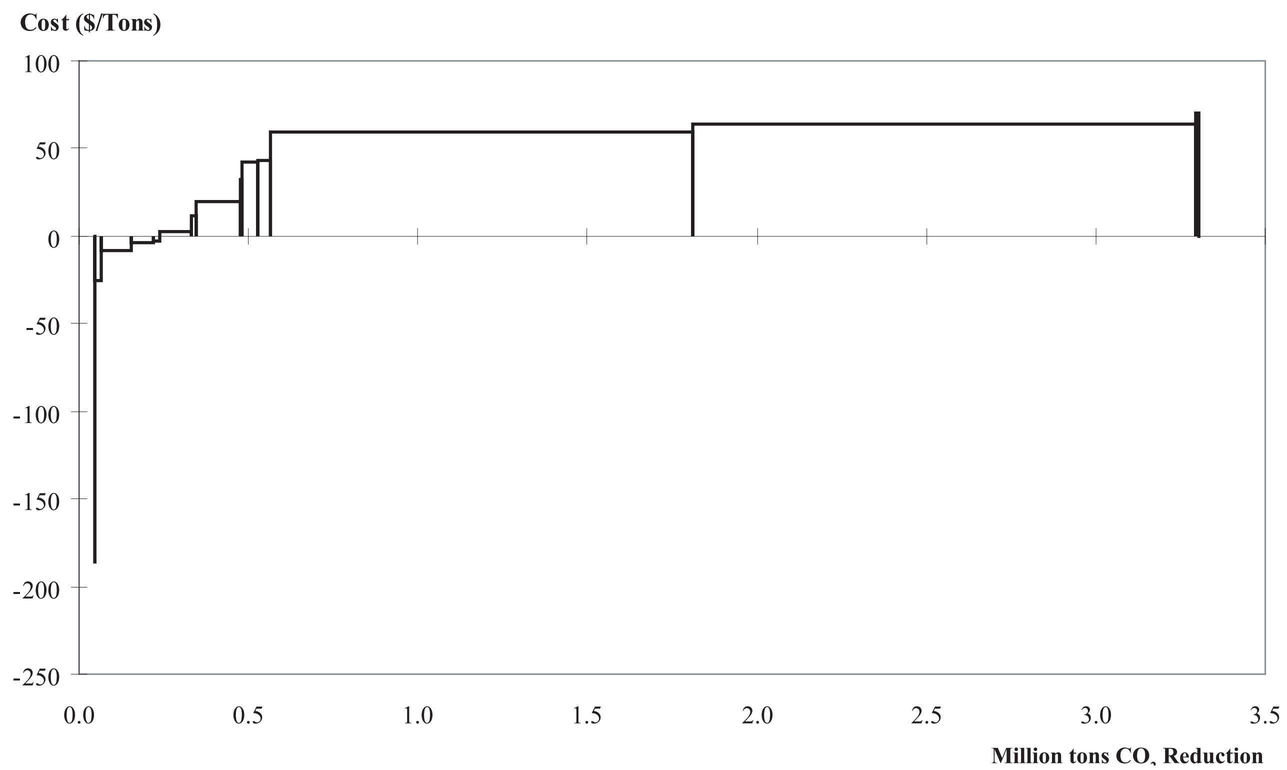


Figure 3.3. CO_2 abatement cost curve for the year 2010



4. Priorities for abatement technologies implementation

The measures presented in Section 2. are indicative of the situation in the country and they do not constitute an exhaustive catalogue of all the measures that could be taken in order to reduce GHG emissions by the year 2010. This year is chosen since it is a midyear in the first commitment period 2008-2012 in the Kyoto Protocol to the UNFCC. The measures have been quantified and compared with the baseline scenario, and for all of them difficulties in possible implementation have been identified. In Table 4.1 a brief comment about the effectiveness and the applicability of each measure is presented.

