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# Evaluating GHG Mitigation Options and Technology Needs in the Energy Sector in Macedonia

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# 1. Environmental Aspect of the Energy Sector

- The energy sector in Macedonia is highly polluting and in critical need for modernisation.
- The contribution of the energy sector is about three-quarters of the total GHG emissions, the rest being shared nearly equally by industrial processes, agriculture and waste.
- Within the energy sector itself, the GHG emissions appear to be mostly due to electricity generation (73%), followed by heat generation (17%) and transport (10%).
- Need for more effective and energy-efficient technologies

# 2. Mitigation Options

| No. | Technology | Base unit |
|---|---|---|
| | **Energy-intensive consumer goods** | |
| 1 | Efficient lighting | 1000 bulbs |
| 2 | Efficient refrigerators | 1 unit |
| 3 | Air conditioning | 1 unit |
| 4 | Replacement of bus diesel motors | 1 bus |
| | **Electricity production and renewables** | |
| 5 | Introduction of liquid fuel in power generation | 1 plant |
| 6 | New hydro power at Boskov Most | 70 MW plant |
| 7 | Mini hydro power (4 plants of 1 MW) | 4 MW plant |
| 8 | Wind power plants | 1 MW |
| 9 | Landfill gas power plant | 1 plant |
| 10 | Geothermal heating for greenhouses and hotels | 1 plant |
| 11 | Biogas from small agricultural industries | 1 plant |
| 12 | Grid-connected solar PVs | 1 kW |
| 13 | Solar heater for hot water in individual houses | 1 unit |
| 14 | Large solar heaters for hot water in hotels, hospitals | 1 unit |
| | **Energy-intensive industry** | |
| 15 | Efficient motors | 1 kW |
| 16 | Efficient boilers | 1 boiler |

## 2.1. Economic and Environmental Evaluation

- Use of the software tool GACMO (GHG costing model)
- Total baseline GHG emissions in 2010 amount to 18 Mt $CO_2$-eq
- Energy–intensive consumer goods options chosen for elaboration of the economic and environmental effectiveness of the technologies in Macedonian conditions, as well as the country-specific barriers and opportunities for their transfer and diffusion

# *Economic and Environmental Evaluation of the Efficient Lighting*

| **General inputs:** | Discount rate: 6% |
|---|---|
| Fraction of time using low tariff | 75% |
| Fraction of time using high tariff | 25% |
| Average electricity price | 0.036 US$/kWh |
| $CO_2$-eq emission coefficient | 1.000 t $CO_2$-eq/MWh |

| **Mitigation option: Compact fluorescent lamps** | | |
|---|---|---|
| O&M | 0.15 | US$/lamp change |
| Activity | 1,000 | Locations |
| Cost of efficient lamp | 12.00 | US$ |
| Lamp lifetime | 12,000 | Hours |
| Lamp wattage | 15 | W |
| Daily usage | 4 | Hours |
| Annual electricity | 21.9 | MWh |

| **Reference option: Incandescent lamps** | | |
|---|---|---|
| O&M | 0.15 | US$/lamp change |
| Activity | 1,000 | Locations |
| Cost of the lamp | 0.70 | US$ |
| Lamp lifetime 1 | 2,500 | Hours |
| Lamp lifetime 2 | 625 | Days |
| Req. replacements | 4.8 | Times |
| Lamp discount rate | 10.27% | |
| Lamp wattage | 75 | W |
| Daily usage | 4 | Hours |
| Annual electricity used | | 109.5 MWh |

| **Costs in US$** | **Red. Option** | **Ref. 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 |
| Electricity cost | 794 | 3,972 | -3177 |
| Total annual cost | 2,710 | 4,899 | **-2,188.51** |
| **Annual emissions** | **Tons** | **Tons** | **Reduction** |
| Total $CO_2$-eq | 21.9 | 109.5 | **87.60** |
| **US$/t $CO_2$-eq** | | | **-24.98** |

# 2.1. Specific Costs and Achievable Reduction

## (A) Cost effectiveness:

- The most cost effective option appears to be the application of geothermal energy in greenhouses and hotels.
- The replacement of old bus engines with more efficient ones is on the second place.
- PVs connected to electric grid is by far the most expensive option due to the high initial investments.

