Economics of Greenhouse Gas Limitations

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Hungary Country Study

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ECONOMICS OF GREENHOUSE GAS MITIGATION

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Table of Contents

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Glossary

ABBREVIATION	LONG NAME
DHW	Domestic Hot Water
DSM	Demand Side Management
EBRD	European Bank for Reconstruction and Development
EIA	(US) Energy Information Administration
EIB	European Investment Bank
EU	European Union
FCCC	Framework Commission on Climate Change
GEF	Global Environmental Facility
GHG	Greenhouse gas
GWP	Global Warming Potential
HEO	Hungarian Energy Office (or MEH in Hungarian,see below)
HES	Hungarian Energy System
HNFS	Hungarian National Forest System
HUF	Hungarian Forint
IIASA	International Institute for Applied System Analysis
IPCC	International Panel on Climate Change
KTM	Kornyezetvedelmi es Teruletfejlesztesi Miniszterium (Ministry for Environmental Protection and Regional Development)
LCA	Lifecycle cost analysis
MAC	Marginal cost curve
MEH	Magyar Energia Hivatal (Hungarian Energy Office, see above)
MVM Rt	Magyar Villamos Muvek Rt. (Hungarian Electricity Works Ltd.)
NAFTA	North American Free Trade Agreement
NMVOC	Non-methane volatile organic carbon
NPP	Nuclear power plant
TPER	Total primary energy requirement
UN	United Nations
UNEP	United Nations Environment Programme

I. INTRODUCTION

Hungary recognises the importance of limiting greenhouse gas emissions in order to prevent or mitigate their impact on the global climate. On an international level, Hungary is not a significant carbon dioxide emitter, neither to the absolute degree nor on a per capita basis. This means that the principal reason for Hungarian participation in emission's reduction is not perceivable international consequences but solidarity and participation in the common action of the countries of the world. Hungary is a signatory to both the Framework Convention on Climate Change and the Kyoto protocol. However, the (Hungarian) National Environmental Program also emphasises that the fulfilment of international conventions must happen at a level and pace reasonable for Hungary. The goal of this study is to investigate the potentials, costs and implementation strategies of greenhouse gas abatement in Hungary.

I.1. Basic principles of responsible greenhouse gas mitigation approaches

Decreasing the atmospheric accumulation of greenhouse gases and the mitigation of their emission is an environmental problem that is related mainly to the production, storage, transportation and use of fossil energy forms. The differing interests of energy production and environmental protection may be approximated. This would depend on how energy intensity can be reduced and the proportion of natural, less polluting or non polluting renewable energy production that can be increased. By now the majority of the developed industrial countries recognise that environmental policy avoiding other sectorial policies cannot be implemented and that sectorial policies ignoring environmental aspects are unfounded, outdated and eventually are against the "public" interest.

The basic principles of integrated energy and environmental policies are as follows:

- prevention principle: Highlighting precaution and prevention we have to acknowledge that only unproduced energy does not pollute. There is need for feasible programs preventing environmental problems, which enable more efficient production and use of energy, and encourage the producers and consumers to reduce their energy consumption.
- the principle of "identical handling":
- Ranking of environmental harm and risks of different energy sources highlights treatment of some pollutants. Their marking as environmentally friendly (e.g. "clean energy") is inefficient and useless since we know that environmental and health damages develop from the accumulation of their impacts. Therefore, prevention should be aimed at a joint and simultaneous handling of all the environmental criteria.

– economic and ecological sustainability: Services accompanying by the operation and development of the economy and social welfare should be provided continuously and adequately in the long run by using the least possible energy. In other words, integrating energy and environmental policies is an instrument of public service, which by using natural and economic resources does not take away or restrict the achievements of civilisation. On the contrary such service provides for current needs, taking the interests of the future generations into account. It prolongs the use of resources and does not cause irreversible changes.

– international compliance: The strategy that takes the interests of environmental protection and energy into account coincides with our efforts to join the European Union and meets the expectations of OECD and IEA membership. The international environmental conventions Hungary has signed also promote the development of an integrated energy and environmental policy and prepare the energy sector for the reduction of environmental pollution.

Our plan for the implementation of an integrated energy and environmental policy and for our commitment to the Kyoto convention within the framework of the National Environmental Program. Within the Climate Protection Action Program:

– we have to calculate the numerical alternatives of energy use and greenhouse gas emissions (primarily carbon dioxide and methane) according to fuels taking economic development, power station reconstruction, fuel replacement, energy imports, the price-income relations and the improvement of energy-efficiency jointly into account.

– we have to evaluate the possible legal/regulatory, technological, financial etc. measures which lead to a further decrease of specific energy uses. The analysis should indicate to what extent they support our obligations regarding the limitation of carbon dioxide (in general greenhouse gas) emission.

– in addition we have to evaluate to what extent the international, financial, technical and technological relations developing in connection with the Convention are able to promote the implementation of the program and the development of its concepts.

I.2. Outline of the study

First presented is a background of Hungary's economy and a summary of the economic transitions in Hungary. A brief description of the Hungarian energy sector is included, with a short summary of carbon dioxide emissions, and of the Hungarian forestry sector. The following chapter is devoted to the development of baseline scenarios, from bottom-up and top-down perspectives. In the chapter on mitigation, the spectrum of energy efficiency measures in the residential and public sectors is discussed. Fifteen specific measures, whose impact is considered important, are selected and discussed in detail. The cost curves are developed for the discussed mitigation options. Then, we discuss the issues related to the implementation of energy efficiency measures in the Hungarian residential and commercial sectors. After a general background and a framework on the implementation of the energy efficiency measures in the sectors chosen, we elaborate on the practicality of these concepts. As a case study, the concept and the feasibility of carbon/energy taxes are examined. To complete the implementation chapter, we discuss the various forms of assistance available for the implementation of energy efficiency projects in the residential and commercial sectors.

II. Economic background

II.1. Basic indicators

Hungary has a population of 10.6 million and a land area of 93,000 km^2, with a population density of 114 inhabitants/km^2. Approximately one-fifth of the population lives in the capital city of Budapest.

Hungary was a member of the CMEA (Council for Mutual Economic Assistance, COMECOM) for several decades, tying its economy strongly to the Soviet Union and other Warsaw pact countries. Even during the socialist regime, however, Hungary had one of the most "liberal" economies, allowing for small private enterprises. In 1989, Hungary contributed to the fall of the Berlin wall and the "fall of the iron curtain" by allowing East German citizens through its border to Austria. Also in 1989, Hungary took its first major steps towards a transition from socialism to a market economy among socialist countries. Hungary held its first free elections in 1990. Today, leading among economies in transition, the majority of the country's economy has been privatized, including land and the energy sector.

II.2. Economic performance of Hungary since 1990

The changing structure of GDP

Based on changes in GDP, the economic performance of Hungary in the early 1990s resembled the country's economic performance during the later half of the 1970s. The most dramatic decline (15.4%) occurred in 1990 and 1991. The decline slowed in the years following, and, according to available statistics, moderate growth began after 1994. If the level of GDP in 1988 were considered 100%, the level in 1994 could be regarded as 84%.

Table -II-A   Economic indicators for 1990–1995

	1990	1991	1992	1993	1994	1995
REAL GROWTH PER YEAR	%	%	%	%	%	%
GDP	-3.5	-11.9	-3.0	-0.8	2.9	1.5
Domestic use	-3.1	-9.1	-3.6	9.7*	2.1	-(3-4)
Private consumption	-3.6	-5.6	-0.1	1.5	0.7	-(5-6)
Community consumption	2.6	-2.7	6.4	25.3*	-11.2	-6
Investments	-7.1	-10.4	-2.7	1.7	12.2	1
PRODUCTION INDICES						
Agricultural production	-4.7	-6.2	-20.0	-9.7	3.2	0
Industrial production	-10.2	-16.6	-9.8	4.0	9.6	4.8
PRICE INDICES						
Consumer price index	28.9	35.0	23.0	22.5	18.8	28.2
Industrial production index	22.0	32.6	11.5	10.8	11.3	28.9
EMPLOYMENT, INCOMES						
Rate of unemployment	1.9	7.5	12.3	12.1	10.4	10.4
Net real wages	-4.0	-5.1	-1.8	-3.9	5.2	-12.2
BALANCE OF PAYMENTS						
Balance of payments on current account as a percentage of GDP	0.4	0.9	0.9	-9.1	-9.5	-5.6
*****Balance of public finance as a percentage of GDP**						
Total balance	0.3	-4.4	-6.5	-5.8	-8.1	-6.5

** Including Russian military import. Without it, the community consumption index is -2.3%.*

(KOPINT-DATORG, prosperity report of 1996 October, page 80.)

Most notably, between 1990 and 1992, the performance of the so-called “production sectors” (industry, construction, agriculture) decreased by 30%. The most important reasons for this decrease are the loss of conventional export markets, the decline in domestic demand, the decrease of investments, and price liberalization after the change of regime. Foreign products appeared as a result of price liberalization, “stealing” a part of the demand from domestic manufacturers who, in any case, could hardly compete with western manufacturers (primarily because of product quality). A large number of plants equipped with out-of-date technology failed as a result of the end of the earlier subsidization system, privatization, and other kinds of capital investment.

Industrial production decreased by 36% between 1990 and 1992; in 1993, however, the volume of gross production increased by 4%. Production continued to increase by almost 10% in 1994 and 5% in 1995. The decline after the change of regime and the slow increase around 1993 and 1994 resulted in some sectoral modifications as well.

For example, mining production declined by 45% between 1990 and 1994; consequently, its share of industrial production fell to 1.1%. The energy sector, in 1991, had experienced a temporary increase in its share of industrial production

(14.7% compared to 12.4% for the previous period); by 1995, however, energy's production share had fallen again to 12.1%. In contrast, the production share for manufacturing decreased from 85.7% to 83.8% in 1991 but, by 1995, had increased to 86.8%.

With respect to foreign trade, the period after 1990 was rather hectic. The countries of the eastern European region made simultaneous efforts to restructure their foreign trade relationships towards the markets of developed industrial countries. In the meantime, their conventional trade relationships among each other were forced into the background. (In addition, these efforts occurred at the same time as the recession in the industrial countries.)

Based on its GDP, the Hungarian economy could not achieve the modestly expected 0.5–1% growth (however, official data for this period are not yet available), and 1996 was characterized by stagnancy. In real terms, this means that the GDP for 1991 and 1996 are actually the same if you account for inflation.

The stabilization policy has been successful in balancing payments on current accounts and the central budget. (According to the prosperity report in October 1996, the deficit of the balance of payment on current accounts was $967 million in the first seven months of 1996, which was $1.1 billion less than in 1995. In addition, according to the data for the first eight months of 1996, the budget balance has a surplus of 105 billion Forints; this means a deficit of 121 billion Forints even after subtracting the single 226 billion Forints mainly from privatization, which is about 100 billion Forints less than in 1995).

II.3. Population Growth

During the fifteen years between 1980 and 1995, Hungary's population has decreased progressively by half a million people. During the last five years, the population decreased by about 160 thousand people. On January 1, 1996, there were 10,214,000 people living in the country. Population is also decreasing in eight other European countries: Bulgaria, Croatia, Estonia, Germany, Italy, Latvia, Romania, and The Ukraine.

The low fertility rate (small number of births), high mortality rate, and unfavorable structure of ages are factors that influence long-term population growth. The change over time in life expectancy at birth is a widely accepted population indicator, and its tendency is alarming in Hungary. It is important to note that there has been a continuous decrease in the life expectancy for men since 1966, while the life expectancy for women has increased somewhat. The mortality indices for Hungarian men are among the worst in the world. In some male age groups (particularly ages 35–64), the mortality rate is similar to that of the 1920s and 30s. Due to the different social conditions, the mortality rate is remarkably higher in villages than in towns.

