Hungarian Country Study Team

MITIGATION ANALYSIS FOR HUNGARY

Interim report

Budapest, August 1996

AUTHORS:

Dr. Sándor Molnár	Systemexpert Consulting Ltd. 2-4 Mikoviny S. u. 1037 Budapest, Hungary Phone: 36-1-250-50-78 Fax: 36-1-250-17-13 e-mail: SMOL@URSUS.BKE.HU
Dr. Zsolt Harnos	University of Horticulture 29-35 Villányi út 1118 Budapest, Hungary Phone: 36-1-166-92-73 Fax: 36-1-166-92-73
Dr. Tibor Takács	Systemexpert Consulting Ltd. 2-4 Mikoviny S. u. 1037 Budapest, Hungary Phone: 36-1-168-72-60/ext. 178 Fax: 36-1-250-17-13
Dr. Zoltán Somogyi	Forest Research Institute 42-44 Frankel L. u. 1023 Budapest Hungary Phone: 36-1-326-17-69 Fax: 36-1-326-16-39
Dr. Tibor Faragó	Ministry for Environment and Regional Policy Department of Environmental Cooperation 44-50 Fő u. 1011 Budapest, Hungary Phone: 36-1-201-41-33/ext. 633 Fax: 36-1-201-40-91
Dr. Tamás Pálvölgyi	Ministry for Environment and Regional Policy Department of Environmental Cooperation 44-50 Fő u. 1011 Budapest, Hungary Phone: 36-1-201-41-33/ext. 633 Fax: 36-1-201-40-91
Dr. Tihamér Tajthy	University of Technology, Budapest 3 Műegyetem rakpart 1111 Budapest, Hungary Phone: 36-1-204-11-11 Fax: 36-1-463-11-10
Klára Staub	Systemexpert Consulting Ltd. 2-4 Mikoviny S. u. 1037 Budapest, Hungary Phone: 36-1-168-72-60/ext. 178 Fax: 36-1-250-17-13
Dr. Mihály Bacskó	Hungarian Power Companies 5-7 Vám u. 1011 Budapest, Hungary Phone: 36-1-201-54-55 Fax: 36-1-202-12-46

Summary: This paper describes options and measures for the different sectors of the Hungarian national economy, which may assure that the country will be able to fulfil her duties undertaken by signing and ratifying the Framework Convention on Climate Change (FCCC). These investigations were carried out in the framework of the U. S. Country Studies Program. The basic difficulty of the implementation of the FCCC in Hungary (and in any other countries with economies in transition) is that the country has to recover from a very deep economic recession and at the same time the emissions of greenhouse gases should be stabilized. For this reason Article 4.6. of the FCCC allows for the countries with economies in transition to select a base level different from 1990, which is the recommended base year in general. Hungary has chosen the yearly average emissions of the period 1985-1987 as a base level. Our investigations have proven that a temporary increase of the emissions is unavoidable in the next couple of years, but if the different mitigation options are used, the emissions will not reach those of the base period. However, mitigation requires a great amount of capital. It is expected that the country will need foreign support for the necessary investments and programs. In our study we focussed primarily on the energy and the forestry sector. In these sectors there are ongoing governmental programs, which can be considered as elements of the national mitigation strategy.

1. INTRODUCTION

Hungary is located in the Carpathian Basin in the heart of Europe. The area of the country is less than 1 % of Europe: the extent in north-south direction is 268 km; in west-east direction it is 528 km; the total length of the border is around 2300 km. Hungary is a typical low-lying country: 73 % of its territory is flatland, which is less than 200 meters above the sea level.

Six major terrains can be identified: the Great Plain and the Small Plain are filled lowlands, while the Transdanubian Hills, the Transdanubian Mountains, the Subalpine Region, and the Northern Mountains are denuded formations.

The country lies in the catchment basins of Danube and Tisza rivers and their tributaries. The Lake Balaton, with an area of 600 km^{2}, is one of the largest lakes in Europe. Bauxite, brown coal, lignite, and hydrocarbons are the most significant mineral resources found in Hungary, while, as a result of past volcanic activity, the country has a lot of thermal springs.

The number of inhabitants is 10.2 million with an average population density of 115 capita/km^2 (Central Statistical Office, Hungary 1995).

Hungary is located at the shifting frontier between the temperate continental (with hot summers and relatively cold winters) and the Mediterranean (with hot, dry summers and rainy winters) climate zones with complementary effects of the temperate oceanic climate.

In general, the mean annual precipitation varies between 400-800 mm throughout the country with large interannual and regional variability. The driest part is the Great Plain, and the rainiest part is the area along the western border of the country. One of the main features of the climate is the insufficient precipitation with a tendency for dryness and frequent droughts especially in the Great Plain area. This part of Hungary belongs entirely to the semiarid and dry subhumid climatic belts. The annual mean temperature is about 9-11°C. This means that Hungary has 'cool climate' in terms of the IPCC Guidelines.

Hungary is in the process of a substantial socio-economic transition. In most cases, the efficiency of economic activities based on cheap Eastern European raw materials and energy imports, considerably lags behind advanced international market competitors. For a number of products, the Eastern European market has disappeared. In the case of some important product groups, the previous Hungarian market share has been taken over by multinational companies, which are able in many cases to produce products with higher technical standards at lower prices. The considerable fall in production has not left the industrial structure untouched: half to two thirds of the previous industrial capacity was unused in the recent years. The changes are more obvious in a sectoral analysis. A considerable proportion of the metallurgy, mining, and agriculture co-operatives, the electronic and telecommunications industry, and the artificial fertilizer industry has disappeared. Undoubtedly, new activities have also appeared (e.g., passenger car production). Nevertheless, they are unable to compensate for the deterioration of other areas in terms of the overall economic outcome. The extremely strong centralization of the Hungarian economy decreased considerably in recent years. This process should be continued and strengthened by direct methods of transformation and privatization of state companies, by indirect methods of strengthening and supporting the small and medium-size enterprises, and through consistent actions against monopolies.

According to current government strategy, domestic privatization fundamentally means the sale of property. Experiences to date, however, indicate that demand and supply conditions are inadequate for the quick privatization process that had been initially envisioned by the government. The supply side has been weakened by worsening economic conditions and the increasing number of bankruptcies and liquidations experienced by companies. On the demand side, limited domestic purchasing power, moderate foreign investor interest, and the high nominal interest rate caused by high inflation are among the many influences that have impacted the pace of privatization.

Hungary joined the FCCC, and the Parliament ratified it in December, 1993. The FCCC aims at the stabilization of anthropogenic greenhouse gas emissions on a certain base level. The base level of the stabilization is generally the emission level of 1990. However, Article 4.6 of the FCCC allows for countries with economies in transition to choose a diiferent base level, since the deep economic crisis, which led to the profound political changes in the late 80's, involved the drastic decrease of these emissions. Therefore, the Hungarian government decided to stabilize the anthropogenic greenhouse gas emissions on the yearly average level of the period 1985-1987.

With the support of the U. S. Country Studies Program, Hungary has developed a comprehensive inventory of greenhouse gas emissions for the selected base period. For international comparisions and synthesis, also the inventory for 1990 was developed. As the second element of the Country Study, the Hungarian Country Study Team has elaborated mitigation scenarios for mid and long term for different sectors of the national economy. This interim report summarizes the results of this work. The mitigation analysis focused on two main sectors as foolows:

- Energy

- Forestry

Energy is the main source of greenhouse gas emissions. As far as CO2 is concerned, only the power generation itself is responsible for almost one third of the overall emission. Since the power plants are old and relatively unefficient, the emission levels can cosiderably be decreased by installing new units and/or by application of different abatement technologies. There are opportunities also on the demand side to reduce the emissions, since there are a lot of appliances of high specific energy consumption used in the country. The second important area of mitigation is the forest sector. Acoording to the results of the inventories, a considerable amount of CO2 emission could be removed by increasing the forest cover of the country. There is another important aspect, why we focused mainly on these two areas: after the political change, Hungary has launched governmental programs to develop both the energy and the forest sector. The first program aims at energy saving, while the second one targetted the increase of forest cover by 10% within ten years. Unfortunately these ambitious programs had to slow down because of serious financial problems. Finally, agriculture should also be mentioned, because this is a very important sector of the national economy producing a lot also for export.