## (B) Abatement potential

- The application of efficient industrial boilers (annual reduction of 1.48 Mt $CO_2$ -eq ) and the introduction of liquid fuel in electricity production (annual reduction of 1.24 Mt $CO_2$ -eq ) are the greatest contributors to the overall emission reduction. In total, these two options reduce about 2.72 Mt $CO_2$-eq annually.
- The cumulative reduction of all other options amounts to 0.83 Mt $CO_2$-eq.
- The total achievable reduction (if all considered options are implemented) in 2010 is estimated to be 3.55 Mt $CO_2$-eq, which is 19.74% of the baseline emissions.

**The mitigation options belonging to the sub-sector of energy–intensive consumer goods:**

- Exhibit high favourableness from the economic standpoint.
- Three out of four examined measures have negative specific costs
- Relatively low environmental effectiveness, being assessed to 0.89% from the baseline emissions in 2010.

**IF** by 2010

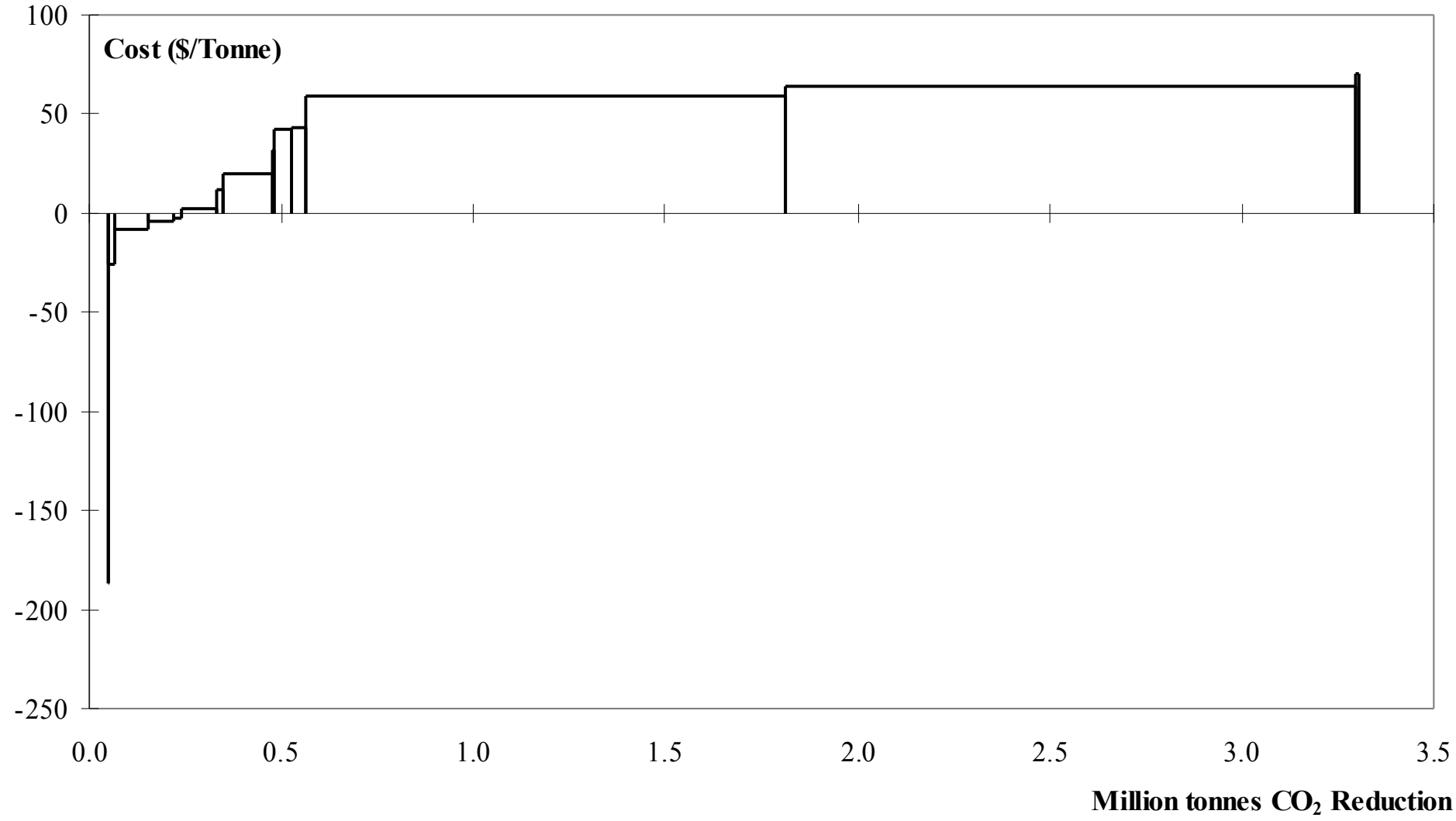
the motors of 2,000 buses are replaced by more efficient ones,