Table 4.1a. Comments on the examined supply side measures

	Measure	Comments
	Energy supply options	
1	Introduction of liquid fuel in power generation	High cost but high abatement potential as well. It also extends the use of indigenous lignite for longer period and delays introduction of new capacities.
2	New hydro power at Boskov Most	"Win-win" measure for which a feasibility study is done in 2001.
3	Mini hydro power (4 plants of 1 MW)	Relatively high cost.
4	Wind power plants	Further studies for the allocation of best sites are needed. Low load factor and uncertainty in availability (depends on wind conditions) with relatively high cost.
5	Landfill gas power plant	Promising option but must be incorporated in an integrated MSW management system to function optimally.
6	Geothermal heating for greenhouses and hotels in Bansko	Cost effective but with very low emission reduction.
7	Biogas from sewage water and animal manure in small agricultural industries (milk and diary production)	Relatively high cost and no detailed analyses and experience.
8	Grid-connected solar PVs	Extremely high cost and very low abatement potential.

Table 4.1b. Comments on the examined demand side measures

	Measure	Comments
	Energy demand options	
9	Solar heater replacing electricity consumption for hot water in individual houses	Campaign and/or incentives for undertaking the initial investment are required. Relatively low cost and low emission reduction.
10	Air conditioning	High costs and very low abatement potential.
11	Efficient refrigerators	Promising "win-win" measure with possible highest penetration rate in 2010.
12	Large Solar heaters reduce electricity consumption for hot water in hotels, hospitals, public buildings and industry	See comment 9.
13	Efficient office lighting	"Win-win" measure that is most easy to implement.
14	Efficient electric motors	Most promising measure in the industry, which is "win-win" as well.
15	Efficient boilers	High costs and highest abatement potential but low chances for implementation due to industry weakness.
16	Replacement of bus diesel motors	A measure with lowest cost, but with low emission reduction. Further analyses are needed.

4.1. Constraints

It is obvious that in an economy in transition like Macedonia, the climate change issues are not the first priority in the development policy and there are many constraints concerning their resolution.

In most of the cases there are constraints for implementation at a systematic or institutional level and sporadically at personal level, which is not a surprise bearing in mind the character of the measures and the current situation in Macedonia.

Concerning the measures quantification, one can conclude that in cost effectiveness low, medium and high cost measures are equally present, while their environmental effectiveness can be ranked as medium and high in almost all measures. Unfortunately, the situation regarding the difficulties for implementation is the opposite one, i.e. the measures that are most environmentally effective are most difficult to implement and there are many constraints in those cases. Only small portion of the measures can be assigned medium implementation difficulty, just the measures with low environmental effectiveness.

The biggest constrain appears to be the lack of finances and low potential for attraction of foreign investments, which is caused mainly by the bad economic situation and political circumstances in the country.

In many cases there is a lack of inter-ministerial communication and/or legislative and administrative barriers including lack of legislative commitments and limitations concerning the climate change.

Concerning the energy efficiency measures and renewable energy sources there are many cases where the main constraints are the lack of expertise and reluctance to new technologies along with the low level of awareness and interest even for the application in resolving vital energy related problems. Concerning the climate change problem, there is a low level of interest for investment since the economic criteria is the leading one in decision making.

In some of the measures, different interests of the stakeholders are serious constraints, since very large number of independent decision makers are present whose objectives are very difficult to harmonise.

The implementation of the measures can be supported either by administrative policies, which focus on the necessary regulations, or by economic policies, which strive to modify the behaviour of the stakeholders, and the criteria according to which their energy-related decisions are adopted.

In general terms, the priorities emerging from the measures are within the power generation sector where the solid fuels are dominant (this situation is not going to change significantly in the near future), so that any fuel switch will be beneficial from environmental point of view. Moreover, due to the great share of solid fuels in power generation, the energy efficiency measures gain major importance in the GHG abatement policy. Further exploitation of the natural gas in the energy system (power generation, industry, households and tertiary) is strongly recommended, as Macedonia has already the appropriate infrastructure. In such a way the use of indigenous lignite can be extended for a longer period, but it is economically unfavourable due to low electricity price and higher production costs. There is capacity to cope with this problem but the main constrain to be resolved remains the different interests of the stakeholders.