2. ENERGY SECTOR

Method and Data

Supply Side Management

The Hungarian Country Study Team has chosen the ENPEP program system (developed by Argonne National Laboratory, USA) as the primary tool of modeling the energy sector. The team members have many years of experience in development of energy models and also in adaptation and application of well known models (see Molnár and Takács 1995). ENPEP seemed to be the best tool for modeling of energy related greenhouse gas emissions. The emissions of three greenhouse gases, namely the CO2, the CO, and the NOx were modeled. In our model runs, we focussed on the power generation and on the district heating. For these activities, there are several opportunities to abate the environmental pollution. In particular, the following measures are planned in the near future:

- Fuel switch for less polluting energy carriers
- Retirement of aged power plants of low efficiency
- Construction of fluidized bed units and combined cycle gas turbines
- Construction of a new nuclear power plant
- Increasing of the share of cogeneration in the electricity and heat supply

Table 2.1. presents the recent retirement and investment program of the Hungarian Power Companies, which was taken into consideration in the model runs.

Table 2.1. Retirement and investment program of the Hungarian Power Companies (in MW)

Year	Existing power plants	Retirement	New capacity	Total capacity
1996	7307	70	299	7536
1997	7536	85		7451
1998	7451	70	284	7665
1999	7665	40	240	7865
2000	7865	85	230	8010
2001	8010	595	590	8005
2002	8005	352	510	8163
2003	8163	177	420	8406
2004	8406	469	0	8567
2005	8567	41	630	8526
2006	8526	86		9070
2007	9070	89	630	8981
2008	8981	55		8926
2009	8926	59		9017
2010	9017	69	150	8948

We have examined the following three scenarios:

- Case A: high final energy demand growth rate and the retirement program will be realized
- Case B: medium energy demand growth rate and the retirement program will be realized
- Case C: low energy demand growth rate and the retirement program will be realized

For each case, we examined its alternative, when the planned retirement/investment program will not be realized (‘doing nothing cases’ or baseline scenarios).

- Case D: high final energy demand growth rate and the retirement program will not be realized
- Case E: medium energy demand growth rate and the retirement program will not be realized
- Case F: low energy demand growth rate and the retirement program will not be realized

Demand Side Management

As far as Demand Side Management (DSM) is concerned, Hungary has already taken measures in particular in the following fields:

- Establishment of an adequate tariff system
- Auditing anf influencing the consumers' behaviour
- Promotion of energy conservation and saving
- Automatization and telemechanization
- Application of houshold appliances of low specific energy consumption
- Increasing the intensiveness of the utilization of the electrical energy
- Remote control of the thermal household appliances with audio frequency (ripple-control)

Of course, the DSM cannot be separated from the Supply Side Management (SSM). Therefore, in 1991, a national program was launched conducted by the Hungarian Ministry of Industry and Trade aiming at the energy efficiency inprovement and energy conservation. This program intends to integrate both sides.

Use of Renewable Energy Sources

Acoording to different studies and papers (see, e.g. International Energy Agency, 1995), Hungary may utilize the following renewable energy sources in near future:

- Direct solar energy (in particular the use of biomass and agricultural residues)
- Indirect solar energy (hydro and wind power)
- Geothermal energy, geothermal waters combined with heat pumps

Because of high investment and operational costs, conversion of solar energy to electricity is very limited in Hungary. About 10 kW capacity is installed in the communication network for the moment. The crop waste utilization in the agriculture is about 5 PJ/year. The utilization of biomass is realized mainly by direct combustion for the moment. About 600 burners and boilers are fired by agricultural residues in residential, commercial and communal use. The capacities of these burners are in the range of 25-850 kW, but in cca 70 villages the capacity exceeds 1 MW, where the co-fuelling is realized with coal or natural gas because of the seasonality of the biofuel. The total installed capacity of the burners is about 300 MW. Biomass is used for district heating in Tata (7 MW), in Sárospatak (2 MW), and in Putnok (5 MW). There is also a biogas pilot plant in Szécsény (110 kW).

The overall hydro power plant capacity of Hungary is 47.8 MW (including micro, mini and small plants) producing about 161.23 GWh in a year. Earlier a plant of 800 MW was planned in Nagymaros on the river Danube, but the Hungarian Parliament cancelled it because of environmental, financial, and political reasons. Special pumped storage hydro power stations are considered to be built for peaking purposes (cca 2000 MW in total). The wind energy is not economical for extensive utilization in Hungary. In special cases the wind power may be used for off grid electricity generation (0.5-1kVA) to supply electricity for consumers far away from the public supply network.

In Hungary the geothermal basis is very favourable. The estimated geothermal water capacity is about 2500 km3, and its estimated heat content is 573 EJ. The recoverable amount is cca 500 km3, cca 50 km3 can economically be utilized in the housholds and in the commercial and agricultural sector. The geothermal waters in Hungary contain significant quantities of CH_4. This is cca 120 l/m3. Before utilization, CH_4 has to be separated. Also the dissolved salt content of geothermal waters is sometimes very high. The cooled water cannot be driven back to rivers and lakes without dilution. The reinjection has not proven to be economical.

Application of Carbon Taxes

We have also examined how the different carbon taxes would influence the greenhouse gas emissions of the Hungarian energy sector. For these calculations the model system ENPEP (Energy and Power Evaluation Program) and the model

EFOM_ENV (Energy Flow Optimization Model) were applied. Three scenarios were taken into consideration as follows.

- Scenario I. This is the baseline scenario. It is supposed that GDP will begin to increase in the near future, i.e. before 2000.
- Scenario II. Different significant energy saving measures are added to the baseline scenario. These measures should be supported by the government.
- Scenario III. This is a pessimistic scenario. It is supposed that GDP will begin to increase only after 2000, and the level of the energy consumption in 2000 will not exceed that of 1995.

Four different cases of carbon taxation were examined.

- Case 1, without carbon tax on fossil fuels
- Case 2, where 50 USD/Mg C in 2000 and 100 USD/Mg C in 2010 is built in the prices of fossil fuels
- Case 3, where the measure of taxes are 100 USD/Mg C and 200 USD/Mg C in 2000 and in 2010, respectively
- Case 4, where 35 ECU/Mg C carbon tax and 0.7 ECU/GJ energy tax will be introduced for fossil fuels from 2000

Results

Supply Side Management

Figures 2.1. through 2.3 show the main results of the model runs as far as the emissions of the examined greenhouse gases are concerned.