200,000 efficient lamps are installed,

150,000 efficient refrigerators are put into operation, and

60,000 households instead of outdated window air conditioners buy air conditioners with greater coefficient of performance,

**THEN** the total baseline emissions will be reduced by 0.16 Mt $CO_2$-eq.




Marginal cost abatement curve for the year 2010

# 3. Prospects for Transfer and Diffusion of Technologies

## 3.1. Driving Factors

***"No Regret" Implementation***

- Almost half of the examined options have negative specific costs or are "no regret" or "win-win" options in the long run.
- This could be explained by the high energy intensity in the present national economy, providing thus much room for improvements.
- Achievable reduction in 2010 by "no regret" options (Geothermal heating, Replacement of bus diesel motors, Efficient lighting, Efficient refrigerators, Hydro power plant Boskov Most, Efficient motors and Landfill gas power plant) amounts to 0.49 Mt $CO_2$-eq, which is 2.7% of the total baseline emissions in 2010.
- This particularly holds true for the options belonging to energy-intensive consumer goods subsector, since in Macedonian conditions most of them appear to be with negative costs.
- Even if climate change is not an issue, there will be still a strong case for implementing these options on the grounds of their economic benefits alone.

# 3.2. Limiting Barriers

## *Financing*

- The largest constrain to technology transfer in Macedonia,
- Even in the case of “no regret” technologies, it is very difficult to find national sources for the initial investment.
- The potential for attracting foreign investments is quite low, as a result of the high degree of uncertain political circumstances, bad economic situation and unfavourable business climate in the country.

**Possible improvements:**

- Rationalization of energy prices in the country.
- Introduction of economic incentives, such as import duties and tax deduction.
- Creation of Energy Efficiency Fund and Agency

## *Private and Public Decision-making*

- Lack of actual awareness of the situation and of possibilities for environmentally and economically beneficial interventions in the energy sector, among which is the transfer and diffusion of new technologies.

- Inertness and reluctance to new technologies along with the low level of interest even for the application in resolving vital energy related problems.

- Not always appropriately established criteria for selection of the technology to be bought or installed, particularly in the sub-sector of energy-intensive consumer goods.

- Different interests of the stakeholders; Very large number of independent decision-makers involved and their objectives difficult to harmonise. A starting point then, could be the implantation of the new technologies to public buildings, where the decision is made on a centralised level.

- The fact that in the countries with economy in transition, the economic criterion is the leading one in the decision-making, is the main rationale behind the low level of interest for investment in new technologies. For this reason, uncertainties related to expected energy and economic savings in such circumstances obtain more influential role in the decision-making and become more pronounced barriers to the process of technology transfer.

## *Required Infrastructure*

- Macedonia lacks the required infrastructure in terms of institutions, legislative framework and economic incentives, as well as personnel capable to deliver the required technical, managerial and financial services.
- In many cases the inter-ministerial communication is missing or insufficient, which holds true for almost all other stakeholders.
- The national legislation fails to address necessary commitments to contemporary technologies, having the situation further impaired by the complex and inefficient administration.
- The available human capacity is not enough and needs further empowerment in terms of skills, knowledge and awareness.
- The transfer and diffusion of technology in the country could not be realised without all stakeholders' support, including substantial "buy in" from the private sector.
- Development of specialized national private companies that would assume the financing and execution of technological breakthrough is strongly recommendable and deserves serious consideration.