4.2. Financial aspects

The measures related with energy efficiency can be further promoted by adoption of a combination of appropriate financial legislative and measures for the promotion of energy efficiency and renewable energy sources projects. Rationalization of energy prices is essential, so that they reflect the actual costs and motivate the energy users towards energy efficiency measures. The most important actions include development of a strategy for energy efficiency up to 2020, legislative and other incentives (e.g. import duties and tax deduction for energy efficiency projects), creation of an Energy Efficiency Fund and Agency, development of technical specifications and financial guides, development of regulations, standards and other acts for efficient use of energy. The Energy Efficiency Agency will be responsible for the design of surveys, and the collection, collation and analysis of data related to energy supply and demand. These data will be reviewed and evaluated for their social, economic and environmental impacts. Additionally, the Energy Efficiency Agency will be responsible for promoting policies and activities that encourage the broad development and participation of the non-governmental sector in the implementation of energy efficiency programs. The real barrier to the creation of the Energy Efficiency Fund and Agency appears to be the commitment of financial and staff resources from an already constrained national budget.

The main Energy Efficiency Fund revenues should be additionally analyzed. In Macedonia coordination and collaboration of both the Ministry of Economy and the Ministry of Environment and Physical Planning will be essential to the success of both the Energy Efficiency Agency and the Energy Efficiency Fund. Development of specialized companies that would assume the financing and execution of energy conservation measures is an interesting possibility, which deserves serious consideration.

4.3. GHG abatement through renewable energy sources, transport and waste

Macedonia must examine more thoroughly the renewable energy sources (RES) that is gifted with. The RES technology advances very fast, mainly due to the increased international environmental concern. Overall RES costs dropped considerably and will continue to decrease providing that appropriate strategies are implemented for the technological development and the introduction of RES in the market. In some years several RES options will be competitive to conventional energy sources. Geothermal energy is already exploited in great extent and the perspective for wind and solar energy can be very promising in the near future. The world-wide experience has shown that the implementation of a wind power generation program at a national level requires both to solve complex legislative issues, to have a sufficient and reliable electricity grid and finally to attract private investment funds. The use of solar collectors for water heating can be a fruitful application because it will reduce the respective electricity load, which is significant. Moreover, solar energy is a renewable source of energy that is proved to be also cost- effective for countries with adequate solar radiation such as Macedonia.

In the transportation sector, which is not a major contributor to GHG emissions, it is necessary to integrate the requirements for GHG reduction in the general strategy for the transport sector in the country. There is necessity of system approach to the problem and preparation of relevant studies in the county, which should address the different interests of the stakeholders.

Municipal waste management is sector that offers opportunities for GHG emissions reduction. According to EU official policy, the first priorities that should be examined are either to avoid waste generation or to reduce its volume by recycling. The waste left after recycling can be managed with an environmentally sound way by implementing one or more of the existing technologies. It is doubtful if incentives alone can be sufficiently effective. In addition to the financial question it seems that another major obstacle is the lack of actual awareness of the situation and of the possibilities for profitable interventions. Increasing public awareness through campaigns and educational programs will help the society to understand the implications of GHG emissions and environmental pollution in general.

4.4. Public awareness and capacity building

Moreover, public awareness is a pre-requirement in order to successfully apply the measures, especially in the residential sector. Typical household measures like energy efficient lighting and insulation can be applied in order to reduce GHG emissions. As GDP grows, more and more people will shift to such products and will also seek to use more energy efficient buildings. Macedonia must set the legislative framework and must also put forward economic incentives to encourage people to buy energy-efficient appliances (e.g. reduced tax). Such an effort will also have economical advantages since it can create new markets and new services and production sectors (solar water heating is a characteristic example). A starting point could be to implement such technologies to public buildings like hospitals, schools, universities, etc.

Systematic and institutional capacity building will create the possibility to design, implement and enforce policies as well as to monitor their results. Diffusion of the environmental aspect as a parameter to other policies that are considered of primary importance to the country will assist to rationalize the economy and to create an environmental-concerned society. The attraction of foreign investment will ease the burden of the significant capital cost requirements, which are related to GHG emissions reduction.

5. Identification of potential projects

After performing a comprehensive analysis the working team proposed three projects, one from the Energy supply side, one from Energy demand in commercial/residential sector and one from Energy demand in industry, complying with the requirement for diversification of the selected measures.