Figure 2.1. CO2 Emissions by cases

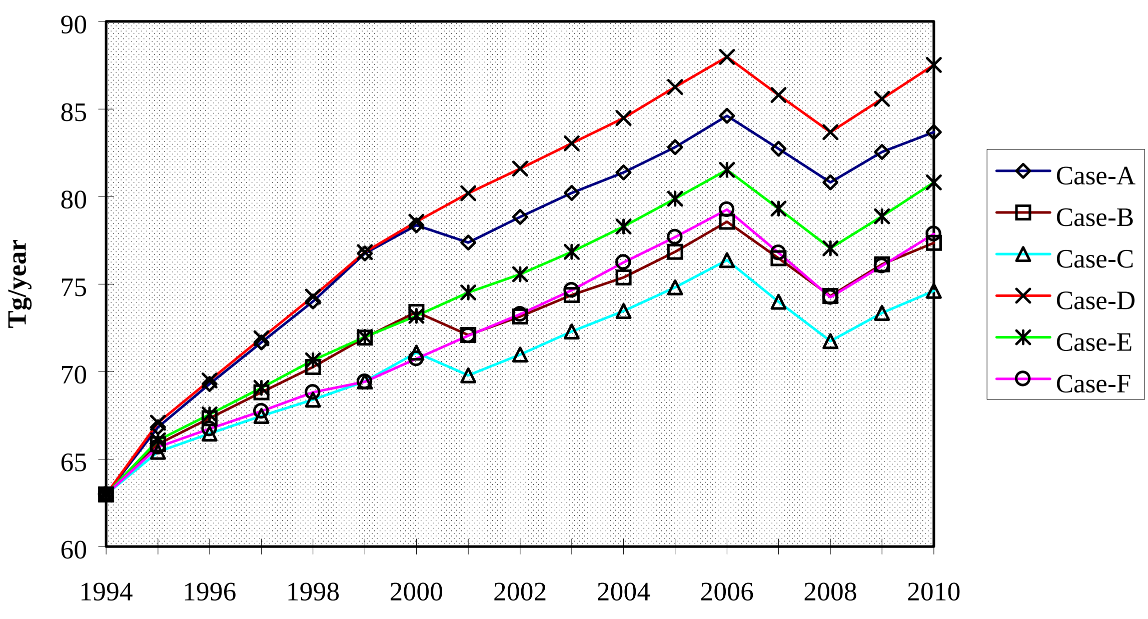


Figure 2.2. CO emissions by cases

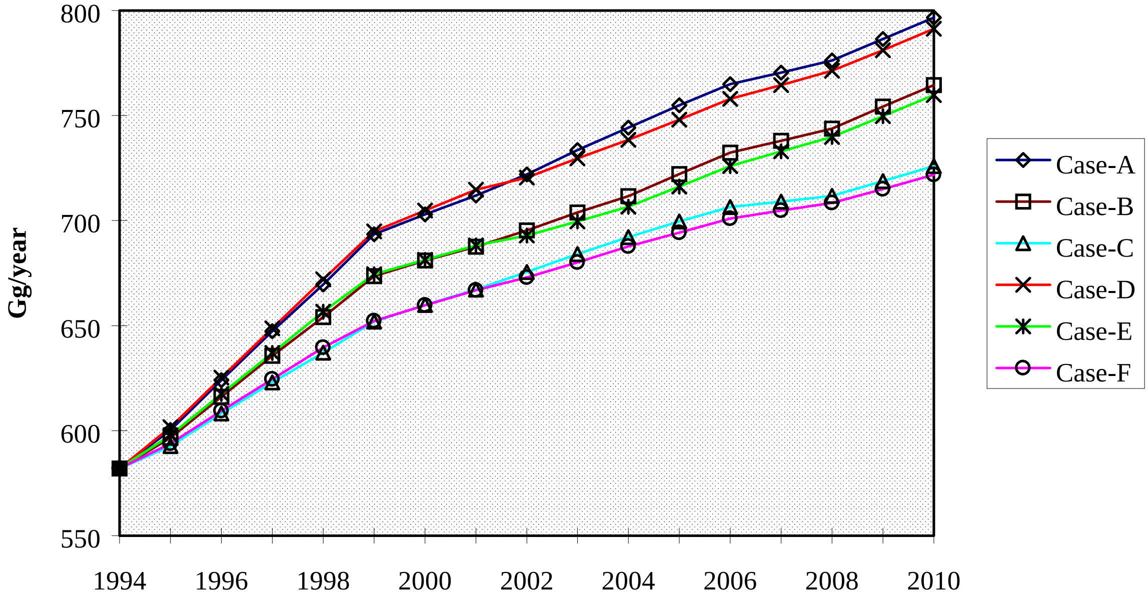
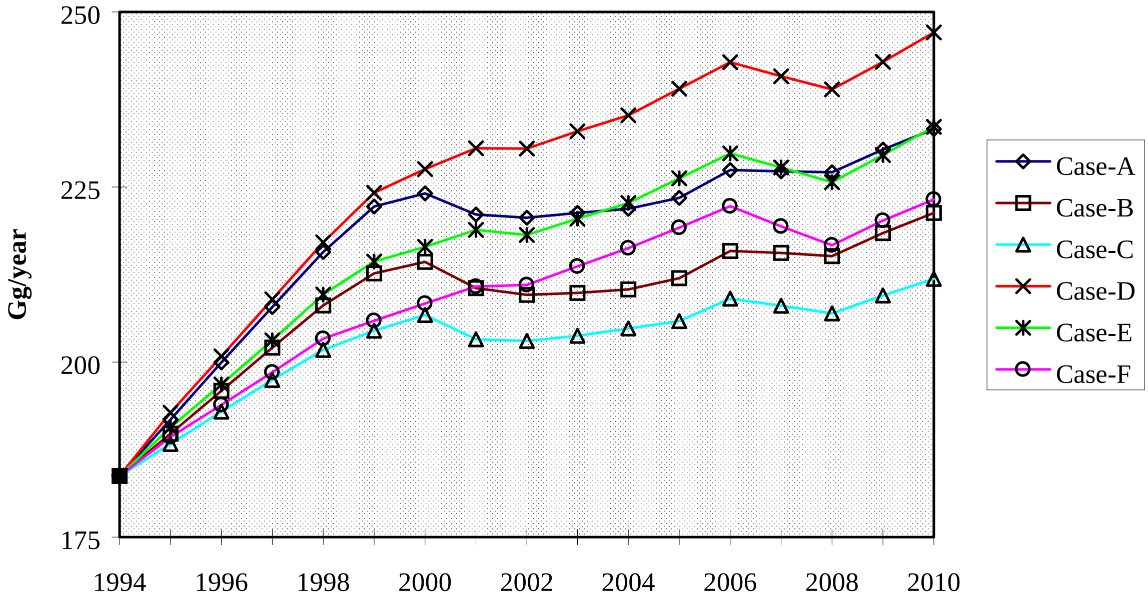


Figure 2.3. NOX emissions by cases



For the moment, the medium demand level is considered as the most probable scenario (Cases B and E). At this demand level, the mitigation scenario results in 28.4 Tg CO2 and 122.6 Gg NOx reduction in the examined period 1996-2010 compared to the baseline scenario.

Demand Side Management

The expected energy saving of the above mentioned national program can be estimated for the particular DSM-measures as it is shown in Table 2.2 (see Hungarian Commission on Sustainable Development, 1994).

Table 2.2. Expected energy savings of the national energy saving progam (in PJ)

Measures	*Medium-term minimal*	*Medium-term maximal*
Raising of Energy Awaremess	34.5	69.0
Updating of Industrial Technologies	2.0	4.0
Updating of Agricultural Technologies	0.5	1.0
Efficiency improvement of consumer's equipments	4.5	9.0
Improvement of the energy management in buildings	2.8	5.6
Improvement of thermal insulation	1.5	3.0
Optimizing the public transport cooperation	5.0	10.0
Reduction of energy consumption of vehicles	4.5	9.0
Total	55.3	110.6

Taken into account these estimations, the DSM-measures of energy saving in terms of PJ-s may reach minimum 5% of the total yearly energy consumption. Based on this, we estimate a minimum of 1000 Gg CO2 emission reduction from the DSM.

Use of Renewable Energy Sources

For the moment, the yearly utilization of renewable energy sources in Hungary can be estimated as 20-22 PJ. It might be increased up to 35-60 PJ by 2005. First of all, the utilization of agricultural residues, and the utilization of residues of wood industry, forestry and agro-industrial production (either as waste or by-products) is expected to increase. The utilization of the renewable energy resources is realized mainly by direct combustion, but their indirect utilization (e.g. biobriquette) has come into the limelight lately. In optimal case, the CO2 emission can be reduced by cca 3-5 Tg if the use of renewable energy will be enhanced.

Application of Carbon Taxes

According to our results, the introduction of the carbon tax for fossil fuels significantly decreases the coal consumption. It also decreases the rate of increase of hydrocarbons to a certain extent. In particular the use of gas increases less than that of oil products, since the supply of natural gas involves higher investment costs (extension of the pipeline system). It was found that there are practically no difference between the effects of Cases 2 and 4. However, these effects are significantly smaller than those of Case 3. The application of 100 and 200 USD/Mg C would result in a cca 6-8% CO2 reduction compared to the baseline scenario. At tthe same time, the 200 USD/Mg C might double the price of fossil fuels.

Conclusions and Limitations

Supply Side Management

As it can be seen from Figures 2.1. through 2.3., the increase of greenhouse gas emissions from the enrgy sector cannot be avoided in the near future, even in the case of a minimum growth rate of demand. This will be a natural consequence of the expected economic development after the deep recession of the late 80's, which led to a profound political change in the region. Because of this expected increase of emissions, Hungary has chosen the period 1985-1987 as a base level for the implementation of the FCCC. The results of the inventory shows that the peak level of CO2 emission in 2006 will not reach the level of the base period. Primarily, the construction of a new nuclear plant may result in a relevant decrease after this year. It is expected that there will be no increase of any other greenhouse gas emissions after the economic recovery, i.e. after 2010.