# Underlying National Reports (www.unfccc.org.mk)

- ICEIM-MANU: Pop-Jordanov J.,... Markovska N.,...: **Inventory of Greenhouse Gases Emissions,** in: *Macedonia's First National Communication under the UNFCCC*, Ministry of Environment and Physical Planning/UNDP, p. 29-46, 2003

- ICEIM-MANU: Pop-Jordanov J.,... Markovska N.,...: **GHG Abatement Analysis and Projections of Emissions,** in: *Macedonia's First National Communication under the UNFCCC*, Ministry of Environment and Physical Planning/UNDP, p. 47-84, 2003

- ICEIM-MANU: Pop-Jordanov J.,... Markovska N.,...: **Evaluation of Technology Needs for GHG Abatement in the Energy Sector,** Ministry of Environment and Physical Planning/UNDP, April 2004

# International presentations

1. Markovska N., Todorovski M., Bosevski T., Pop-Jordanov J.: **Driving Factors and Limiting Barriers of Technology Transfer in the Energy Sector in Macedonia,** full paper, *The IPCC Expert Meeting on Industrial Technology Development, Transfer and Diffusion,* (Ed. Kessels J.), Tokyo, Japan, September 2004, pp. 200-212

3. Todorovski M., Markovska N., Bosevski T., Pop-Jordanov J.: **Energy-Related GHG Emission Analyses and Abatement Options,** full paper, *The 19th World Energy Congress*, Sydney, Australia, 5-9 September 2004.

**Research Center for Energy, Informatics and Materials of the Macedonian Academy of Sciences and Arts ICEIM-MANU (www.manu.edu.mk/icei)**

***Mission:*** to initiate and coordinate national research programs and to perform high-level research in selected fields, both applied and basic.

***Applied research of the Center:*** devoted to energy strategies, energy efficiency and renewable energy sources, as well as the environmental impacts of various energy technologies, including greenhouse gases emissions and climate change.

***The research staff:*** four academicians, two senior scientists, one junior scientist and two research assistants, as well as three postgraduate students. Over twenty collaborators from other national scientific institutions.