Table II-B Changes in life expectancy at birth in Hungary

Year	Life expectancy at birth (years)	
	Men	Women
1960	66	70
1966	68	72
1970	66	72
1980	65	73
1990	65	74
1994	65	74

Source: Based on Central Statistics Office, 1996

In general, a mortality rate is dependent on lifestyle, the quality of health services, and environmental threats. In the last two to three decades, the above mentioned trends in Hungarian mortality were largely influenced by lifestyle - a poor diet, smoking, alcohol consumption, and lack of exercise are all considered to be risk factors. The quality of health services was less of a factor than lifestyle. Environmental threats play a more and more important role in illnesses, but their influence on the Hungarian mortality rate cannot be identified statistically at this time.

II.4. Employment

Through the end of the 1980s, because of guaranteed employment by the government, unemployment in Hungary was not a serious concern. From 1990–1993, however, the numbers of unemployed people increased abruptly. Late in 1993, unemployment stabilized at a high level that resembled the unemployment rate in OECD countries.

More than 80% of the employed have a salaried position within a company or the government, almost 10% are entrepreneurs, and others are cooperative members or are in housekeeping. The distribution of the employed in different sectors modified remarkably between 1990 and 1995. The share of the service sector has vigorously increased so that it is comparable to the service sector share found in developed countries. However, this development did not occur naturally over a long time period, but instead took place over four or five years as a result of the economic recession in Hungary. The most intensive change occurred in the agricultural sector where, over a four year period, the number of the employed decreased by 45%; over the same time period, employment decreased by 24% in industry and construction.

The condition of the labor market has not improved significantly compared to previous years because of the unfavorable composition of the unemployed. The rate of people permanently unemployed (having looked for a job for at least one year) grew remarkably from 26.7% in the fourth quarter of 1992 to 52.8% in the fourth quarter of 1995. In this respect, Hungary’s unemployment rate exceeds that of most OECD countries. The highest rate of unemployment is found in the younger age-class. Examining the overall period of 1992–1995, people under the age of 30 represent 37–40% of the total number of unemployed. In addition, regional factors are important when considering unemployment in Hungary. The northeastern third of the country is permanently suffering unfavorable employment conditions and, throughout the country, the rate of unemployment in villages is 1.5 times greater than the rate of unemployment in towns.

As a result of the Central and Eastern European socioeconomic changes, Hungary has been deeply concerned about the international population movements in the region in the last few years. Immigration has become a sensitive social, economic, and political problem in Hungary. In 1994, some 138 thousand foreigners lived in Hungary for more than one year, most of them as immigrants. Transmigration, however, also continues – mainly among higher educated people. Today, the number of citizens living and working abroad differs only slightly from the number of foreigners living in Hungary.

II.5. Standard of life

The most comprehensive indicators of quality of life are family income and the current consumption structure as a function of the former one. The worsening employment conditions that characterized most of the previous decade significantly influenced the income conditions of Hungarian families. Although the nominal value of gross incomes increased by 370% between 1989 and 1995, the real incomes of those living from wages and earnings decreased by 22% over the same period as a result of drastic inflation. Within that, there is a great difference in earnings between the private and public sectors, with private sector employees making much higher wages.

The following changes are worth noting in the spending structure of the community, on average, between 1989 and 1995:

- Spending rates increased for house maintenance (from 10% to 14%), transportation and telecommunication (from 11% to 13%), food (from 32% to 34%), and health and personal hygiene (from 3% to 4%).
- Spending rates decreased for home building, purchase of real estate (from 10% to 7%), and housekeeping and furnishings (from 8% to 6%).
- Spending rates for clothing, education, and recreation were already decreasing prior to 1989 and continued to decrease through 1995.

In addition to the level of food consumption, the number of durable consumer goods in households can be an important indicator of the quality of life over time. The make-up of stock and the change in stock structure also have important environmental implications with respect to the consumption of materials and energy. The table below indicates the changing supply of various consumer goods in Hungarian households over time.

Table II-C The changing supply of durable consumer goods in occupied households in Hungary (units per 100 households)

Consumer Good	1987	1989	1991	1994
Refrigerator	102	104	103	105
Freezer	22	44	64	69
Automatic washing machine	34	41	47	54
Car	49	54	55	51
(Color) TV	41	61	76	91
Video player (VCR)	3	18	32	47
Personal computer	3	7	10	10

Source: Based on Central Statistics Office (1996)

II.6. Review of the Hungarian energy sector and energy policies

II.6.1. Climate Change Overview

Hungary signed the United Nations Framework Convention on Climate Change (UN FCCC) on June 13, 1992. The Parliament passed a resolution in December 1993 ratifying the Convention (Ogy #102, 1993). The ratification instrument was deposited in February 1994, took effect in May 1994, and was announced to the public by Law LXXXII of 1995. According to this law, the Government undertook that anthropogenic CO_2 emissions in Hungary in the year 2000 will not exceed emissions in the base year (see below). CO_2 emissions in Hungary totaled 59.2 Mt in 1994. Hungarian emissions for 1994 are almost 10 Mt lower than the FCCC base year (1990) emissions of 68.1 Mt; the low quantity of emissions, however, is primarily attributable to the economic recession that resulted from Hungary’s economic transition. Because of the post-89 economic recession, the UN FCCC allowed a certain degree of flexibility in the fulfillment of the general provisions concerning the stabilization of emissions in economies in transition. Consequently, Hungary has chosen the base year emission level to be the average emissions of 1985, 1986, and 1987 (the years in which emission levels were highest prior to the transition), about 80 Mt. CO_2 emission intensities in terms of CO_2/GDP were still almost twice as much as the OECD average in the mid-1990s. Almost 97% of CO_2 emissions originate from fossil fuel combustion, to which the energy and transformation sector contribute 46%, industry 11%, transport 13%, the residential sector 20%, and agriculture and trade less than 10%. The second National Communication to the FCCC took place at the Kyoto conference in 1997.

Hungary recognizes that the most effective strategy for meeting the FCCC targets is the promotion of energy efficiency. Thus, the National Energy Saving Action Plan (NESAP) has been analyzed and endorsed. The government also acknowledges that reducing the country’s energy intensity, which is still two to five times higher than that of OECD countries, will provide numerous economic benefits. Tools used for improving energy efficiency have included the removal of most of the subsidies on energy prices, the liberalization of oil product prices, the privatization of the gas and electricity industry, and joining the OECD and EU .

II.6.2. Major characteristics of the Hungarian energy sector

One of the most characteristic features of the Hungarian Energy System (HES) is the lack of sufficient clean and inexpensive domestic energy resources. Thus, the ever-increasing national energy demand has to be met by increasing energy imports. Currently, Hungary relies on imports to meet more than 50% of its energy needs. This percentage is expected to increase significantly in the future because of the exhaustion of proven reserves of domestic fossil fuel beyond the year 2000.

In Figure II.A (below) the sources of the energy supply are shown. The energy sources consist of: (1) domestic production, (2) energy imports, and (3) energy from decreasing stock.

The total primary energy requirement (TPER) of the country is equal to the energy sources minus the energy export and minus the increase in the energy stock.

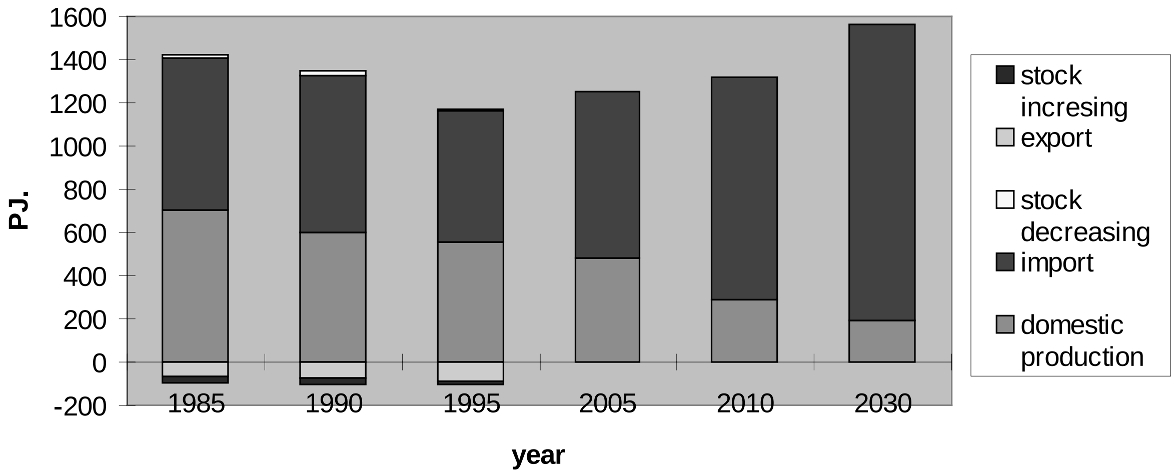
The share of energy imported to meet Hungary's energy needs cannot be significantly reduced because the country is poor in domestic energy resources. However, to ensure the security of energy supply, energy imports should be diversified. In the past, Hungary's imported energy has come from one exporting country; this situation is not advisable from the point of view of the national energy security. If energy imports are modified in the future, emissions of pollutants will also be effected because of the different properties of imported fossil fuels.

When calculating the TPER, the electricity generated by hydropower plants and imported electricity is taken into consideration with their fuel equivalent (i.e. with the average heat rate of the domestic power plants in the calendar year). It should also be emphasized that the nuclear electrical energy production is accounted for in the imports because the fuel rods used by Hungary's single nuclear power plant were imported in spite of domestic uranium ore mining. There will be no uranium ore mining after the year 2000 in Hungary because it is not economical (i.e. the uranium concentration of the ore is very low and thus its mining is too costly).

Due to the economic recession discussed above, the transition period for the whole economy, and declining industrial production, GDP has decreased significantly over the last few years. Because of economic restructuring and the aging production systems, the share of different sectors in GDP production also changed significantly. The industrial sectors that produced very energy-intensive uneconomical products have stopped production or their production has been significantly reduced. These production changes, along with sharp changes in the structure of energy consumption, significantly affected not only energy consumption but also environmental pollution (e.g., national pirogeneous GHG emissions).

It should be mentioned that, during the planned-economy period, the prices for different types of energy were dictated by the Hungarian government. These prices were relatively very low, constant over a long time period, and independent from the variation in world market prices. Thus, energy conservation was not a priority for either energy producers or consumers and there was no incentive to promote conservation through such activities as retrofitting aged production systems, installing more effective new technologies and equipment, introducing low energy consuming devices and appliances, increasing insulation, and so on. Consequently, the overall energy intensity of the Hungarian economy and the specific energy consumption of the consumers in all sectors are very poor when compared to highly industrialized countries (compared to the countries of the former Soviet blocks, however, Hungarian energy intensity and specific energy consumption data are among the best). Although per capita energy consumption in Hungary is even less than the European average, the energy intensity is much higher than for the European Economic Community; this fact reflects the low efficiency of the Hungarian economy and not of the energy industry.

Figure II.A. Total primary energy requirement in Hungary by sources.



II.6.3. Electricity Supply

The installed electricity generation capacity in Hungary was 7288 MW in 1995. The maximum national peak demand in 1995 was 5731 MW.[1] Net electricity production in Hungary was 34 TWh in 1995, which is so far the highest in Hungarian history . The country imported 3.2 TWh of electricity, which accounted for less than 10% of the 36.4 TWh demand. Electricity demand reached its lowest during the post-89 recession in 1992 with 35.1 TWh, down by 16% compared to its peak in 1989. In 1994 and 1995, electricity imports reached their lowest since the 1980s, down by 80% compared to the late 80s. Exports were basically negligible with 0.8 TWh in 1995. In the near future, electricity demand is expected to grow as a result of the reconstruction of national industry as well as the rapidly increasing penetration of household electric equipment. According to the medium IEA forecast, electricity demand is going to reach its 1989 peak again by 2000, and will increase rapidly thereafter at an annual rate of approximately 1.3 TWh. In 1996, 44.7% of electricity was generated by nuclear power, 29.2% by coal, 12.0% by fuel oil, 14.1% by natural gas, and 0.5% of hydropower. These shares have remained relatively constant throughout the 1990s, with the share of oil increasing from a very low share at the turn of the decade.