Demand Side Management

The national program for energy saving launched in 1991 is delayed because of financial problems. Further (foreign) sources should be found to reach the original targets. An example of it was the so-called "German Coal Aid". In 1991 the Government of Germany made 50 million DEM available to support the purchase of coal by households in order to offset the unsatisfied coal demand in Hungary. On the basis of an agreement signed by Germany and Hungary the Government declared that 60% of the amount received from the sale of coal may be spent on preferential credit facility aimed at energy saving. The opportunities of DSM for the country is being discussed in Krommer (1995) and in Láczai Szabó (1995).

Use of Renewable Energy Sources

Both and environmental and financial aspects have to be taken into consideration when the use of renewable sources is planned. We have already mentioned the case of the hydro power plant in Nagymaros, which was not built because of possibly serious ecological consequences. It is also worth mentioning the environmental problems connected with the operation of wind turbines as well: the noise near inhabited areas, the TV disturbances and the danger to birds. However, it is expected that the primary hindrance of increase of renewable resources will be the lack of capital.

Application of Carbon Taxes

As it was mentioned above, if we want to reach a significant decrease in greenhouse gas emissions by carbon taxes, a sharp increase of prices should be tolerated. Our calculations proved that the political consequences are too serious compared to the environmental benefit (i.e., the CO2 reduction). Therefore, we do not consider the application of carbon taxes as a suitable mitigation option for Hungary.

3. FOREST SECTOR

Method and Data

The method of this mitigation assessment was developed on the basis of the respected chapters of the manuals Country Studies Management Team (1995) and Meyers and Sathaye (1995). In the mitigation assessment, first, mitigation options were analysed. Based on the analysis, four scenarios of expanding carbon sinks by reforestation were developed. The possible benefits of other options - e.g., enhanced regeneration - were also analysed, but they were considered to be uneffective and, hence, rejected. Then, the Carbon Sequestration Model by Reforestation (CASMOR) was developed to describe the processes of a reforestation system, as well as to assess the rate of carbon seuqestration, and its costs and benefits. Finally, the results of running the model in the four scenarios were analysed. The CASMOR model used in assessing the rate of carbon seuqestration, as well as costs and benefits was designed by developing the respective submodel of Comprehensive Mitigation Analysis Processes (COMAP) to fit to Hungarian conditions. The development was necessary, because

• COMAP bases on average values that are difficult or impossible to obtain for Hungary
• More detailed data are available in Hungary, which makes it possible to increase accuracy
• The stream of carbon sequestration, costs and benefits can be followed if not the average, but the actual values are used
• A more complicated forest management system must be used under Hungarian conditions than that in original COMAP

It is supposed in the CASMOR model that normal, professional forest management is carried out on the reforested land using three tree species groups. These groups represent the several - about 10 - possible tree species that could be planted complying with site, economic and social conditions in the country. A relatively slow-growing broadleaved species group is characterized by Black Locust, a relatively fast-growing broadleaved species group is characterized by Poplar, and a the evergreens are modelled by Conifers. Any other combination could also be used. As far as the main processes, functions, interrelationships are concerned, we had to consider the following facts.

- Forest cover is increased by reforestations
- Carbon assimilation by plants is the only process that increases sequestered carbon pools and reduces atmospheric carbon
- Carbon pools in Baseline Scenario are also grow in time, but slowly
- Carbon pools in Mitigation Scenarios are modelled in a bit more detailed way than in COMAP
- Carbon released in forestry operations may be small compared to the carbon fixed, yet, it is accounted for here to get a complete picture of the carbon cycle
- The Stream of Costs and Benefits is very difficult to model, but the stream is better modelled if yearly costs and benefits are taken as they emerge rather than taking averages as in COMAP

As it was mentioned above, the only option in Hungary to contribute to the reduction of air carbon to a considerable extent is reforesting large areas. Since forestry is fairly developed in Hungary, not too much could be achieved by, e.g., enhanced regeneration, agroforestry or urban and community forestry. Note that the term “reforestation” is used here in general to plant trees on bare lands, because most of the agricultural fields, bare lands or clearcut, but not yet regenerated areas used to be forested ares. “Afforestation”, on the other hand, is used for all kinds of afforestations, including reforestation and regeneration. As compared to the size of the country and to the forest area, a large area of agricultural land could be reforested. This can, however, be done on the long run. Therefore, it is assumed that reforestations can be carried out by 2050. It is also assumed that the reforestation project can be started next year, i.e., in 1997.

Based on all above, it can be stated that the majority of the forests in Hungary are managed in a sustainable way. This means that protecting and maintaining existing stocks is done without extra effort. Thus, to speed up mitigation expanding carbon sinks is necessary. The most important methods for this expanding are afforestation, and enhancing reforestation in forest compartments where reforestation is delayed for some reason. According to recent surveys, *more than one million ha of former agricultural land* awaits conversion. Most of this land used to be covered by forests before the intensive extension of arable land centuries ago. Roughly one half of this area is found in the lowland of the Eastern part of the country, the other half is scattered in the hilly parts of the Northern and Western parts.

After a large-scale privatisation program, a considerable part of this land is owned by local farmers. It is generally in their interest to utilize their land profitably, which may mean that the timber grown in their forests is used in the farm itself. Many people are planning to develop a farm where agriculture and forestry are combined. However, afforestation could not be limited to smallholder's lands. There are large areas, too, that are owned by regional and local governments. In afforesting these lands, professional forestry companies could help. These companies would also help private landowners to assess site conditions, choose appropriate tree species, provide the landowners with improved propagation material, and to prescribe and assist in technology. The long traditions of afforestation, many nurseries, the expertise of tending and other silvicultural work, as well as other elements of professional background of these forestry companies would ensure high efficiency in afforestation. Because of low wages and relatively high unemployment in the regions concerned, enough workers will be available for doing necessary field work. For mechanisable operations, good quality machines are available, too. The Hungarian Parliament has recently passed the new Forest Act. This will ensure the sustainable management of the new - and also of all other - forests in Hungary.

As for the sites of the land available for afforestation, they are usually of medium quality. About 80% of the afforestations would serve for timber production, and the function of most of the rest would be protection, mainly environment protection. Land for conversion could include several thousand ha belt for arable land protection and channel and canal protection, roadside belt and also snowbelt. Because of site conditions, fast growing species can be planted on a large portion of the land to be converted. Preferable fast growing species include Black Locust (Robinia pseudoacacia), improved (Hybrid) poplars (Populus x euramericana), and conifers (Pinus silvestris and P. nigra). In addition to breeding, the latest achievements of research on silviculture and yield can also be used to optimize tree growth and, hence, maximal CO_2-sequestration.

Scenarios are developed from current trends, as well as from natural and technical potentials. The forest cover of the country is still below the European average. Hungary can meet only about 70% of her need for timber from the country's own forest resources. In addition, large areas abound, where agriculture is not profitable any more. We would like to join the European Union, within which the potential of agricultural production has a substantial surplus. Because the market of agricultural products is saturated, agricultural production has - and increasingly will - become unprofitable on large areas. This has also resulted in high unemployment in agricultural regions.

All this prompted the government to launch a new afforestation program in 1991. The aim was to afforest 150 thousand ha by the year 2000. Contrary to the plan, which outlined that the yearly afforested area would increase by the time, it dropped from 6700 ha in 1991 to 2874 ha in 1994. Today, i.e., at the half of the original period, only 16% of the total 150 thousand ha has been afforested against the 50% planned. Because the reforestation rate dropped under 3000 ha by 1995, and by considering the difficult economic situation of the country, it may happen that not a single ha of new reforestation will be done for several years. For the *most-likely-trend scenario*, i.e., the *baseline scenario*, therefore, it is assumed that no reforestation will take place until 2050.

It is also likely that an afforestation of 3,000 ha per year will be taken. This will require effort of the country, but it can easily be done if politicians decide so, in which case no extra propaganda should be pursued. This will be taken as a mitigation scenario, namely, the *likely-trend scenario* (I).