When identifying the potential projects, the following criteria were put into place. Namely, the activity should:

a) Be of win-win type
b) Have significant environmental effectiveness
c) Have relatively good prospects for implementation

Accordingly, the projects proposed for further development are listed in the Table 5.1 and argumentation for their selection provided.

Table 5.1. Proposed projects for further development

Potential project	Criterion a)	Criterion b)	Criterion c)
Energy supply side			
HPP Boskov Most (see appendix A)	–4.09 US$/t $CO_{2\text{-eq.}}$	Highest abatement potential of 202.2 kt $CO_{2\text{-eq.}}$ within the win-win energy supply measures	– A feasibility study already exists – Increased interest in RES in the country – The measure is supported by the National electric power company
Energy demand in commercial/residential sector			
Efficient lighting Assumption: In 2010, 200,000 bulbs are replaced. (see appendix B)	Best cost effectiveness of –24.98 US$/t $CO_{2\text{-eq.}}$ within the measures in energy demand in commercial/residential sector	Abatement potential of 17.5 kt $CO_{2\text{-eq.}}$ which could be taken as satisfactory	The easiest measure for implementation, since – No specific qualifications is required for changing the bulbs, – Centralized decision for and control of the implementation is possible – Low time consuming measure
Energy demand in industry			
Efficient electric motors Assumption: In 2010, 25,000 motors are replaced (see appendix C)	This is the only one win-win measure in this sector with cost-effectiveness of -3.22 US$/t $CO_{2\text{-eq.}}$	Abatement potential of 19.4 kt $CO_{2\text{-eq.}}$ which could be taken as satisfactory	– The measure is in accord with the general need for modernization and restructuring of the industry sector in the country

Details on the identified projects

A. New hydro power plant Boskov Most

In the abatement study performed for the First National Communication, a new hydro power plant Boskov Most should be built in the near future, around the year 2010. Also, a feasibility study for this hydro power plant already exists. Besides the environmental benefits, with the improvement in using national hydro-potential the construction of gas fired plants is within the capacity of the existing gas pipeline and their introduction in the power system is delayed for a few years compared with the base case. In this measure we consider construction of a lignite-fueled power plant as a reference option. The investments for the referent plant are 1,200 $/kW and the fuel price is 24 $/t.

The summarized information on this measure is presented in tables below, in a form prescribed within the GACMO methodology.

As can be seen the Table A.1 has two parts, namely upper part with the general and measures' specific input data and lower part with the calculated costs and emission savings. In the Table A.1 two options have been compared: construction of the HPP Boskov Most (reduction option) versus construction of new lignite fired power plant (reference option). For the reduction option, it was assumed that the HPP Boskov Most will have installed capacity of 70 MW used for 1,860 hours annually which yields 130 GWh annual electricity production. The investments for the plant are 1,000 $/kW and the O&M costs are estimated at 1% of the investments. The reference option (construction of a new lignite fired power plant) supplies the same amount of electricity (130 GWh) using lignite with emission factor of 0.142 t CO_{2-eq}/GJ where the fugitive emissions were included as well. The price of the lignite is 24$/t which is equivalent to 3.2 $/GJ. Assuming plant efficiency of 0.33 the reduction option could save 1,420,364 GJ lignite fuel annually. The lignite power plant has a capacity factor of 7,000 hours annually and its investments are 1,200 $/kW with 2% O&M costs.

Assuming HPP lifetime of 30 years, in the reduction option a decrease of 827,664 $ in total annual costs can be achieved, while the reduction of GHG emissions is 202,196 t/year. Accordingly, the specific costs (costs for reduction of 1 t CO_{2-eq}) amount to -4.09 $/t CO_{2-eq}.