[1] Please note that at the time of the writing of this report, November 1997, no detailed official energy statistical data were yet available for 1996.

II.6.4. Residential and communal energy use

GHG emissions of the residential and communal sectors account for a significant share of the total GHG emissions of an economy. As seen in Table II–D, gross energy use in Hungary has declined during the 1990s to a greater extent than the energy demand in the residential and communal sectors.

Table II-D Gross energy use and energy consumption of the Hungarian residential and communal sectors

Energy consumption (TJ)	1985	1990	1995	2005	2010	2030
Gross	1323	1244	1067	1250	1320	1560
Residential sector	275	273	261	293	316	375
Communal sector	79	73	81	108	120	167

Source: Based on the Baseline scenario by Tihamer Tajthy

Based on Table II-D, residential energy use amounted to about 20% of the gross energy use in Hungary in 1985; in later years, as forecasted, this share increased to about 24%. The same trend can be observed for the communal sector's energy use (from 6% in 1985 to 8-9% in 2005 and 2010). This trend has been paralleled by a phenomenon called the "environmental gratis effect", which means that a decline in industrial production may have beneficial effects on a number of environmental factors, including the energy intensity of an economy and the emissions of important polluting materials such as greenhouse gases. Historical and agricultural demand had declined but the residential and communal energy consumption has not. The result is that the latter sectors now have a larger share in the total energy demand.

The two sectors' share in the total energy consumption of the country (around 32%) indicates that mitigation scenarios in these sectors of the economy play an important role in policy considerations.

II.6.5. National Energy Policy

Beyond securing sufficient energy supply, the primary goals of the Hungarian national energy policy are diversification of generation within the country and origin of fuel imports, flexibility, environmentally sustainable generation and use, encouragement of more environmentally acceptable energy sources, improved energy efficiency, research and development, undistorted energy prices, free and open trade, and cooperation among all market participants. The tools to achieve these goals include legislative reform (the new Electricity Act, XLVIII tv., was passed in 1994), restructuring, privatization, vertical and horizontal break-up of the electricity and gas supply sector, removal of subsidies, energy tariff liberalization, and the harmonization of environmental standards to EU norms. The realization of these goals has had varying success so far. The privatization of the energy sector has been declared a success by various international and national entities; however, some social, environmental and national economic concerns remain, and some negative social and economic impacts are recently coming into the spotlight. The privatization of the Nuclear Power Plant of Paks is currently being discussed. The liberalization of energy prices and some other processes are described in more detail below and in other sections of this document.

II.6.6. Energy price policy in Hungary

Prior to the “New Economic Mechanism” introduced in 1968 in the energy sector the so-called prime cost type pricing was applied. When the new mechanism was announced one of its aims was that prices should reflect market conditions, thus orienting producers and consumers in their economic decisions. The aim of reforming the price system of industrial products – among others of energy sources – was to determine the prices on the basis of producer expenditures.

One of the main objectives of energy policy was to transform the existing energy structure, namely to reduce the use of low (lower) quality Hungarian coal and increase the import of Soviet natural gas and crude oil. To increase the proportion of using hydrocarbons was meant to be encouraged by prices as well. As a consequence a changeover from coal heating to oil heating started in Hungary. This ‘favourable’ tendency was brought to a stop by the oil price explosion in 1973, due to which import became more expensive for Hungary even though this price rise was only gradually felt with delay on the CMEA market.

A significant step in transforming energy prices on market principles was the resolution of Parliament of 19 November 1990, which declared the principle of forming a liberalised price system, according to which energy prices are shaped by market conditions, by the market itself (Act No. LXXXVII, which came into effect on 1 January 1991). The Act declared that fixed prices should remain in force only in case of natural monopolies (electric energy supply, natural gas supplies, and district heating), and as a result the Act on Prices was also amended in February 1992.

The costs of energy import were greatly influenced by the fact that in 1991 rouble accounts were changed to dollar accounts. This meant that costs more than doubled. Managing the problem was made even more difficult by the ‘deformed’ structure of Hungarian producer and consumer prices. The Hungarian price system (in the field of energy sources) favoured the communal consumers (on social considerations) in shaping producer and consumer prices. Consequently prices were not determined on the basis of effective costs. While in countries with a highly developed economy the basis for shaping the tariff system was the amount of effective costs, in Hungary, on social considerations, communal consumer prices were held below the effective costs. The resulting ‘cross-financing’ means that the profit originating from non-communal consumers who pay higher tariffs but whose costs are smaller, or a part of this profit finance the loss appearing in subsidised communal prices.

Starting from 1992 one of the objectives of energy price policy was that the margin of all the three sectors (household, general and industrial) should cover prime costs and should contain a fixed (accepted) profit part. Naturally, this objective applies to all the mentioned energy supplies. According to the law as of 1992 communal energy purchases are not subsidised by the state (except for the subsidy of socio-political character on district heating).

According to plans the basic principles of price policy to be followed are:

- Inasmuch as the specific features of “energy” allow for it (natural monopoly situation in case of energy sources, etc.) energy should be present on the market as a commodity, and its price should be shaped by market conditions. The task of the government is to limit the development of unnecessary monopolistic situations and facilitate the operation of market-conform conditions of competition.
- The prices of energy sources appearing as natural monopolies should be fixed as fixed prices. Fixing the pricing is also the task of the government. The price should contain justified (acceptable) costs, including the costs of additional investments, necessary developmental expenditures and appropriate profit in proportion to capital. (This principle will also be especially important for the new owners of producing and service companies to be privatised in the future.)

The higher consumer price appearing as the acceptance of justified cost (and which is constantly adjusted to the inflation rate) can cause further problems from the aspect of social policy as well. Prices based on economic costs put increasing burdens on certain social strata, certain consumer groups. If the real income of the population or that of certain social strata decreases, social assistance compensating energy price rises seem to be necessary.

In August 1995 the Government passed a resolution (Government decree No 1074/1995 on price regulation of electric energy and its adjustment before 1 January 1997), according to which the market prices of energy sources should be shaped in three steps. Raising the price of natural gas, price regulation of natural gas and price adjustment before 1 January 1997 was announced in a Government decree No 1075/1995 (4 Aug.).

There was a significant price rise of energy sources in September 1995 and March 1996 (natural gas by 8%, average 25%, electric energy by 8% , average 18%.). All energy prices and tariffs have been revised several times a year since then. Electricity tariffs have gone under a major revision over the last three years. According to governmental commitments, energy price subsidies were to be entirely lifted and to cover costs plus a 7% profit margin by January 1, 1997. Between 1994 and 1996, residential electricity tariffs have doubled, which resulted in a strong public opposition towards the planned price 1997 price reform. As a result, the January 1, 1997 price increases were slightly less than it would have been required to cover all costs plus the profit premium, but the government in the end satisfied the needs of foreign investors by a minor cost redistribution between foreign and still nationally owned generation facilities. As a result of 3 more tariff revisions in 1997, residential electricity prices are currently[2] between 12.9 HUF (~US$ .07) and 18.1 HUF (~US$ .09), excluding VAT during the day, depending on consumption level; and 6.8 HUF (~US$ .03) and 7.6 HUF (~US$ .04) during the night[3]. These prices are several times higher than the 0.90 HUF - 2.01 HUF tariffs in 1990. The industrial cross-subsidy has been removed from residential tariffs. Marginal electricity generation costs were 15 - 16 HUF (~0.08 US$) in 1995. The structure of the communal tariff system did not

[2] As of Oct. 1, 1997

[3] Please note that night electricity is not available for the majority of the residential consumers, because it requires special equipment and meters.

change, the average price rise was 25%. The prices are given in Appendix 1. District heating companies raised the price of the thermal energy purchased in this way by 32%, and that of hot water by nearly 22%. If a district heating company supplies energy from other sources than purchased thermal energy, i.e. if it produces hot water in its own boiler, the price of this energy is established by the authorised local government.

II.6.7. Institutional structure

As discussed before, the electricity industry in Hungary has been vertically and horizontally broken up. Electricity is generated by 23 major power stations organized into 13 power station companies, which are under an average of 25% foreign ownership. By mid-1997, six major generation companies have been purchased by Belgian, British, German and American investors with majority shares. Electricity is distributed by six regional distribution companies, with an average of 47.7% foreign, mainly German and French ownership. Municipalities received approximately 40% of shares in the distribution in 1997 for their investments in infrastructure, some of which have been sold to small or large foreign and small local investors. High voltage transmission is still owned by MVM Rt. (Hungarian Electricity Trust Ltd.), the original owner of all distribution, transmission and generation.

Several new institutions were established during the energy restructuring process in Hungary. The Ministry of Industry and Trade (MIT) still has the primary responsibility for energy policy, and the Ministry of Environment and Regional Development (KTM) for addressing environmental issues, but some of their roles have been taken over by new organizations. The Hungarian Energy Office (HEO or MEH in Hungarian) was established by the gas law of 1994 to license gas and electricity supply and regulate gas and electricity prices. In addition, it also has an energy efficiency department. Other organizations involved in the Hungarian energy policy arena include the Hungarian Privatisation Ltd. (ÁV Rt.) reporting to the Parliament and responsible for privatisation, the Council for the Protection of Energy Interests (EÉT) established in 1995 to assist MEH in the protection of electricity and natural gas consumers; and the independent Coalition for the Protection of Consumer Rights (FVSz).

II.6.7.1. Public sector institutions

On the consumer side, the “Energy Fund” was established to support low income households in compensation for the most recent electricity tariff hikes. It is housed by MVM Rt. (Hungarian Electricity Works Ltd., see above), which contributes to the governmental fund. On the producer and program design side, the EU Synergy, Thermie II (for the development of energy technology), ALTERNER (for renewables), and PHARE (environmental protection) programs will be available for limited types of assistance. The Hungarian-EU Energy Centre (which was funded by the EU and is currently under reorganization, probably will be mainly funded by the Hungarian government) is taking part in or administering several energy projects funded by these sources. The various support schemes for the improvement of energy efficiency will be discussed in more detail in further sections of this document.

Other organizations include the “Coalition of Hungarian Energy Consumers” (Magyar Energiafogyasztók Szövetsége, MESZ), which is an independent professional body consisting of professionals from the energy industry (Porpáczy, 1997); the “Technical Safety Authority” assuring safety in the energy industry, established by governmental order and reporting to the Minister of Industry and Trade; the public interest organization Energy Information Authority (Energia Információs Ügynökség Kht.); and the State Energy Management and Safety Authority (ÁEEF).

II.6.7.2. *Non-governmental organizations (NGOs)*

Hungary has one of the most developed non-governmental movements among economies in transition. As a result of several problems related to energy in recent history that enjoyed wide public attention, such as the Danube dam, the Paks NPP, energy price increases, etc., there are several NGOs concerned with or dealing exclusively with energy related problems. Recently, a so-called "energy coalition" has been established that coordinates these NGOs. Selected NGOs with some energy-related experience include (with the location in brackets): Energia Klub (Energy Club, Budapest), Pécsi Zöld Kör (Pécs Green Circle, Pécs), E-Misszió (E-Mission, Nyíregyháza), Energia és Környezet Alapítvány (Energy and Environment Foundation, Nyíregyháza), Életfa Környezetvédelmi Szövetség (Életfa Environmental Coalition, Eger), Ifjúsági Természeztvédõ Kör (Youth Nature Conservation Circle, Hajdúböszörmény), Holocén Egyesület (Holocén Club, Miskolc), Zöld Akció (Green Action, Miskolc), Reflex (Gyõr), and Göncöl (Vác). The Energy Club of Budapest has established an energy training center for the non-profit movement, the FAIRE program (Free and Applied Internships towards Renewable Energy).