# *Projects:* Environmental research, particularly CC issues

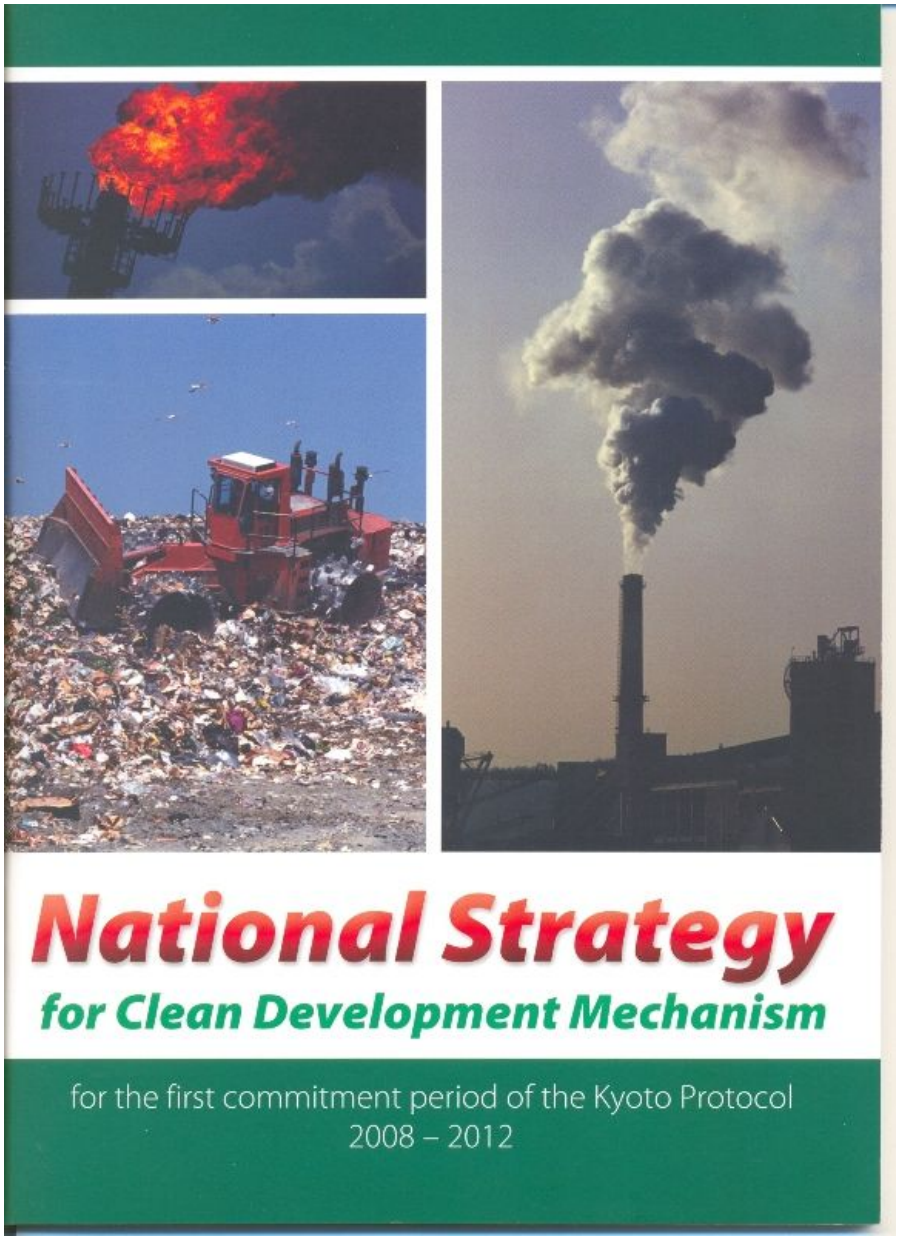
- Undertaking Inventory of GHG Emissions from Sources and Removals by Sinks in Macedonia, First National Communication to UNFCCC (financed by UNDP, period: 2001-2002)
- Undertaking GHG Abatement Analysis in the Republic of Macedonia, First National Communication to UNFCCC (UNDP, 2001-2002)
- Capacity Building in Balkans in Order to Deal with the Climate Change Problem (Greek Government, 2001-2002)
- Technology Needs Assessment in Energy Sector (TNA) – Expedited Financing of Climate Change Enabling Activities, Top-up activity (UNDP, 2003-2004)
- Capacity Building for Improving the Quality of Greenhouse Gas Inventories, Europe/CIS region (GEF Implementing agency: UNDP; Executing agency: UNOPS, 2003-2006)
- Preparation of GHG Inventory under the Second National Communication to UNFCCC (UNDP/GEF; Ministry of Environment and Physical Planning, 2005-2006)
- Undertaking GHG Abatement Analysis in the Republic of Macedonia under the Second National Communication to UNFCCC (UNDP, 2006-2007)

# *Projects:* Energy planning

- National Development Strategy for Macedonia, Energy Sector (UNDP and Rep. of Austria, 1995-1997)
- Establishment of a Country Specific Database for Macedonia, Containing Technical, Economic and Environmental Data for Electricity Supply Options and Strategies (UN IAEA, Vienna, 1996-1999).
- Fossil Fuel Energy Strategy (USAID/Electrotek, 1998-1999).
- Energy Sector Development Strategies (USAID/Electrotek, 1999-2000)
- Hydropotential, Natural Gas and Nuclear Energy in the Power System of Macedonia (Macedonian Academy of Sciences and Arts, 2000-2002)
- Lignite Substitution with Residual Fuel Oil in the Macedonian Power System - Economic and Environmental Aspects (Macedonian Academy of Sciences and Arts, 2002-2004)

# *Projects:* Renewables and energy efficiency

- Optimization of Building-integrated and Grid-Support Photovoltaic Solar Systems in Macedonian Conditions (US-Macedonian Fund, 1997-2000)
- Renewable Energy Strategy (USAID/Electrotek, 1999-2000 )
- Energy Efficiency Strategy (USAID/NEXANT, 2002-2004)
- Renewables for Isolated Systems – Energy Supply and Waste Water Treatment (RISE), Specific Target Research Project – STREP (EU FP6, 2004-2007)
- Production Process for Industrial Fabrication of Low Price Amorphous-Microcrystalline Silicon Solar Cells (LPAMS) Specific Target Research Project – STREP (EU FP6, 2004-2007)
- Solar Water Heaters (Austrian Development Cooperation, 2005-2008)
- More Microgids - STREP (EU FP6, 2007-2009)




http://www.moepp.gov.mk/default-en.asp