Table A.1. Evaluation of hydro power plant Boskov Most

General inputs		
Discount rate	6%	
Reduction option: Hydro power plant		
O&M	1.0%	
Activity	70	MW
Investment in hydro power	1,000	US$/kW
Capacity factor	1,860	hours
Electricity production	130,200	MWh
Reference option: Lignite fueled power plant		
O&M	2.0%	
Investment saved	1,200	US$/kW
Efficiency	0.33	
Annual fuel saved	1,420,364	GJ
Cost of fuel saved	24.00	US$/ton
Cost of fuel saved	3.20	US$/GJ
$CO_{2-eq.}$ emission coefficient	0.142	ton $CO_{2-eq.}$/GJ
Capacity factor	7,000	hours

Costs in US$	Reduction Option	Reference Option	Increase (Red.-Ref.)
Total investment	70,000,000	84,000,000	
Project life	30	30	
Lev. investment	5,085,424	6,102,509	-1,017,085
Annual O&M	700,000	1,680,000	-980,000
Corrected lev. investment	5,085,424	1,621,524	3,463,900
Corrected annual O&M	700,000	446,400	253,600
Annual fuel cost		4,545,164	-4,545,164
Total annual cost	5,785,424	6,613,087	-827,664
Annual emissions (tons)	Tons	Tons	Reduction
Total $CO_{2-eq.}$ emission	0	202,196	202,196
US$/ton $CO_{2-eq.}$			-4.09

B. Efficient office lighting

The replacement of the conventional, incandescent lamps by new energy saving lamps (fluorescent etc) is one of the most popular measures for energy conservation. In the present case where the share of solid fuels in the power generation mix is significant, the electricity saving measures are even more effective from the environmental point of view. The summarized information on this measure is presented in tables below, in a form prescribed within the GACMO methodology.

In the Table B.1 two options have been compared: use of compact fluorescent lamps (reduction option) versus use of incandescent lamps (reference option). For the reduction option, it was assumed that compact fluorescent lamps will have capacity of 15 W used for 4 hours daily at 1,000 locations which yields 21.9 MWh annual electricity used. The investments for these lamps 12 $/lamp and the O&M costs are estimated at 0.15$/lamp change. The reference option (use of incandescent lamps) supplies the same amount of light using but with a capacity of 75 W at 1,000 location, so that 109.5 MWh electricity are required annually. The price of these lamps is 0.7 $/lamp while the O&M costs are the same as for the reduction option. The lamp lifetime for the reduction option is 12,000 hours (they will last 8.2 years at 4 hour daily usage), while in the reference option the lamp lifetime is 2,500 hours, so they have to be replaced 4.8 times on average or on each 625 days. That is the reason why their discount rate is bigger (10.27%) compared with the reduction option where it is 6% annually. It was assumed that in both cases the lamps will be used with 75% of the time in periods with low electricity tariff while the other 25% will be in the periods with high tariff, so that the average electricity price will be 0.036 $/kWh. The emission factor for the whole power system is 1 t $CO_{2\text{-eq.}}$/MWh.

Assuming compact fluorescent lamps lifetimes of 8.2 years, in the reduction option a decrease of 2,188.51 $ in total annual costs can be achieved, while the reduction of GHG emissions is 87.6 t/year. Accordingly, the specific costs (costs for reduction of 1 t $CO_{2\text{-eq.}}$) amount to -24.98 $/t $CO_{2\text{-eq.}}$.

Table B.1. Evaluation of the efficient office lighting

General inputs:	Discount rate: 6%	
Fraction of time using low tarif	75%	
Fraction of time using high tarif	25%	
Average electricity price	0.036	US$/kWh
$CO_{2\text{-eq.}}$ emission coefficient	1.000	ton $CO_{2\text{-eq.}}$/MWh
Reduction option: Compact fluorescent lamps		
O&M	0.15	US$/lamp change
Activity	1,000	Locations
Cost of eff. Lamp	12.00	US$
Lamp lifetime	12,000	Hrs
Lamp wattage	15	W
Daily usage	4	Hrs
Annual electricity used	21.9	MWh
Reference option: Incandescent lamps		
O&M	0.15	US$/lamp change
Activity	1,000	Locations
Cost of incand. Lamp	0.70	US$
Lamp lifetime 1	2,500	Hours
Lamp lifetime 2	625	Days
Required lamp replacements	4.8	Times
Lamp discount rate	10.27%	
Lamp wattage	75	W
Daily usage	4	Hrs
Annual electricity used	109.5	MWh