Although the momentum of the former afforestation programs has been hindered by the ailment and the transition of the economy, the conversion of the land from agriculture to forest must be speeded up. The country has great potentials for that. The three other mitigation scenarios will be developed by analysing these potentials.

The second mitigation scenario, the *programmatic scenario* (II) that could be carried out is similar to the current afforestation program of the government (i.e., to make afforestations on 150 thousand ha in the next decade). That would require finding additional sources in the country, and some foreign aid, too. However, the program is already prepared by making fairly good assessment of the land available, its allocation and site conditions, as well as of the species to be planted. In this scenario we assume that the program is restarted and that 210,000 ha forest will be planted by 2010 (this equals to a yearly reforestation of 15,000 ha).

The third mitigation scenario, the *achieveable scenario* (III) requires a yearly reforestation of 11,000 ha land by 2050. This would result in reforesting almost 600 thousand ha land. According to the latest analyses, this is the area the site of which can be regarded as suitable for forest management with acceptable benefits. In addition, the rate of reforestation is still comparable with the production capability of the country, although foreign aid would help decision makers a lot to engage in the program.

The fourth, and last, mitigation scenario, the *technical potential scenario* (IV), represents a reforestation of nearly 1 million ha land by the year 2050 at a rate of 18,000 ha per year. This program requires aid for the country. This is, however, the mostly preferred scenario because of its beneficial effects, such as it ensures C-sequestration, green cover on unused or marginal agricultural land, it creats the most job opportunities, it increases biodiversity to the greatest extent, etc. Most data are taken from earlier measurements and correctly describe both natural processes and thecnological aspects. I our calculations we used information from Csóka (1994) and from Führer (1995).

Results

We summarize the most important results of running the model in the four scenarios.

Table 3.1. Aggregated netto carbon gain (Tg C)

Scenario/Yea	*1997*	*1998*	*1999*	*2050*
I	-0.02	-0.02	-0.01	12.59
II	0.00	0.00	0.00	6.56
III	-0.01	-0.02	-0.01	24.05
IV	-0.02	-0.03	-0.01	39.36

Table 3.2. Cost effectiveness indicators for the four mitigation scenarios

	I	*II*	*III*	*IV*
Net Present Value of Benefits				
- USD/Mg C	-7.018	-6.491	-6.481	-6.480
- USD/ha	-420.630	-262.842	-262.461	-262.394
Benefit of Reducing Atmospheric Carbon				
- USD/Mg C-yr	-0.526	-0.487	-0.486	-0.486
Initial Cost				
- USD/Mg C	0.007	0.014	0.004	0.002
- USD/ha	0.425	0.550	0.15	0.092
Endowment (Present Value of Costs)				
- USD/Mg C	25.447	39.921	21.522	18.839
- USD/ha	1525.093	1616.604	871.549	762.895

Figure 3.1. Carbon sequestration by scenarios

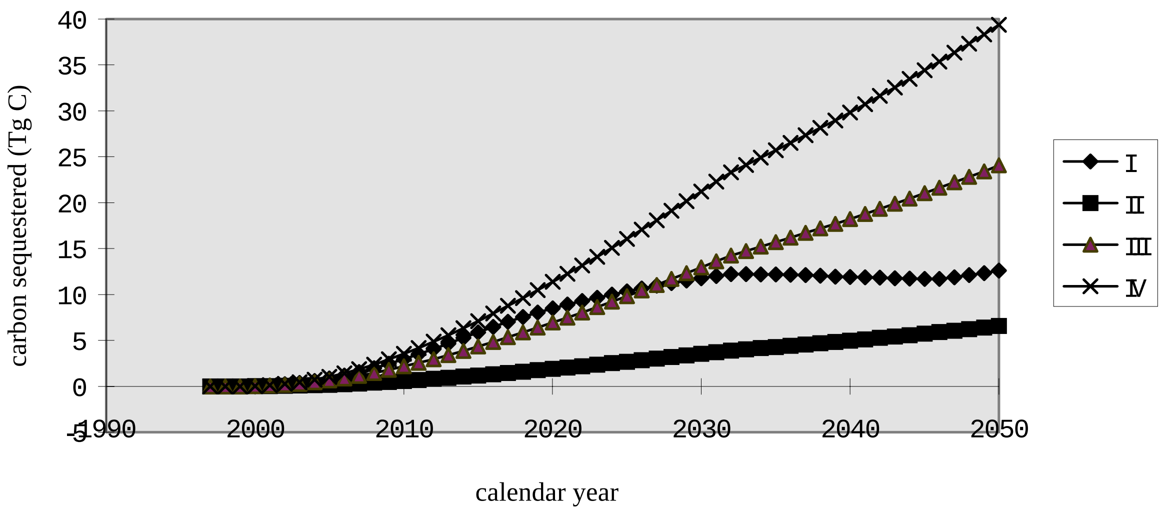


Table 3.1 and Figure 3.1 show the results of the carbon sequestration, and Table 3.2 presents the cost-effectiveness indicators that speak for themselves. As for the carbon sequestration, it can be stated that there are considerable differences between the scenarios. However, the rate of carbon sequestration is relatively small compared to the

amount of carbon released in Hungary every year: the total amount of carbon fixed in the technical potential scenario (some 40 Tg carbon over 54 years) is barely double the amount of carbon that was released in 1990, i.e., in a single year (about 22 Tg carbon). Both prices and benefits have been assessed from the practice of the government-owned forestry enterprises. The cost of afforestation in Hungary, 1000-1010 $/ha, is higher at present than the cost of $230-1000 $/ha reported by Meyers and Sathaye (1995). Timber prices, on the other hand, are lower than in other countries. This is one of the reasons why the net present value of benefits is negative, and why the endowment is relatively high in each scenario. However, with the Hungarian economy getting more integrated in the European one, and with the ongoing privatisation, prices will go down and benefits will go up. Costs of forestry operation will also decrease and benefits will also increase because of higher efficiency of the private forest management.

Conclusions and Limitations

Mitigation scenarios III and IV would be a major achievement for the Hungarian forestry. According to some analysis, the forest cover in Hungary would be optimal at around a rate of 25-30 %. If either of these two scenarios were implemented, the forest cover would be raised to 25 and 28,5 %, respectively. This would create a green surface with a lot of benefits for people, as well as for the local and regional environment. Either of these scenarios would increase the production of wood products, which would be beneficial for the import-export budget of the country. Currently, the country is struggling with a foreign deficit, i.e., more products are imported than exported. Our reliance of timber products on the willingness or capacity of other countries to export would largely decrease with our growing capacity to produce these timber products.

Another beneficial effect of a large-scale afforestation program would be the job creation. The average unemployment rate is over 10% in the country, and there are some regions where this rate exceeds 20%. These are usually agricultural regions where it creates considerable tensions that agriculture becomes unprofitable. These are the regions where afforestations should be made, which would increase employment opportunities. According to a recent decision of the Hungarian government, a certain sum of money is allocated for public and communal works to cope with unemployment. A reasonable and efficient way of using this money could be the implementation of large-scale afforestations.

However, such a program requires an ample source of financial support. The establishment and first thinning costs amount to ten or several tens of millions of dollars. This is several times more than what the Hungarian economy could afford in the last few years, and what it seems to be able to afford in at least the next decade. The program could be implemented with joint effort, i.e., joint investment for both economic and environmental benefits.

Hungary has a long tradition of agriculture. People in the countryside are used to this type of work also because the industry is not evenly distributed in the country. Since 1990, a sharp change of political and economic system, the acceptance is growing that agricultre will be no more profitable on lands of relatively poor quality. It is, however, not straightforward at all for most people on which lands agricultural production will become marginal or unprofitable, and what these lands should be used for. Careful economic analyses, conducted jointly with land-owners, must be carried out to find solutions that are suitable both for the landowners and for the national economy and environment. This would also imply a general re-analysis of the use, structure and allocation of agricultural lands of the country. This would be necessary even if no afforestation programs will be implemented.