Academic organizations active in the field of energy and environment include the department of Environmental Sciences and Policy of the Central European University, the Budapest University of Economics, and the Technical University of Budapest.

II.6.8. *Environmental impacts of the Hungarian energy sector*

The energy sector (generation, distribution and use) is the single largest source of environmental pollution in Hungary. Electricity generation and district heating was responsible for more than half of all SO_x emissions, 22% of NO_x emissions, 13% of particulates, and over 35% of CO_2 emissions. Power plant emissions are exacerbated by the poor quality of domestic coal and lignite and the aging equipment and low combustion efficiency of some plants. Besides the CO_2 emissions described in detail in other sections of this document, other greenhouse gas emissions comprised 776 thousand tons of methane, 1.2 Mt. of N_2O, 1.3 Mt of CO, 1 Mt of NO_x, and 84 thousand tons of non-methane volatile organic carbon (NMVOC). Of this, the energy sector was responsible for 51% of methane, 95% of NMVOC, 93% of CO, 21% of $NO_{x,}$ and negligible amount of N_2O emissions. Besides the pollution generated by the generation and use of electricity, safety issues are raised by the Paks nuclear power plant (NPP) with 1840 MW capacity. The 4 units of the NPP are of a Russian VVER-440 design. Although the safety of Paks was concluded to be acceptable by the IAEA recently if three Level 3 and eleven Level 2 changes are implemented[4] (Bárány, 1997), the long-term storage of the used fuel rods and other waste issues remain unsolved. A recently completed temporary fuel storage facility has raised concerns.

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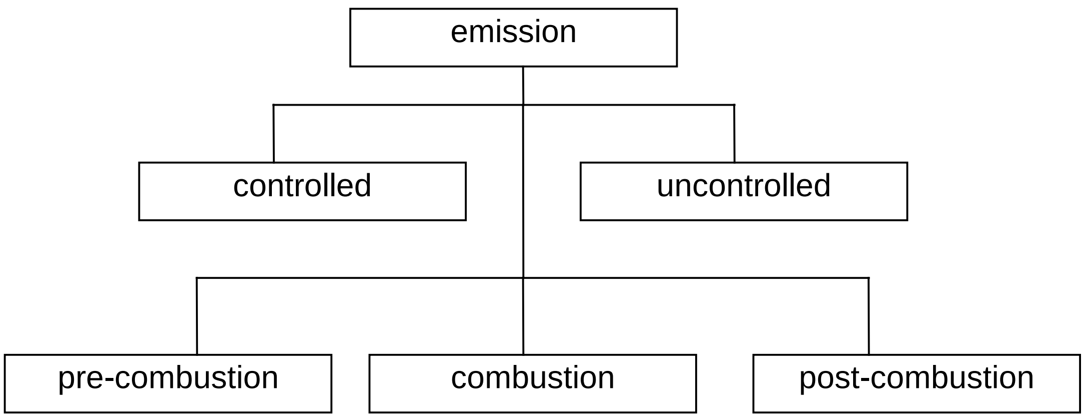
[4] Level 4 problems require the shutting down of the NPP; Level 3 problems require immediate attention, and Level 2 problems are recommended to be addressed.

Besides these, the utilization of the low quality domestic energy resources, the environmental pollution caused by the fuel use in Hungary is relatively high. With respect to environmental pollution, these are fundamentals and deterministic. We are forced to use the low quality domestic fuels, and a huge amount of energy for operating our aged production system, our aged car fleet, devices, and appliances. The energy sector did its best to offer reliable and effective energy supply to the country within its possibilities i.e. the structure of the fuel use was changed, new technologies and new types of energy have been introduced (e.g. desulphurization of the oil products, combined -cycle gas turbine, fluidized bed combustion for electrical energy production, electrostatic precipitators in all coal-fired power plants, combined heat and electricity production, intensive natural gas program, introducing nuclear electricity, adequate tariff system to promote the structural change in the fossil fuel consumption, diversification of the energy import, destructive technologies in the oil refinery etc...), but the promotion of reducing environmental pollution is still needed, specially for the bulk energy consumers.

The fulfillment of the environmental requirements lays a very high burden on the HES, and specially when the lack of capital and investments limits our possibilities. We have to utilize our existing resources efficiently and effectively. The greatest problem for the HES is that in a relatively short period, we are forced to eliminate all the mistakes and negligence of the recent past while dealing with very difficult circumstances.

II.6.8.1. Emission control technologies used in the Hungarian power industry

When determining and evaluating the emissions, it is also important to consider their control technologies. In Hungary significant post-combustion control technologies are used for controlling the particulate emissions in public power plants only, e.g. mechanical filters (cyclones, multicyclones) and electrofilters (electrostatic precipitators, ESP). In every coal-fired power plants of large capacity there are ESPs, and in a hydrocarbon (HC) fired power plant a single ESP unit is installed to a 215 MW block.



Within the post-combustion technologies, the three-way catalisators and selective catalytic reduction must also be mentioned, specially in the transportation sector e.g. for controlling the emissions of gasoline driven (spark ignition) cars.

Combustion modification is realised in Hungary, by the following technologies:

- fluidised-bed combustion is introduced in the coal-fired Ajka power plant (Hybrid AFBC atmospheric fluidised-bed combustion, combined with pulverised coal firing, if the load on the boilers exceeds 75% of their rated capacity, thus the N_2O laughing gas emission will not increase)

The most significant modification in the GHGs emission has been realised by the introduction of different pre-combustion technologies, such as:

- A modification of the structure of the fuels. For example, the introduction of nuclear electricity generation, thus in 1994 about 40% of the fuel used by public power plants was nuclear fuel. The fossil fuel used by public power plants in the year 1995 was less then before the penetration of the nuclear electricity generation. An intensive natural gas program, for substituting the coal used by households and industrial sectors and destructive technologies has been introduced in the refinery, selective catalytic cracking, viscosity-breaking, and hydro-cracking. Thus, the share of high sulphur content residual oil drastically decreased.
- An increase in the efficiency of the fossil fuel used. For example are combined heat and power generation. About two-third of the heat supplied to district heat by the public power plants is co-generated. A combined cycle gas-turbines were installed. By retrofitting and other means, the heat rates of the old coal-fired power plants have been decreased.

II.6.9. Overview of CO2 emissions in Hungary

In Hungary, 7 tons of carbon dioxide are emitted per capita annually. Among the OECD countries this is equivalent to the figures of Austria, France, Greece, Japan, Italy and Switzerland. It is below the OECD average. The following data illustrates the significance of carbon dioxide emissions resulting from fuels and power stations.

Table II-E Tendency of the total anthropogenic emission of carbon dioxide in Hungary (thousand tons)

	1980	**1985**	**1990**	**1992**
from fuel consumption	92 050	88 830	74 200	65 930
from other sources	29 964	28 226	26 588	21 176
altogether	122 014	117 056	100 788	87 106

Source: Tajthy, 1995

Three-quarters of the total amount of carbon dioxide comes from fuels and a quarter of it from other activities (animal keeping, production of carbonic acid, etc.). In Hungary, in1994 carbon dioxide emissions coming from fuels were approximately 64 million tons (6.24 tons per capita).

Table II-F Hungarian carbon dioxide emissions broken down to sectors in 1994

	thousand tons/year	%
power stations	20 937	32.7
other heat generation	3 009	4.7
industry	14 027	21.9
transport	6 925	10.8
agriculture	1 723	2.8
services	3 258	5.1
inhabitants	14 064	22.0
altogether	63 943	100.0

Source: MERP

Figure II-B Carbon dioxide emission from fuel consumption of Hungary broken down to sectors in 1994

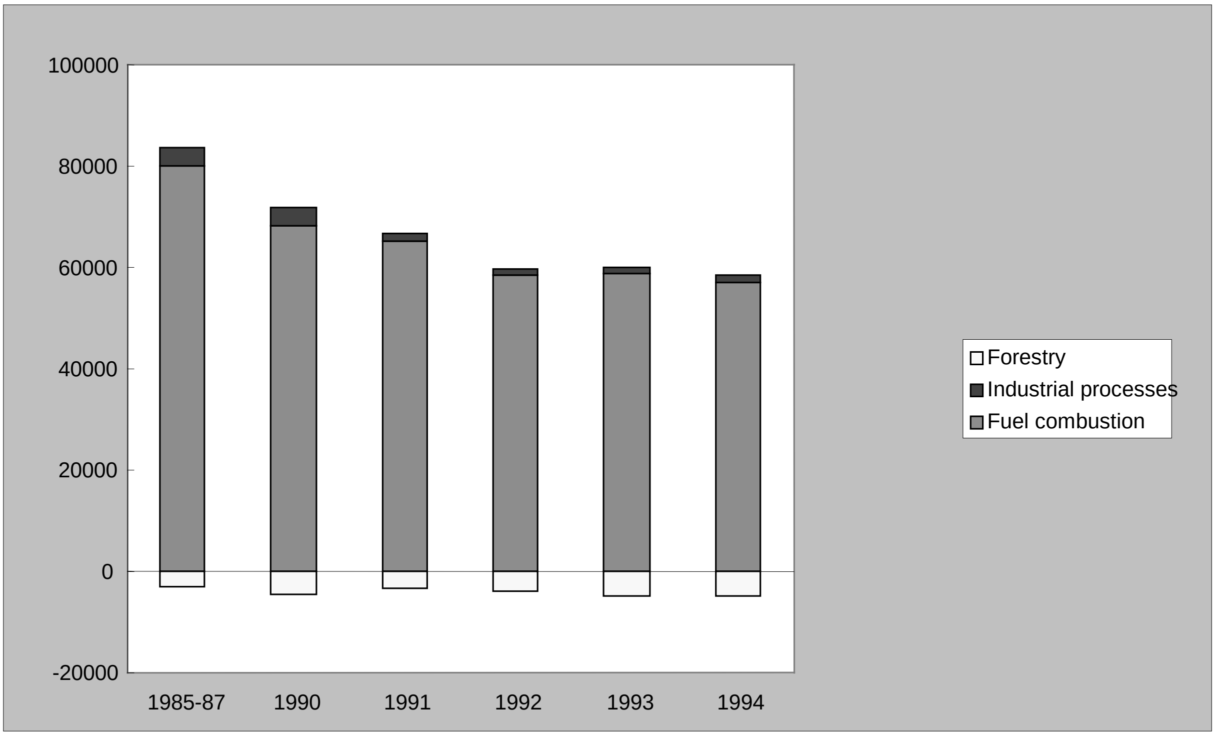


Table II-G Primary energy consumption of MVM Plc. by the types of fuels in 1995

fuel	PJ	%
nuclear	152	39
coal	114	29
natural gas	68	17
oil	61	15
altogether	395	100

II.6.10. Overview of the Hungarian residential sector

There were 4 million dwellings in Hungary in 1995[5], only 3.5% more than in 1990 and 13% more than in 1980. The average number of inhabitants per dwelling was 2.6, the average floor space 71 m^2, while the average number of rooms per dwelling was 2.4; 86% of dwellings were occupied by their owners, while the rest were occupied by tenants. There were 24.4 thousand dwellings built in Hungary in 1995; 20% of them are situated in Budapest. Hungarian households consumed 34% of all electricity in 1995, with an average of 2160 kWh annual electricity consumption per household, or 957 kWh average per Hungarian. The average annual net income of a Hungarian in 1995 was 190,000 Ft (app. US$ 1100), of which an average of 6250 Ft was spend on electricity bills. Although this represents only 3.3% of the average income, it is 6% in the lowest income decile of the population. With the increase in electricity prices, this has risen substantially, and a significant number of households are unable to pay for their electricity bills[6]. As a result of recent electricity tariff hikes, the government has established a compensation fund to which a limited number of low income households can apply for partial support in paying their bills. Unfortunately, the availability of these funds are low because foreign investors are less willing to contribute than originally expected.