Costs in US$	Reduction Option	Reference Option	Increase (Red.-Ref.)
Total investment	12,000	4,077	
Project life	8.2	8.2	
Lev. Investment	1,892	643	1249
Annual O&M	24	284	-260
Annual electricity cost	794	3,972	-3177
Total annual cost	2,710	4,899	-2,188.51
Annual emissions (tons)	Tons	Tons	Reduction
Total $CO_{2\text{-eq.}}$ emission	21.9	109.5	87.60
US$/ton $CO_{2\text{-eq.}}$			-24.98

C. Efficient electric motors

In this measure small size (1 kW) electric motors in industry have been evaluated. Two types of motors have been considered, with different efficiencies of 72% for the old ones and 84% for the new motors. Practically, the following two cases which may arise when there is a failure in the existing motors in industry are compared: to buy a new more efficient motor with 150 $/kW price or to repair the old one at price of 30 $/kW. In both cases, it was assumed that the motor is running 245 days/year (365 days minus 100 weekdays and 20 days holidays) in 16 hours per day with 50% of the time in low and high tariff, so that the average electricity cost is 0.023 $/kWh. The electricity prices for the industry, as well as peak load prices in both cases have been taken. The summarized information on this measure is presented in tables below, in a form prescribed within the GACMO methodology.

For both options, it was assumed that the annual O&M costs will be 1% of the investment and that the lifetime period for both motors is 10 years. In both options the motor output is the same (1 kW), while the input is 1.190 kW for the reduction option (efficiency: 0.84) and 1.389 kW for the reference option (efficiency: 0.72), so that the annual electricity used is 4,667 kWh in the reduction option and 5,444 kWh in the reference option. The emission factor for the whole power system is 1 t $CO_{2\text{-eq.}}$/MWh.

Assuming motor lifetime of 10 years, in the reduction option a decrease of 3 $ in total annual costs can be achieved, while the reduction of GHG emissions is 0.8 t/year. Accordingly, the specific costs (costs for reduction of 1 t $CO_{2\text{-eq.}}$) amount to -3.2 $/t $CO_{2\text{-eq.}}$.

Table C.1. Evaluation of the efficient electric motors

General inputs:	Discount rate 6%	
Fraction of time using low tariff	50%	
Fraction of time using high tariff	50%	
Average electricity price	0.023	US$/kWh
CO2-eq. emission coefficient	1.000	ton $CO_{2\text{-eq.}}$/MWh
Reduction option: New efficient motors		
O&M	1.0%	
Activity	1	kW
Lifetime	10	Years
Utilisation time	3,920	Hours
Motor efficiency	0.84	
Annual electricity used	4,667	kWh
Capacity needed	1.190	kW
Investment in eff. Motor	150	US$/kW
Reference option: Old motors		
O&M	1.0%	
Activity	1	kW
Utilisation time	3,920	Hours
Motor efficiency	0.72	
Annual electricity used	5,444	kWh
Capacity needed	1.389	kW
Repair of old motor	30	US$/kW

Costs in US$	Reduction Option	Reference Option	Increase (Red.-Ref.)
Total investment	150	30	
Project life	10	10	
Lev. investment	20	4	16
Annual electricity cost	113	132	-19
Total annual cost	133	136	-3
Annual emissions (tons)	Tons	Tons	Reduction
Total $CO_{2\text{-eq.}}$ emission	4.7	5.4	0.8
US$/ton $CO_{2\text{-eq.}}$			-3.2

Abbreviations

CO_2	Carbon Dioxide
$CO_{2\text{-}eq}$	Equivalent Carbon Dioxide
COP	Conference of Parties
EU	European Union
GACMO	GHG Costing Model
GDP	Gross Domestic Product
GHG	Greenhouse Gases
HPP	Hydro Power Plant
ICEIM-MANU	Research Center for Energy, Informatics and Materials Macedonian Academy of Sciences and Arts
MSW	Municipal Solid Waste
O&M	Operation and Maintenance
PV	Photovoltaics
RES	Renewable Energy Sources
TNA	Technology Needs Assessment
UNFCCC	United Nations Framework Convention on Climate Change