In case only either of the first two scenarios (i.e., the baseline and the likely-trend scenario) will take place, no special measures must be taken. If either of the other scenarios are to be fulfilled, first a survey of suitable and available land is necessary. This would also mean a survey of farmers` willingness to afforesting their land and to join to forest associations. An economic analysis and consulting may also be necessary for the farmers to accept afforestation as a viable form of land use.

4. AGRICULTURAL SECTOR

Method and Data

The agricultural sector of Hungary developed relatively rapidly till the mid 80's. The level of agricultural production was close to that of the Western European Countries. In case of certain products we exceeded the production level of the developed countries. In the late 80's, the agricultural production began to decrease drastically. Reasons of this decrease are as follows:

- Serial droughts
- As a consequence of political changes the structure of ownership drastically changed
- We lost the stable Eastern European markets
- Lack of capital
- The decrease of domestic consumption
- Appearance of foreign competing firms
- Lack of comprehensive agricultural strategy.

As a consequence of this, the emissions also from the agriculture has considerably decreased. Since the situation of this sector is not stable yet, it is extremely difficult even to give a realistic prediction for the development. It is however foreseen that the decreasing tendency is going to continue for a couple of years because of the use of out-of-date technology and of the uncertain market conditions. If Hungary can join the European Union (it is expected around 2000), the agricultural sector will have to become conform with the regulation of the Union, but it is still unclear what implication it may have for our strategic products. We may suppose that the production level will be the same or a bit higher than the present level, but the intensity of production will be definitely higher. In our predictions, the production level in 2000 will roughly coorespond to that of 1990. As far as 2010 is concerned, we base it on the development till the mid 80's, but it is supposed that the structure of production will be more rational and also the biomass will be used.

Plant cultivation can be characterized by the production of wheat, barley and maize. These species are produced on almost two third of cultivated areas of Hungary, and their importance will not decrease, if we take into consideration the present tendencies of the world market. Tables 4.1 and 4.2 show the cultivated ares and the structure of production, respectively.

Table 4.1. Cultivated area (1000 ha)

	1980	2000	2010
Wheat	1276	1221	1250
Barley	246	297	250
Maize	1229	1082	1400

Table 4.2. Structure of production (in Tg)

	1980	2000	2010
Wheat	6077	6200	7215
Barley	929	1370	1375
Maize	6673	4500	11340

The most important source of biomass production is the by-products of corns. According to our estimations the rate is 1:1 in case of wheat and barley, while it is 1:1.8 for maize. It is expected that these rates will improve if returns will increase. We remark that rice is also produced in the country on about 12-13 thousand ha, which covers a certain share of domestic consumption. No increase is supposed, moreover this level may decrease, if the costs of irrigation and of the necessary investment increase in the future.

The unfavourable soil conditions on cca 50% of cultivated area hinder the efficiency improvement of plant cultivation. About 16% is exposed to erosion. The protection is expensive, and the increase of small scale production may have worsened the situation. This is also a problem in the developed countries, because these costs may decrease the returns in short term, although in long term it is obviously advantageous. The conditions of production may be improved by application of meliorative technologies or by increase of soil improvement by organic materials. Earlier, when large scale production was extended, meliorative technologies could be applied with state support. This method is expected to decrease in the future because of high costs. Experiments have proven that the use of agricultural by-products and residues should be increased. These organic materials further the retention of nutritive matters and improve the chemical characteristics of the soil.

The prediction of animal husbandry is even more difficult for Hungary than that of plant cultivation. Earlier the meat export was the most important driving force of the agriculture, but primarily the meat production has decreased. The intensity, the feeding and the demand have considerably changed. Several, sometimes contradictory factors may influence the prediction of meat production as follows.

- Increase of share of ruminant livestock (this share is extremely unfavourable in Hungary for the moment)
- Increase of share of cheap meat (poultry), which the domestic consumers can afford
- More intensive production
- More reasonable use of pasture lands
- Adjustment to market conditions

No predictions have been made in Hungary taking all these point of view. It is supposed that a certain share of meat production will be intensified (large scale production), while the rest will be extensified (small scale production). Table 4.3 presents predictions for animal husbandry.

4.3 Number of animals (1000 head)

	1980	2000	2010
Dairy Cattle	765	630	993
Non-dairy Cattle	1216	941	1518
Sheep	3090	1865	3826
Poultry	42764	27713	45500

Results

According to our estimations the CH4 emissions from rice production will not increase considerably compared to the 1990 level. (As it was mentioned above it might decrease as well.) This means that we can reach about 0.4 Gg reduction compared to the base level (which is the yearly average of 1985-1987).

As it was mentioned above, emissions can be reduced by utilization of agricultural by-products and residues. We have examined the opportunities of economical and environmentally sound use of biomass. It can be used for feeding, for soil nutrition and for enrgetic purposes (biogas). The use of biomass as soil fertilizer decreases the emissions, increases the humus content, i.e. it increases the carbon content of the soil in an indirect way. The extension of small scale production is favourable from this point of view. We estimate that cca 200 Gg N2O emission (10%) reduction can be reached from this source compared to the base level. However, it should be mentioned that use for energetic purposes is not supposed to increase considerably in the near future, since it is expensive, the necessary investments sholud be supported by the state. Taking into consideration the present economic situation of the country, this cannot expected in the next couple of years.

As far as animal husbandry is concerned, we do not expect considerable changes in CH4 emissions.The increase of small scale production may lead to the efficiency decrease of specific utilization of feedstuff. At the same time, the big agricultural firms well provided with capital will intend to intensify their production, and these two tendencies may compensate each other. According to some long-term forecasts Hungary may reach 5000 l/year for dairy cattles on average. In case of swine and poultry, the specific utilization of feedstuff might be improved by 20-30% at intensive animal husbandry.

Conclusions and Limitations

As it can be seen, there are still no specific scenarios for the agriculture of Hungary, even the forecasts are rather uncertain. The intensity of production, consequently the amount of emissions of this sector will be influenced by the ownership structure and the amount of capital invested in this sector. However, as it was mentioned above, it is expected that greenhouse gas emissions even from this strategic sector of the national economy can be decreased compared to the base level.

5. COAL MINING AND WASTE MANAGEMENT

Methods and Data

Coal Mining

In Hungary coal is extracted from both open pit and underground mines. Only brown coal and lignite is produced. It should be emphasized that this classification is different from that of the IEA/EUROSTAT statistics. Table 5.1 shows the differences. (In the usual terms our categories correspond to peat and lignite.)

Table 5.1. Classification of coal types (in MJ/kg)

	Lignite	*Brown Coal*	*Hard Coal*
Hungarian Energy Statistics	3.5-10.0	10.0-17.0	17.0-33.0
IEA/EUROSTAT Statistics	<17.4	17.4-23.9	>23.9

Since the coal mining proved to be more and more uneconomical in the 80's and in the 90's in Hungary, the production considerably went back. It is expected that in the future the coal demand will be covered by the increase of coal import. Because of the unfavourable characteristics of domestic coal (low calorific value, high ash and sulfur content, etc.) import is more economical even from remote countries than the domestic coal production. Table 5.2. presents the coal production in the period 1985-1987 (this is the base period for Hungary in the implementation of the FCCC) in 1990 and in 1994.

Table 5.2. Coal mining in Hungary (in Tg)

	average of 1985-1987	*1990*	*1994*
Underground Mines	16.15	12.11	7.39
Open Pit Mines	7.47	5.72	6.73
Total	23.62	17.83	14.12

We consider the stabilization of the coal mining activities on the level of 1994 as a baseline scenario. The alternative (and not unrealistic) scenario will be a further 50% decrease.

Waste Management

The yearly amount of wastes in Hungary is cca 20 million m3, cca 4 Gg. This was practically the same in the past decade, which was examined from the viewpoint of greenhouse gas emissions. The yearly amount is only estimated, the composition of the waste is unknown. In Hungary there are 2682 registered disposal sites, where 85-88% of the waste is placed. Composting is not applied in Hungary for the moment, and only seven site has a system of biogas use. For the lack of corresponding statistical data, determination of emissions had to be based primarily on empirical data.

About 53% of the domestic waste waters is still not treated. The remaining 43% is treated as follows.

- Mechanical cleaning - 14%

- Mechanical and biological cleaning - 31%
- Three steps cleaning - 2%

The emissions were calculated according to the IPCC method.