II.6.11. Overview of the communal sector

Unfortunately, there is very limited statistical information on the energy use of communal, commercial or industrial buildings. The Central Statistical Office (KSH) does not collect information on these sectors. Also, it is important to recognize that these sectors are largely in transition: most industries, services and public sector organizations have been privatized or gone bankrupt since 1989. Thus, the buildings associated with them have also usually have changed owners, or have been pulled down. The construction of new office buildings, shopping centres, etc. has been blooming in Hungary in the last decade. On the other hand, communal buildings in governmental or municipal ownership, such as hospitals, other medical facilities, schools, and other educational buildings, are often in poor technical condition, and are equipped with obsolete energy technologies.

[5] Please note that at the time of the writing of this report, the 1996 statistical publications were still in print.
[6] Unfortunately no utilities, government agencies or organisations approached were willing to disclose information on non-payment of bills.

II.7. Review of the Hungarian forestry sector and forest policy

II.7.1. Overview of forest policies

Hungary has a long tradition of afforestation programs. After the peace agreement of the First World War, the forestation of the country was around 11%. To increase the forested area and to provide the country with forestry products a new afforestation program was announced. The aim of the afforestation program in the Great Plain was to improve the environmental conditions there. In spite of the program declaration the actual work begun only in 1950. As a result by the year of 1990 more than 600 thousand hectare of new forests was established. The program slowed down in the 80s, and the area of the new afforestation halved. The program resulting in 19% of forest-land, increased the proportions of conifers, soft broad-leaved and Black Locust (and their higher harvest proportions as well). In spite of the large new afforestation areas, Hungary, with respect to forestation, is in the lower third in the rank among the European countries.

II.7.2. Actual and future forestry activities in Hungary, and their impact on the bio-energy potential of Hungarian forests

Actual forest bio-energy potential depends on existing forests as well as forestry activities in the region. The annual allowable cut (AAC) is potentially determined by the current annual increment of stands being sustainable. It is allowed to cut a lesser amount of wood in a year than the annual increment. The economical crises in Hungary after the political changes in 1990 resulted in only about 60% of AAC cut annually. That is why the standing volume and increment data of the Hungarian Forestry Database (HFD) is used for our projections instead of the actually harvested annual timber in the last years. Interviews were made with representatives of leading Forestry enterprises in the investigated regions, and their opinion and data are also reflected in this Report.

Based on HFD data of Hungarian National Forest Service (HNFS) for the beginning of the 1996 year we have the estimates of carbon content of stands, as well as annual carbon sequestration and heating value of the fixed carbon (Table II). The total standing volume of Hungarian forests was more than 314 million m3 in 1996, and current annual increment was 11.5 million m3. Current annual increment contains 3.2 million tons of carbon, and the heating value of the total current annual increment is 118 million GJ. Quite naturally, the estimated values are just for our orientation, because it would be impossible to use all the annual increment as wood fuel. The firewood part of a harvested volume mainly depends on the species and the quality of the living stock. Total harvest was 6.049 million m3 in Hungary as above ground yield (gross volume) including all species in 1995 (Rumpf, 1996). The roudwood was accounted to be 4.840 million m3, and thus the on site wastes at harvesting were about 20%. Firewood from the total harvest was 46.3% for all the species.

Table II-H Growing stock, annual carbon sequestration and heating value of Hungarian forests

	Growing stock[7]					Current annual increment			
	Volume	Density[8]	Biomass[8]	Carbon content		Annual increment	Carbon sequest.	Energy content[9]	Heating value[9]
Species	m^3	t/m^3	t	%	t	m^3/year	t/year	GJ/m^3	GJ
Oaks	82810	0.630	52170	43.24	22558	2529	689	11.20	28330
Turkey Oak	41197	0.630	25954	43.24	11223	927	252	11.20	10377
Beech	38540	0.650	25051	50.89	12748	878	290	10.97	9631
Hornbeam	17883	0.720	12875	48.65	6264	365	128	11.87	4337
Black Locust	37585	0.700	26310	49.20	12944	2290	789	11.51	26353
Other hardwood	12814	0.635	8137	49.69	4043	529	167	10.96	5800
Poplar	20161	0.400	8064	50.00	4032	1220	244	6.69	8162
Other softwood	16741	0.510	8538	48.93	4178	737	184	8.97	6609
Conifers	46937	0.510	23938	50.04	11978	2019	515	9.36	18894
Total	**314667**		**191037**		**89969**	**11493**	**3258**		**118492**

(based on data of HMA Forest Service, 01/01/1996)

The Hungarian forestry sector will potentially contribute in carbon sequestration by planting, growing and maintaining forests, harvesting trees and using them for industrial purposes or as energy resources. Experts suppose that annual available cut (AAC) will be harvested in the future. Although the annuall proportions of timber for industrial purposes and firewood could be computed based on long term estimations of existing and future forests' growing stock, further research is needed in the field of life cycle analysis of forests and wood products to estimate detailed amounts of fixed and emitted carbon quantities of forestry sector as a carbon balance.

Relevant results of the state-of-art Forest Science are not detailed enough for estimating the internal carbon cycles of different forest ecosystems in various ecological conditions. There are also significant differences between the time and quantity relations of carbon conservation using the timber as raw material or firewood. There are even quite big differences among the time relations of different wood products. Wooden constructions like beams, rafters, struts, doors, windows or furniture can fix the carbon for hundreds of years, while paper napkins usually decomposed in some months or in a year. Firewood burning will very soon put back its carbon content into the atmosphere, but the impacts of biomass carbon or fossil carbon for an uptake into atmospheric carbon are not the same. Because of these scientific uncertainties presently it is relevant to model dynamic carbon sequestration capacity of the Hungarian forestry sector only on the basis of accumulating growing stock and the annual allowable cut, without worrying about the detailed inclusive assimilation or decomposition processes of forests or about the potential use of timber in various wood products.

[7] Above ground total dendromass
[8] Oven dry dendromass
[9] At water content w=20% (by Jonas and Görtler, 1988)

III. Baseline scenario

III.1. Structural scenarios for economic growth

Hungary will not instantly modernize and become a part of the developed world perhaps until after the year 2005. The transition period is only the first step. After this will come upgrading. These two stages will not take place simultaneously. The market economy can be established in the first step while the upgrading through successful modernization needs much more time.

Therefore, the period between the years 1990 and 2005 can be divided into two phases. The first part of the 1990s was characterized by a recession. After this followed a short growth period of serious equilibrium problems. The years of 1995 and 1996 were the years of stabilization. Thus it is only in the second half of the decade that we can deal with the issues of growth. The estimated rate of GDP growth was 3.5-4% annually for these 2 years.

Table III-A Growth rates 1993-2030 (%/year)

	1993-1996	1997-2010	2010-2030
Export sector	-1.0	5-6	3-4
Non-export sector	0.5	1.5-2.0	1.5-2
GDP (produced)	0.0	3.5-4.0	3
Capital investment	3-4	7-8	6-7
Consumption	-0.5-0	3-4	3

Note: Calculated with the annual figure for capital import of 1.2-1.4 billion USD and a stock of debt rising by 0.5 billion USD per year.
Source: Ehrlich, Révész, Tamási 1994, p170.

A large shift in the composition of GDP took place in the first three years of the 1990s. A proportion of agriculture will decline further up to the year 2030. A smaller but more noticeable decrease can be predicted. There will be significant growth in trade and other services.

Table III-B Composition of the GDP

Sector	**1985-87[10]**	**2010***	**2030***
Agriculture	15	7	5-7
Industry	34	26	20-30
Construction, transport, post and telecommunications	17	17	15-17
Trade and other services	34	50	50-60
Total	**100**	**100**	**100**

** Estimation*
Source: Central Statistical Office, estimates by András Vértes and the Technical University of Budapest, Department of Environmnetal Economics.

[10] Including product taxes

III.2. Main tendencies between the years 2005 and 2030

In the previous section the probable processes were briefly discussed. As long term analyses are essential for considering climatic policies and cost-efficient climatic strategies, we now need to look ahead to the following 25 years, to the year 2030.

Unfortunately, the situation from the transition of the Central and Eastern-European region and that of Hungary make it difficult to consider long-term analyses. Additionally, the region has found itself in a situation of which no historic experience exists: how is it possible to re-join the capitalist development after a deformed socialist development which itself shaped from a weak and deformed capitalist system. Thus, decisions and conceptions, are as a rule, short-term.

As follows from the above prediction, up to the year 2005 there is much uncertainty. When Hungary takes part in EU integration, it will join the process characterizing Europe as a determinant world economic center. Within this the situation of Hungary will be influenced by the semi-peripheral subregion within Europe which has also joined the Union late.

Taking all this into account and considering the relatively optimistic scenario it is assumed that after the year 2005:

– in the first phase, up to about the year 2015, the GDP will grow relatively quickly (4% annually), due to the initial advantages of joining the EU,

– then this growth will decrease in the period between the years 2015 and 2030 to 2 to 3% annually.

Thus the average growth rate for the next 25 years will be around 3%.

As for the economic structure, the 7% share of agriculture in the GDP will not change considerably. The proportion of those employed in agriculture will fall and be less than 10% resulting from efficiency increases.

The industrial sector will decrease slightly and the communal sector will increase slightly.

Evidently Hungary will step onto the road of development, which will lead the country into being a natural economic part of Europe.

III.3. GHG inventory of Hungary (based on the “bottom-up” approach)

When making the inventory, the “bottom-up” method has been selected: the emissions of the different sectors of the national economy have been aggregated to give the country’s level emissions.

One of the principal commitments under the UN Framework Convention on Climate Change (FCCC) is to communicate one's contribution to the overall global greenhouse gas emissions. The Convention "requires that communications include a national inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol for years subsequent to 1990"(FCCC, Article 12, 1992).

Though the Hungarian proportion of anthropogenic greenhouse gas emissions is insignificant in the overall world emissions in absolute values, it is quite high in proportion to its population or its GDP. The per capita CO_2 emission rate is approximately 40% more then the global average.

As summarized earlier, the country is in the process of a substantial socio-economic transition and the strong decline in the economic performance has resulted in a considerable change in the consumption of energy. Domestic primary energy production has been decreasing since the year 1989 and in 1994 it was 568.3 PJ, which is lower than the 1970 year level. The total energy consumption of the industry was lower by 40% in the year 1994 than in 1987. The largest reduction took place in the electricity import: net import of 11.1 TWh in 1990 fell back to 2.5 TWh by 1994.

Due to the recent decline of the economy, the CO_2 emissions from combustion sources have fallen by 18% between the baseline years of 1985-1987 and 1994. Owing to the growing sink capacities enhanced by reforestation, the total net CO_2 emission has only dropped by about 20% for that time period.

Because of the rapid decline of domestic coal mining and oil production, the methane emissions from fugitive sources decreased by 16% between the years 1991 and 1994. The methane emissions from enteric fermentation have also dropped by 28%. This drop was caused by the decline of the animal feedstocks.

III.3.1. The national climate change policy context

As briefly mentioned before, the special situation of a number of countries in the Central and Eastern European region was repeatedly expressed during the intergovernmental negotiations on the Convention. The two common key elements of these interventions were as follows:

– the relatively low per capita greenhouse gas emission rates as compared to those of the most of the industrialised countries, and

– significant economic constraints attributable to the profound socio-economic changes and the process of the transition to market economy.

These aspects were repeatedly underlined in the Government declaration issued in April 1992:

“The Government of the Republic of Hungary (...)

– expresses its intent to co-operate with international organisations and institutions concerned in the interest of protection of the earth's environment and the climate and to seek, at the same time the economic and technical co-operation with the developed countries in order to, among others, be able to fulfil the requirements of environmental protection, in general, and to also keep protecting the earth' atmosphere and the climate, in particular, in the course of the country's economic transition and stabilisation (...) and

declares that Hungary joins the position of the European Community and the European Free Trade Association, however, in the light of characteristic features of the process of its economic transition ,the period of 1985-1987 which precedes the current economic recession is considered as the reference period for comparison of the carbon dioxide emissions (...)