Results

Coal Mining

As a first element of our Country Study we have developed a comprehensive greenhouse gas inventory. According to these results, the fugitive CH_4 emission from coal mines connected to the direct mining activities was 146.58 Gg. Based on this result we estimate that the alternative scenario may lead roughly to 70 Gg reduction in the CH_4 emission. Although the domestic coal production has decreased dramatically in Hungary, it is not planned that the whole amount of coal should be imported. Lately some coal (lignite) mines and the near power plants have been integrated. These mines will supply these plants with fuels even in the future.

Waste Management

Table 5.3 present the calculated yearly greenhouse gas emissions. The values were valid for the past decade (from 1985).

Table 5.3. Greenhouse gas emissions from waste management (in Gg)

	CO_2	CO	CH_4	NO_x
Flue Gases	600	0.134		0.518
Land Disposal Sites	150		82.8	
Waste Water Treatment			190	
Total	750	0.134	272.8	0.518

For the moment, no information is available about any foreseen measures to decrease these emissions. Hence we consider these figures to remain constant in the near future.

Conclusions and Limitations

Coal Mining

We emphasize that the estimation of CH_4 reduction as a consequence of the decrease of coal production should be considered as a rather uncertain estimation. Since in Hungary there are a lot of aged power plants, new plants has to be constructed in the near future to substitute them. However, there are only development scenarios for the electricity sector, but it is very difficult to predict the future fuel structure. For example, the construction of a new nuclear power plant may considerably influence it, but no decision has been made about it. The influence of different political and economic interests should also be taken into consideration (need for diversification of fuel structure, unemployment, interests of independent environmental organizations, etc.)

Waste Management

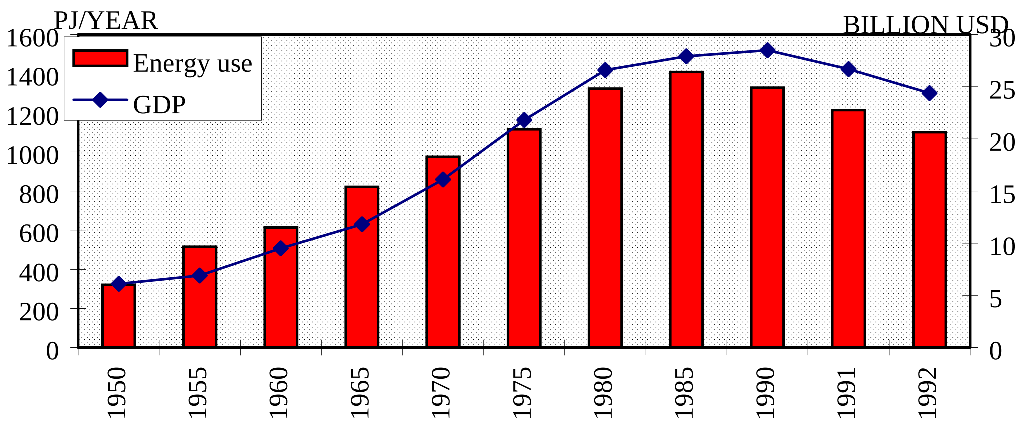
It can be supposed that in the future treatment of wastewaters will be improved. However, for lack of information about it we cannot quantify it as a potential mitigation option for the moment.

6. MACRO-ECONOMIC ANALYSIS

Methods and data

The assessment of the main economic indicators are rather difficult by the classical econometric methods since in the past 10-15 years the real processes can hardly be approximated by linear models. Furthermore, the whole statistical system has changed after the political change of the late 80's. Figure 6.1. presents the evolution of the Hungarian GDP and energy use from 1950. After 1992 GDP has been stagnating.

Figure 6.1. Evolution of the GDP and energy use in Hungary



As it can be seen on Figure 6.1., the Hungarian GDP decreased about 16 % in the last couple of years, which has determined the evolution of the energy consumption, too. The economic depression, the restructuring of the economy, the transition from centrally planned economy to market economy are the main driving forces of the above decrease. If this reduction were the result of the restructuring of the energy intensive, inefficient industrial production, it would be a great success of this transition period. But in the reality it is rather the result of the overall economic recession.

In the centrally planned period the prices of the different energy types was relatively low and they do not reflect the real costs. All the prices were dictated by the State Bureau of Prices, they were nearly constant for a long period of time and were independent from the world market prices. Thus the producers and consumers had no interest in the energy saving, and did not intend on energy conservation of retrofitting of their inefficient technologies. Due to these factors the energy intensity of the whole economy is extremely high compared to the standards of the developed countries. Furthermore, the utilization of low physical-chemical quality fuels, and the aged boilers result in the high specific energy consumption, and the relatively high environmental pollution.

It is also difficult to forecast the population. It has been decreasing since 1981. The population was 1,0246,000 in 1995, and the yearly average decrease is around 0.2% (see Central Statistical Office 1990-1995). It is expected that this tendency will continue at least for mid term, since the rate of decrease reached 3% in 1994 and in 1995. About one fifth of the population lives in the capital, i.e. in Budapest. The unemployment rate has been being constantly above 10% since 1990.

In case of all macro-parameters, we can rely only on heuristic estimations.

Results

As far as GDP is concerned, 1-2% growth rate is expected till the end of the century, then 4-5% can be reached. This development path is in accordance with our assumptions of energy demand increase made during our model runs for the energy sector. However, a recent World Bank country study (see World Bank 1995) predicts only 2% GDP growth till 2005. Furthermore, this study assumes that the gross foreign debt as percent of the GDP will grow up to 74% in 2005 (at present it is 70%). This predictions seem to be rather pessimistic. As a result of an austerity program launched in 1995, state budget deficit has been reduced. Therefore, it can be expected that inflation will go back below 20% in the next couple of years. Drawing of foreign capital by privatization may reduce the high foreign debt of the country. The privatization will contribute to the technological development, too.

Population of the country may go down below 10,000,000 in 2010, if the present tendencies continue. Aging of the society may seriously burden the state budget in the next century.

Conclusions and Limitations

We have to emphasize again that the present macroeconomic assessments are rather uncertain. The economic crisis was not expected to last so long. In this economic situation, the environmental issues are low priority in the governmental policy. However, the country has certainly to fulfil the requirements prescribed by those international conventions and contratcts, which she joined. The increase of economic activities and the stabilization or reduction of emissions - in particular of greenhouse gas emissions - seem to be contradictory tasks for the country. Using of domestic and foreign sources for the necessary investments and national programs, these tasks can be harmonized. The available sources should primarily be concentrated on technological development, improvement of energy efficiency and energy saving and on enhancement of greenhouse gas sink capacities, i. e. on increase of forested areas.

7. SUMMARY OF ASSESSMENT RESULTS

For the overall national economy, we consider two mitigation scenarios, which have been compared to the baseline scenario (‘doing nothing case’). In the first one, the programmatic scenario is taken into consideration for the forestry sector combined with the mitigation options of the other sectors. The second mitigation scenario includes the technical potential scenario of the forestry sector combined with the same mitigation options in the other sectors. Results are summarized by Table 7.1.

Table 7.1. Assessment of mitigation options for the Hungarian national economy

Criteria	***Option 1***	***Option 2***
1. Potential for Large Impact on CO2 and Other GHG's (Total Reduction for 1996-2010 in MMTCE)	281	290
2. Direct Benefit/Cost Ratio of the Option	Low	Uncertain
3. Indirect Economic Impacts:		
• ***Increase in Domestic employment***	Low	Low
• ***Decrease in Import Payments***	Low	Low
4. Consistency with National Environment Goals:		
• ***Reducing Emissions of Air Pollutants***	Medium	High
• ***Effectiveness in Limiting Other Environmental Impacts***	Low	Medium
5. Potential Effectiveness of Implementation Policies	Medium	Uncertain
6. Sustainability of Option	High	Uncertain
7. Consistency with National Development Goals	High	Uncertain
8. Data availability for Evaluation		
• ***Technology characterization***	High	High
• ***Cost of Implementation Programs***	High	High

8. DEVELOPMENT OF MITIGATION MEASURES AND ACTION PLANS

As it has already been mentioned above, Hungary had to face a serious economic crisis at the end of the 80's. Furtermore it is expected that economy may recover only in the next century. Under these circumstances, the government has only very limited resources to support the solution of a variety of significant and different environmental problems including greenhouse gas issues. However, Hungary has identified several opportunities to prevent the increase of these emissions. These include reducing high specific energy consumption, increasing sink capacities by afforestation, and several other cost-effective strategies. The action plan aiming at the succesful implementation of the FCCC should be connected to those ongoing programs, which may result in reduction of greenhouse gas emissions as well. The following four govermental programs should be mentioned:

- Program of energy efficiency improvement and energy conservation
- Program for VOC (Volatile Organic Compounds) emission reduction
- Afforestation program
- Program to phaseout ozone depleting substances

The original time schedule of these programs cannot be kept because of budgetary problems. Further foreign sources are needed to complete them.