– pronounces the commitment that the annual specific carbon dioxide emissions deriving from the domestic economic activities will not exceed the averaged annual emission level of the basic period accepted for comparison by 2000 and thereafter; and

– emphasises moreover, that the effective implementation of this plan and also the possible further reduction of these emissions considerably depends on that at what rate the country can stabilise, renew its economy and, in this context, how the energy efficiency develops and, furthermore, it depends on the progression of economic and technological co-operation with developed countries (...)

– expresses its interest in that an effective agreement to be prepared for the protection of earth' climate ... and this agreement should take into account the responsibility and situation of all specific groups of countries and declares its readiness to join the convention if its final version properly reflects the enlisted interests."

III.3.1.1. The flexibility provision of the Convention for countries in transition

During the international negotiations on the FCCC, the countries with their economies in transition have emphasized the importance of special circumstances in which they currently find themselves. The beginning of this decade was a milestone in the history for these countries: the centrally planned economies terminated and the comprehensive transition to a market economy had begun. The flexibility term was introduced during the last stage of negotiations (May 1992) in order to take into account the special situation of these countries. Various proposals had been submitted. Hungary supported strongly such a position that focused on the following elements of compromise: (i) an open list of the parties committing themselves to stabilize the greenhouse gas emissions and the transition countries, depending on their individual decision, might choose to be included on this list; (ii) the concrete terms of emission stabilization might differ for these "transition" countries to some extent; (iii) these countries will not be excluded from the technology transfer which is necessary for modernizing their obsolete, inefficient, highly polluting energy and other systems; (iv) at the same time, these countries at this stage will not commit themselves to offer contributions to the financial mechanism of the Convention. Eventually, the accepted package solution included the possibility for these countries to have some flexibility in their commitment to the requirements of emission stabilization (FCCC, Article 4.6; 1992):

"In implementation of their commitments under paragraph 2 above, a certain degree of flexibility shall be allowed (...) to the Parties included in Annex I undergoing the process of transition to a market economy..."

III.3.1.2. National greenhouse gas reduction target

The Parliament's decision on the ratification in December 1993 took note of the opportunity mentioned above, and considered it reasonable and unavoidable to apply for this provision of the Convention. Accordingly, the statement submitted with the deposition of the ratification instrument reiterated this claim at least in relation to the carbon-dioxide emissions:

"The Government of the Republic of Hungary attributes great significance to the United Nations Framework Convention on Climate Change and it reiterates its position in accordance with the provision of Article 4.6 of the Convention a on certain degree of flexibility that the average level of anthropogenic carbon-dioxide emissions for the period of 1985-1987 will be considered as a reference level in the context of the commitments under Article 4.2 of the Convention. This understanding is closely related to the 'process of transition' as it is given in Article 4.6 of the Convention. The Government of the Republic of Hungary declares that it will do all efforts to contribute to the objective of the Convention"(FCCC, Article 4.6; 1992):

This target leaves open commitments to other greenhouse gases. As it will be seen from the assessments given below, the deep recession which started in the second half of the 1980s reached most of the sectors which are generally the basic sources of greenhouse gases. For this reason and also for practical purposes we will use the unique base period of 1985-87 for the base level calculations for all these gases (by deriving mean annual base levels from this period), whilst providing estimates for 1990 for the international comparisons and synthesis.

III.3.1.3. Selection of the base level for emissions

The year 1990 would not be a particularly appropriate base year for Hungary as its economy is in transition. As a result of the transition process, and the current and future economic uncertainties, Article 4.6 of the Convention states that the economies in transition may seek a certain degree of flexibility in fulfilling the commitments of the Convention. A reasonable base period, or other requested flexibility conditions, may vary from country to country in accordance to their historical level of anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol or other significant transition circumstances. Hungary has declared an official position setting the three year period of 1985-1987 as an average base emission level for several reasons:

The economic crisis led to the collapse of the centrally planned economies. From the second half of the 1980s, economic activity fell back considerably, therefore the anthropogenic emission values of 1990 were also significantly lower than those in the previous years.

Another main reason for not choosing 1990 as a base year is that the statistical system has changed considerably around 1990 as a consequence of the substantial socio-economic changes, the fundamental shifts in whole economic sectors, and the large-scale privatisation process. In particular, no detailed and reliable statistics are available at the moment on the industrial activities.

It should also be mentioned that it is more correct under the above-mentioned conditions of uncertainty to choose base emission values for a certain period than for a particular year because emissions may fluctuate to a considerable extent from one year to the next.

III.3.2. Recent trends in fuel combustion and associated carbon-dioxide emissions

For a better understanding of the present and the future energy situation and the fuel-related greenhouse gas emissions in Hungary, the past trends in fuel consumption and associated emissions are discussed. One of the most characteristic features of the Hungarian energy system is the lack of sufficient domestic energy resources. Thus in the earlier periods the continuos increase in energy demand of the country had to be satisfied by import increases. Energy imports in the 1950s and 1960s were equal to 10 - 20% of the total Hungarian energy production. However in the mid 1990's, the domestic energy production and the import was nearly equal.

The structure of the domestic energy production drastically changed in the recent period. In the 1950-60's solid fuel, specially coal mining, was dominant. The domestic coal production peaked in the mid 1960's. After this period the structure of the domestic energy production significantly changed. The role of nuclear energy and of the hydrocarbon mining increased and the coal production, especially deep-mining, drastically decreased. Presently the share of the coal mining in the domestic primary energy production is only 33 %, the share of hydrocarbon-mining is about 42 %, while the share of the primary electricity is roughly 25 %.

In the 1950's low energy import was dominated by coal (80-90 %). Later on, hydrocarbon, electrical energy and nuclear fuel imports increased significantly. In the period between the years 1965-1990, coal imports, especially the briquette for households and the coke for metallurgical utilization remained practically constant but sharply decreased after the 1980's. Crude-oil import peaked in the 1980's. Later a sharp decrease occurred due to the drop in the demand for motor fuel. Presently, the share of the hydrocarbons in the energy import is approximately 85%. The electrical energy import peaked at around 28-29% of the gross domestic electrical energy demand but in the 1990s it decreased to about one-third of its former level.

As a result of the significant size of energy imports, the main features of the Hungarian energy system is import-dependency. The electrical energy demand of the country peaked in the late 1980's at 40 TWh. After this period consumer demand declined as a result of the economic depression. The decline in the household electrical energy consumption was not significant. The real decline was in the industrial sector's demand.

The share of electricity import decreased significantly in the last few years as a consequences of the electrical energy situation in the former Soviet Republics. Consumer demand also decreased in this period. Thus by increasing the domestic production of fossil-fueled power plants the electrical energy demand of the country could be satisfied.

The share of coal and lignite of the total domestic electricity generation is now only about one-third. The share of fossil fuels of the total electrical energy generation decreased to about 60 %. The share of the hydrocarbons exceeded the share of coal. Today the nuclear electricity covers about 45-50 % of the domestic electrical energy generation.

Figure a *Long-term historic trends in the energy imports of Hungary*

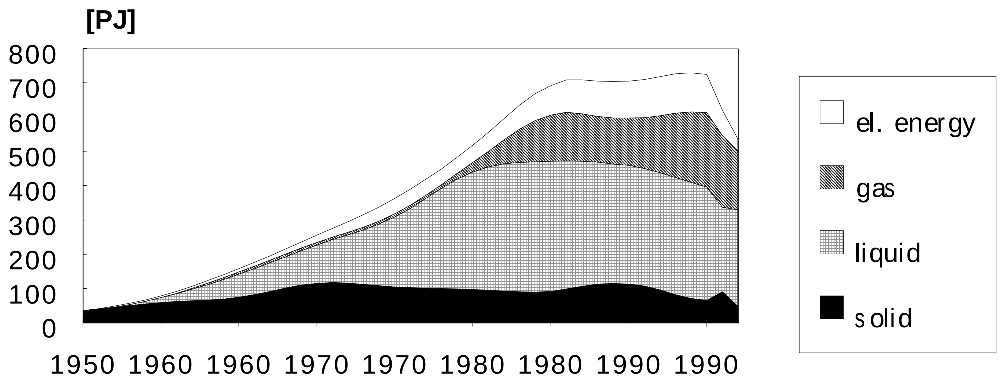


Figure b *Long-term trends in primary energy consumption for electricity production*

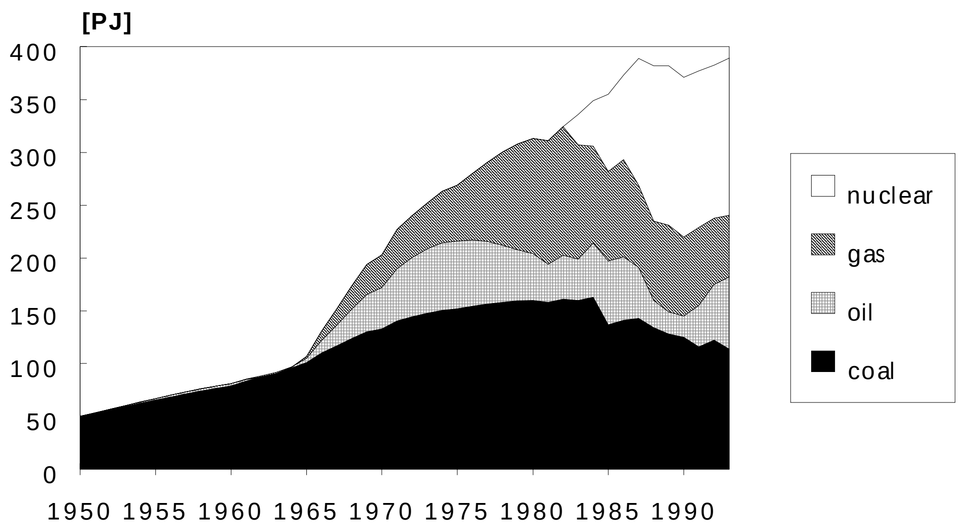
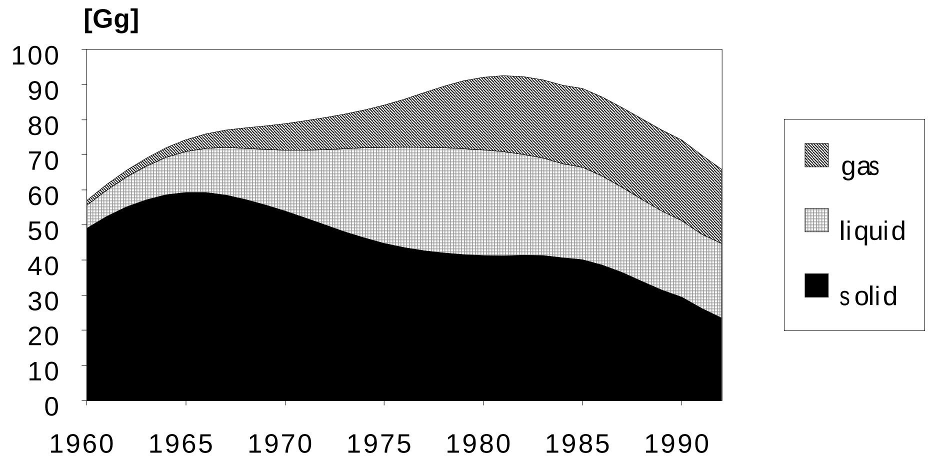


Figure c *Long-term historic trends in the CO_2 emissions*



III.3.3. National inventories of greenhouse gas emissions and removals: 1985-1994

One of the principal purposes of greenhouse gas inventory compilation is the identification of the main sources that contribute to the national level of anthropogenic greenhouse gas emissions.

In Hungary, the first greenhouse gas emission inventory based on the Intergovernmental Panel on Climate Change (IPCC) Guidelines was conducted in the year 1994. Results were published in the First National Communication submitted in that year. A supplemental report with an overview of the greenhouse gas emissions and removals for the years of 1991 to 1994 was published in 1997.

III.3.3.1. Methodology used

According to the decision by the Conference of the Parties the "Guidelines for National Greenhouse Gas Inventories, 1995" should be used in estimating, reporting and verifying inventory data. Consequently, these guidelines and the recommended methodology were taken into consideration when the Hungarian inventory was compiled.

Substantial progress has been made in the adaptation and application of the Guidelines. The availability of the appropriate data has also been improved. As a result of the development in the application of the methodologies, the present estimations are more comprehensive and reliable. Due to the calculations presented in the First National Communication, new sectoral emissions (e.g. CO_2 emissions from waste) have been derived, and new sources (e.g. international bunkers) have been identified. Although the recommended methodology and reporting format was used in the compilation of the Hungarian inventory, it was necessary to deviate from it in certain cases. For the forestry sector, the IPCC Guidelines were followed to determine the net CO_2 sink capacity. In the case of agriculture, the N_2O emissions from soil were determined by the simplified IPCC method which does not require specific coefficients of fertilizer sources and crop types.

III.3.3.2. Energy use and transformation

III.3.3.2.1. CO_2 emissions from fuel use

The majority of CO_2 emissions (almost 97 %) is generated by fuel combustion. In 1991 the total fuel combustion related emissions were about 65 Mt/year, but then dropped to 57 Mt by the year 1994. In the case of fuel combustion, almost half of the total emissions are a result of the fuel transformation process.

The share of the residential sector in overall CO_2 emissions significantly decreased from 24% to 20%, mainly due to the country-wide household gas program. As it can be seen in Table III-C the share of emissions from transport were increasing and reached 13% in the year 1994.

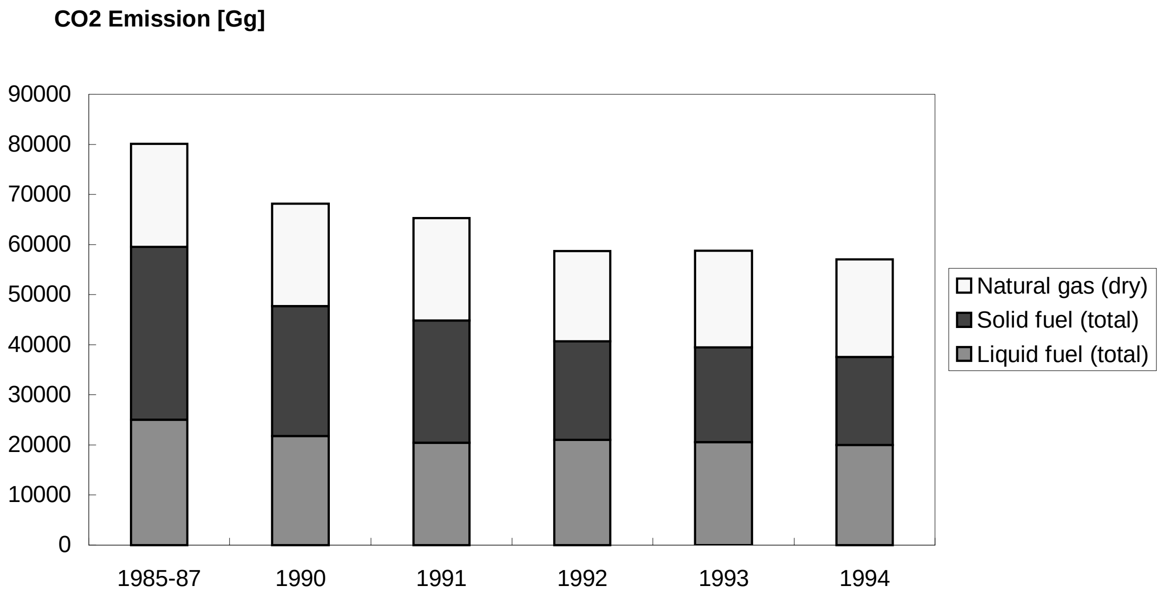
Table III-C Distribution of fuel-related CO_2 emissions by sectors (Gg)

	1985-87	**1990**	**1991**	**1992**	**1993**	**1994**
Energy & Transformation	36928	29746	28520.3	27475.7	27574.8	26290.4
Industry	10893	7893	6379.9	5131.0	5548.1	6306.1
Transport	7741	8208	7382.6	7189.5	7140.8	7211.8
Commercial and Trade	3403	3290	3958.9	3516.8	3821.6	3969.9
Residential	16639	15125	15669.8	12195.5	12270.9	11453.0
Agriculture and Forestry	3132	2462	2119.8	1593.2	1498.6	1536.6
Other	1353	1381	1224.1	1533.8	899.7	277.8
TOTAL	80089	68105	65255.4	58635.5	58754.4	57045.7

In the year 1994, more than 80% of the total carbon dioxide emissions of the transport sector were emitted by the road transport, with passenger transport accountable for the main share of these emissions. The public transport is responsible for less than 20% of the passenger transport emissions. In the freight transport sector, trucks emit the majority amount of carbon dioxide. In total, private cars are responsible for the largest share of emissions in 1995, followed by trucks.

The share of emissions from solid fossil sources has significantly decreased from 37% (1991) to 30% (1994). Additionally during the same period, due to the fuel switch in coal-fired power plants and to the implementation of the natural gas program, the relative proportions of the oil and gas-origin emissions raised by almost 5% (see the figure below).

Figure d *Distribution of fuel-related CO_2 emissions by main fuel categories*



III.3.3.2.2. Non-CO_2 emissions from fuel use

III.3.3.2.2.1.Stationary sources

The CH_4, N_2O, CO, and NO_X emissions from several stationary sources show a substantial shift from the year 1991 to 1994: the emissions from the residential sources have decreased by 25-60% while the emissions from commercial sources have significantly increased. For example, in the case of CO the commercial-origin emissions have been doubled. Table III-D summarizes the CH_4, N_2O, CO, and NO_X from stationary sources. The non-CO_2 emissions from biomass burning is also presented in Table III-D.

Table III-D Non-CO_2 emissions from fuel combustion (in tonnes)

		CH4	N2O	CO	Nox
	1985-87	NA	NA	NA	NA
	1990	NA	NA	NA	NA
Stationary	1991	27069	2330	469638	154366
sources	1992	14770	3105	321411	134587
	1993	14672	3184	339393	130970
	1994	11200	3350	307505	139365
	1985-87	7710	59	72520	NA
	1990	8006	60	54879	NA
biomass	1991	8187	63.8	75479	2320
burning	1992	8023	64.4	75923	2342
	1993	8192	66.5	78659	2418
	1994	8148	67.5	79574	2454

III.3.3.2.2.2.Mobile sources

The total of transport related to non-CO_2 emissions (Table III-E) shows an insignificant decrease of 0-5% in the investigated period. It should also be noted that the minimum of these emissions was around the year 1992 and 1993 and since then the emissions have shown a tendency to decrease.

Table III-E Non CO_2 emissions from fuel combustion (mobile sources, tonnes)

	CH_4	N_2O	CO	NO_x	NMVOC
1985-87	NA	NA	NA	NA	90500
1990	NA	NA	NA	NA	72500
1991	1530	176	862967	73184	84800
1992	1451	177	815975	70643	80149
1993	1468	175	833165	69034	81527
1994	1451	176	822459	68323	80461

III.3.3.2.3. Fugitive fuel emissions: oil industries and coal mining

In Hungary, coal is produced from both underground and surface mines. According to the sharp decline of domestic coal mining and oil production, the methane emission from fugitive sources decreased by 16% from the year 1991 to 1994. One of the most important sources of industrial methane emissions is the fugitive losses of natural gas during its production, transport and distribution. The coal mining activities can be regarded as important industrial methane sources which give off around 30 % of the total methane emissions. This contribution decreased by 20% between the years of 1991 and 1994. The CH_4 emissions from fugitive sources are presented in Table III-F.

Table III-F   Fugitive CH_4 emissions from oil and gas activities (Gg)

		1985-87	1990	1991	1992	1993	1994
OIL	**Production**	NA	NA	0.08	0.07	0.07	0.06
	Transport	NA	NA	Not Est.	Not Est.	Not Est.	Not Est.
	Refining	NA	NA	0.15	0.15	0.16	0.14
	Storage	NA	NA	0.03	0.03	0.03	0.03
	TOTAL			**0.26**	**0.25**	**0.26**	**0.23**
GAS	**Production**	NA	NA	48.35	45.39	48.87	47.17
	Transmission and distribution	NA	NA	148.02	130.12	140.02	141.41
	Non-residential leakage	NA	NA	76.78	65.90	64.83	61.87
	Residential leakage	NA	NA	17.12	15.85	20.09	22.09
	TOTAL			**290.27**	**257.26**	**273.81**	**272.54**
	venting and flaring			1.61	1.51	1.63	1.57
OIL & GAS	**TOTAL**	**225**	**199**	**292.14**	**259.02**	**275.70**	**274.34**
COAL MINING							
Underground	**mining**	216	162	136.36	103.51	90.54	86.58
mines	**post-mining**			19.48	14.79	12.93	12.37
Surface	**mining**	7	5	4.43	5.63	5.54	5.41
mines	**post-mining**			0.37	0.47	0.46	0.45
COAL	**TOTAL**	**223**	**167**	**160.64**	**124.40**	**109.47**	**104.81**

III.3.3.3. Industry

Table III-G presents industrial emissions. Some uneconomical activities in the heavy industry ceased in the 1990's. However, in certain sectors the production began to increase from the year 1993, and resulted in a slight emission's increase. (The industrial emissions were not estimated for the base period and the year 1990, except for CO2 emission related to cement production.)

Table III-G Emissions from the industry

	CO2 (Gg)				CH4 (tons)				N2O (tons)			
	1991	1992	1993	1994	1991	1992	1993	1994	1991	1992	1993	1994
S-M Steel Production	-	-	-	-	5.0	1.4	0.0	0.0	-	-	-	-
Raw Iron Production	-	-	-	-	-	-	-	-	-	-	-	-
Aluminum Production	117.1	49.7	51.6	Not Est.	-	-	-	-	-	-	-	-
Nitrogen Fertilizer Production	-	-	-	-	-	-	-	-	3749.5	2770.7	2508.8	3420.0
Cement Production	1264.5	1118.0	1266.5	1396.5	-	-	-	-	-	-	-	-
Lime Manufacturing	0.3	0.2	0.2	0.2	-	-	-	-	-	-	-	-
Plant Protecting Agent Production	-	-	-	-	-	-	-	-	-	-	-	-
Paint Production	-	-	-	-	-	-	-	-	-	-	-	-
Polyethylene Production	-	-	-	-	-	-	-	-	-	-	-	-
Polypropylene Production	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	**1381.9**	**1167.9**	**1318.3**	**1396.7**	**5.0**	**1.4**	**0.0**	**0.0**	**3749.5**	**2770.7**	**2508.8**	**3420.0**

III.3.3.3.1. CO_2 emissions from aluminum and cement production

The largest source of industrial CO_2 emissions is cement production. There is a slight increase in these emissions between the years 1991 and 1994. However, it should be mentioned that the production level of clinker cement can only be an estimate of low reliability. Moreover, because of the lack of specific emission factors it is not possible to determine the CO_2 emissions from the production of other industrial materials (coke, iron, steel, etc.). At the same time CO_2 emissions from aluminum production dropped dramatically.

III.3.3.3.1.1.Non-CO_2 GHG emissions

The CH_4 emissions form S-M steel production can be estimated as negligible since the year 1993. The N_2O emissions dropped by 30% in the investigated time period, nevertheless a slight increase can be seen in recent years. The CO and NMVOC industry-related emissions were almost unchanged.