The program of energy efficiency improvement and energy conservation provides the best opportunities to reduce the greenhouse gas emissions. This program includes both supply and demand side measures. The highest priority is the technological development of the Hungarian power plant system. The aged coal fired plants of very low efficiency should be replaced by up to date technologies, and change of fuel structure should be changed, too. The share of cogeneration is planned to be increased. Also a new nuclear plant is considered to be built, but there is a certain resistance against it. (The only power plant of the country covers already almost half of the power demand of the country for the moment.) As far as fuel switch is concerned, share of gas will be probably increased in the near future. On the demand side, the specific energy consumption has to be decreased, since it is far higher than in the developed industrial countries.

The Hungarian Country Study Team intends to elaborate a comprehensive action plan which shold consist of the following steps.

- Determination of plan objectives and sectors of interest taking into consideration of the changing economic conditions (privatization and special circumstances of the countries with economies in transition)
- Design of participatory planning process, contacts with governmental and non governmental organizations
- Preparation of comprehensive workplan as the synthesis of individual detailed workplans, which should be prepared for each sectoral and cross-sectoral issues.
- Evaluation and development of sectoral and multi-sectoral measures
- Comparative analysis and refinement of measures across sectors examining the consistency and risks of the proposed actions must be examined. In order to assure this consistency, a variety of environmental, economic and social impacts for each action will be analyzed.
- Preparation of implementation strategies together with all the agencies involved in the development of the action plan
- Preparation and adoption of the climate change action plan in the form of a document providing clear and convincing recommendations for policymakers, describing in detail the costs and benefits for each proposed action.
- Preparation of National Communication according to the INC/FCCC guidelines together with the responsible governmental agencies

9. CONCLUSIONS

In the next 15-20 years Hungary has to recover from the deep economic crisis and to solve several environmental problems at the same time. In particular, the country has to fulfil the requirements of the FCCC, which targets the stabilization of the emissions of different greenhouse gas emissions. Article 4.6. of the FCCC allows for the countries with economies in transition to select a base period different from the generally recommended 1990, since in this year the emissions relevantly decreased in the region because of the economic recession. Hungary has chosen the period 1985-1987, whose yearly average emissions will be the base levels for the implementation of the FCCC. This means that it is unaviodable that the greenhouse gas emissions will increase in the next couple of years, although by application of different mitigation options the emission levels will not reach the base levels. According to the results of the national greenhouse gas inventories, the amount of CO2 emissions was more than 80 Tg in the base period, which decreased by cca 25% till 1994. Policymakers focus on to sectors for the moment, namely on the energy and the forestry sector. Ongoing governmental programs promote the energy saving and the increase of afforested areas. However, lack of capital postpones these programs. It seems that also foreign financial sources will be needed to conduct these and similar programs.

Privatization has already attracted a great amount of foreign capital into the country. Hungary was the most active in the region in this field. Also the utility companies have been partly privatized. Privatization of the energy (in particular the electricity) sector may assure those investments, which will lead to the emission reduction of greenhouse gases and other pollutants.

Our investigations show that economic recovery and the stabilizazion of greenhouse gas emissions will not necessarily contradict to each other.

REFERENCES

Central Statistical Office, Hungary, 1990. *Statistical Yearbook of Hungary*. Budapest, Hungary.

Central Statistical Office, Hungary, 1991. *Statistical Yearbook of Hungary*. Budapest, Hungary.

Central Statistical Office, Hungary, 1992. *Statistical Yearbook of Hungary*. Budapest, Hungary.

Central Statistical Office, Hungary, 1993. *Statistical Yearbook of Hungary*. Budapest, Hungary.

Central Statistical Office, Hungary, 1994. *Statistical Yearbook of Hungary*. Budapest, Hungary.

Central Statistical Office, Hungary, 1995. *Statistical Yearbook of Hungary*. Budapest, Hungary.

Country Studies Management Team, 1995. *Guidance for Mitigation Analysis. Version 2.0.* Washington D.C., Energy Analysis Program. Lawrence Berkeley Laboratory, Berkeley, California, USA.

Csóka, P., 1994. *Basic Information on Forest Resources. Use of Wood, Forest Policy and Legislation in Hungary.* Forest Management Planning Service, Ministry of Agriculture, Budapest.

Dörfner, P. and Bacskó, M., and Vid, K., and de Bristhoven, O. J., and Smeers, Y., 1990. *Risk and Uncertainty in Power Generation, the Hungarian Case. Application of a Stochastic Optimisation Model.* Study developed for the World Bank, Washington D.C., USA.

Führer, E., 1995. *Connection of Carbon Sequestration and Climate Change in the Silviculture* (in Hungarian). Biotechnológia és Környezetvédelem, Vol. 9. Nr.4. pp. 45-47.

Hungarian Commission on Sustainable Development, 1994. *Hungary: Stabilisation of the Greenhouse Gas Emissions*. First National Communication of Hungary.

International Energy Agency, 1995. *Energy Policies of Hungary*. (Country Survey).

Krommer, B., 1995. *Beliefs and Misbeliefs About DSM* (in Hungarian). Elektrotechnika, Vol. 88. Nr. 2. pp. 65-68.

Láczai Szabó, T., 1995. *Once more about DSM* (in Hungarian). Elektrotechnika, Vol. 88. Nr. 4. pp. 187-188.

MacGregor, P. R., and Oplinger, J. L., and Stoll, H. G., 1992. *Electric Utility Integrated Resource Planning*. Turbomachinery International, Vol. Nov-Dec, pp. 16-23.

Meyers, S., and Sathaye, J. (as lead authors), 1995. *Greenhouse Gas Mitigation Assessments: A Guidebook.* Kluwer Academic Publishers, The Netherlands.

Molnár, S., and Takács, T., 1995. *Energy-Economic Modelling in Hungary*. Idõjárás, Quarterly Journal of the Hungarian Meteorological Service, Vol. 99, No. 3-4, July-December, pp 419-428, Budapest, Hungary.

Molnár, S., and Takács, T., and Tajthy, T., 1995. *Estimating Emissions from Energy: Hungarian Experience*. Idõjárás, Quarterly Journal of the Hungarian Meteorological Service, Vol. 99, No. 3-4, July-December, pp 365-374, Budapest, Hungary.

Molnár, S., 1996. *Emissions of Greenhouse Gases in Central and Eastern Europe and the Newly Independent States*. In: Greenhouse Gas Emission Inventories - Interim Results of the U. S. Country Studies Program. Kluwer Academic Publishers, The Netherlands, pp 223-235.

Molnár, S., and Takács, T., and Pálvölgyi, T., and Faragó, T., and Tajthy, T., 1996. *Greenhouse Gas Emissions and Removals in Hungary*. In: Greenhouse Gas Emission Inventories - Interim Results of the U. S. Country Studies Program. Kluwer Academic Publishers, The Netherlands, pp 275-287.

Molnár, S., and Bacskó, M., and Takács, T., 1995. *Mitigation Options in Hungary*. In: Proceedings of the Workshop for Strengthening International Partnerships. Bundesministerium für Umwelt, Vienna, Austria and Department of Energy, Washington D. C., USA, pp 66-74 .

Péczeli, Gy., 1979. *Climatology* (in Hungarian). Tankönyvkiadó, Budapest, Hungary.

World Bank, 1995. *Hungary: Structure Reforms for Sustainable Growth* (country study, Hungarian translation). Washington, D. C., USA.