III.3.3.4. Agriculture

III.3.3.4.1. CH4 emissions from enteric fermentation and manure management

The most important sources of CH_4 emissions in agriculture are manure management and enteric fermentation. CH_4 production through enteric fermentation is a part of the normal digestive activity of ruminants. Methane emission is calculated for beef cattle, dairy cattle, sheep, swine, horse and poultry. Additionally, animal waste treatment methods that provide anaerobic conditions result in CH_4 release. As it can be seen in Table III-H, the CH_4 emissions related to animal husbandry decreased by 30% between the years 1991 and 1994 mainly due to the restructuring of agricultural productions.

Table III-H CH_4 emissions from animals and animal manure (Gg)

	1985-87	1990	1991	1992	1993	1994
Dairy Cattle	60	56	63.73	56.66	51.30	48.45
Other Cattle	83	59	46.39	35.75	29.65	27.97
Sheep	12	9	14.81	14.35	10.25	8.54
Goats	NA	NA	0.31	0.31	0.31	0.32
Horses & Mules	1	1	1.45	1.36	1.38	1.51
Swine	44	41	32.96	29.50	27.51	28.68
Poultry	4.5	3.5	4.29	4.29	4.09	3.29
TOTAL	**204.5**	**169.5**	**163.93**	**142.21**	**124.48**	**118.76**

III.3.3.4.2. CH_4 emissions from rice cultivation

Table III-I shows the CH_4 emissions from rice production in the different years of the examined period. Rice is produced using the continuously flooded water management system.

Table III-I CH_4 emissions from rice production (Gg)

	1985-87	1990	1991	1992	1993	1994
Emission	3.69	3.13	3.7584	2.088	2.088	2.088

III.3.3.5. Waste management

III.3.3.5.1. Solid wastes and flue gases

The yearly amount of wastes in Hungary is 20 million m^3/y, or approximately 4 Gg/year. This was practically the same in every year of the investigated period. In Hungary there are 2682 registered land disposal sites, where 85-88% of all the waste is placed. In Budapest, there is an incineration plant (i.e. in the capital of Hungary), whose capacity is 310 Gg/year. In Hungary there are two basic sources of air pollution caused by waste generation, flue gases of the incineration plant in Budapest and gases generated at land disposal sites.

III.3.3.5.2. Waste water treatment in Hungary

At the moment, a great part of domestic waste water in Hungary is not treated, and this was true also for the examined period of 1985-1995. The Proportion of treated waste water is as follows:

without treatment	53 %
waste water cleaning	47 %
mechanical cleaning	14 %
mechanical and biological cleaning	31 %
three steps cleaning	2 %

About 20 % of the residential waste water is also cleaned biologically.

During the investigated period, the quantity of residential waste water that needed cleaning was approximately 1000 million m^3/year. The amount of used water that could be regarded as industrial water without any cleaning was approximately 4000 million m^3/year. The extension of the drainage system fell behind the water supply. Therefore twenty years ago 90% of residential flats with water supply were connected to the drainage system, and today only 45% are.

Table III-J Emissions from waste management (Gg)

	CO2				CH4			
	1991	**1992**	**1993**	**1994**	**1991**	**1992**	**1993**	**1994**
Flue gases	600.00	600.00	600.00	600.00	-	-	-	-
Land disposal sites	153.72	153.72	153.72	153.72	68.12	68.12	68.12	68.12
Waste water treatment	-	-	-	-	188.46	188.13	187.64	187.04
TOTAL	**753.72**	**753.72**	**753.72**	**753.72**	**256.59**	**256.26**	**255.77**	**255.17**

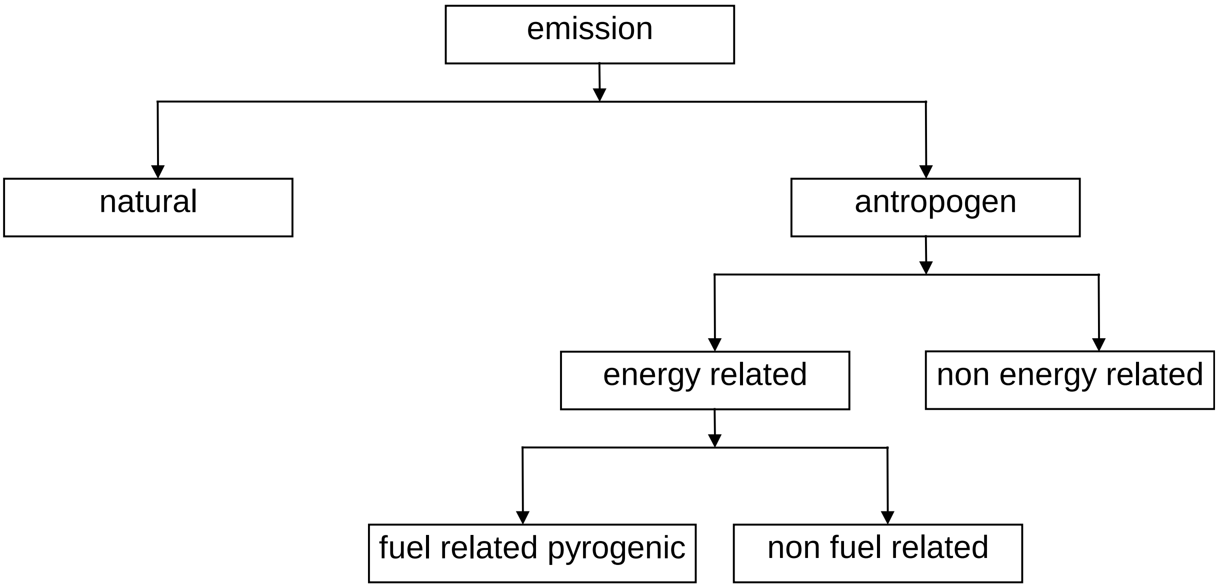
	CO				NOx			
	1991	**1992**	**1993**	**1994**	**1991**	**1992**	**1993**	**1994**
Flue gases	0.134	0.134	0.134	0.134	0.518	0.518	0.518	0.518
Land disposal sites	-	-	-	-	-	-	-	-
Waste water treatment	-	-	-	-	-	-	-	-
TOTAL	0.134	0.134	0.134	0.134	0.518	0.518	0.518	0.518

III.4. Projections of fuel-related CO_2 emissions (using the "top-down" method)

III.4.1. Assumptions

III.4.1.1. General Assumptions

There are direct GHG emissions which are related to the fossil fuel consumption of the sectors, and there are indirect GHG emissions which are related to electrical and heat energy consumption. When investigating the direct Greenhouse Gas (GHG) emissions, first it must be determined which part of the emissions is to be investigated. Taking into consideration the classification of the emissions (shown in the flowchart below), one may see that within the frame of this project we focus of the so-called direct GHGs (CO_2, CH_4 and N_2O) only, thus we do not account for the precursors of the GHGs (NOx, NMVOC, CO) in this study.



Because the emissions connected with the non-normal operations, such as catastrophes, breakdowns, fires and accidents, have a stochastic character, their historical values may be collected, if needed, but their forecast is very uncertain. Therefore, they are generally not taken into consideration in the forecast, and it is impossible to control or influence them generally. Thus they have to be accepted. Only their effects might be reduced.

III.4.1.2. Investigated sectors

As described above, the Hungarian economy has been going through a radical transformation. It is often difficult to predict how some of the sectors will be performing in a future equilibrium economy. Additionally the system of statistical data reporting is also under transition. This had various impacts. Thus, a comprehensive projection of greenhouse gases for all sectors of the economy, with a comprehensive mitigation scenario analysis would be such an extensive task which is beyond the scope of this project. Thus, for this work, two fuel-consuming sectors of the economy have been selected for GHG emission projection and mitigation scenario analysis: the residential and communal sectors. These two sectors have been chosen due to several reasons, including the following. The most radical transitions in these sectors are over, and, although they are not yet in their equilibrium state, their major tendencies can be relatively well predicted. Also, base input data for these two statistical categories can be gathered relatively easily, since these categories have been used in the traditional statistical data collection system.

Since the statistical categories may differ from country to country, it is useful to review our definitions of these two sectors. In fact, the definition of the residential sector is relatively straightforward, since this sector is usually defined similarly in every country's statistical system. The category "communal sector" can be more ambiguous. Under the communal sector, we understand the following economic activities, or subsectors:

- commerce (offices, stores, etc.)
- real estate activities
- government and public administration
- public services (military, police, etc.) and education
- health and cultural services, welfare
- churches and other religious activities
- personal and business services
- financial services
- research, development etc. services
- sewage and refuse disposal.

Unfortunately, due to the difficulties of translation from Hungarian to English, several terms such as *the service sector, the public sector or the commercial sector* have been historically used for the same sector by different authors reporting in English. The editors of this document have made a considerable effort to use the term “communal sector” consistently throughout the report, however, there is no guarantee that at later revisions, or in other connected or referenced documents the same sector is not called by another of the above mentioned names. In general, when any of the three above mentioned sectors are used in reports or documents describing the Hungarian economy, it is very likely that they all refer to this same sector, which we call the “communal” sector.

In addition to fuel-related emissions and emission reduction potentials, forestry is the other key sector from the perspective of total national carbon emissions and carbon sequestration potentials. Thus, in addition to the residential and communal sectors, we have also performed the detailed carbon sequestration potential analysis of the Hungarian forestry sector.

III.4.1.3. Assumptions used in the projection calculations

When estimating the fossil fuel-related emissions of the direct GHGs, the emission factor method has been used because it may be used equally for both the historical and future emissions. The emission factors have been calculated partly based on the physical-chemical characteristic of the fossil fuel fired taking into consideration the main characteristics of the fuelling devices, furnaces, stoves, boilers etc. and the efficiencies of the control devices used. Or, they are taken from the literature or from special guide-books, such as EPA- 42, CORINAIR and CITEPA.

When calculating environmental pollution connected with fossil fuel consumption of the different sectors of the national economy, the fossil fuel consumption has been selected as the activity level, thus the official energy statistics published every year by the State Authority for Energy and Energy Safety are the base of our calculation. For our calculation a special data set has to be generated from the energy statistical year book which includes the fossil fuels actually fired by the sectors. Thus the feedstock and the non-energy use of the fossil fuels are separated, and are not taken into consideration.

In the case of the non-energy related emissions, the activity levels have been selected according to the characteristic data of the technologies investigated.

When investigating the GHG emissions connected with household and communal energy use, we have to take into consideration the direct GHG emissions, which are connected to the fossil fuel use of the sectors investigated, and the indirect GHG emissions which are both connected with the generation of the heat and electrical energy consumed by these sectors. In the latter case, the GHG emissions have been calculated based on the share of the consumption of the sectors investigated to the total generation.

Because fossil fuel consumption has been selected as the activity level for the energy related emissions, it is very important to know the characteristic features of the Hungarian Energy System (HES), which, due to their long lasting effects, are very influential to the system's evolution. For a description of the main characteristics of the Hungarian energy sector, please refer to the earlier sections of this document.

When making energy forecast it was assumed that after the year 2000, the new fossil fuel-fired power plants will be designed with supercritical parameters , i.e. their efficiency will be increased to about 40%, compared to the present average of 30-33%. Our energy forecast has used Hungary's present trends in energy in spite of Hungary's present lack of domestic energy sources. Today there are few new nuclear power reactors contracted for installation in the future. When making the nuclear scenario it was assumed that the efficiency of the new reactors will not increase in the future, but their nuclear safety and reliability will.

When determining and evaluating emissions, control technologies are also to be taken into consideration. For a description of these emission control technologies, refer to the earlier introductory sections of this document. For the baseline emissions all the significant control measurements are to be considered, which had significant effects on the emission of the pollutants mentioned. If the time-series of the emissions are investigated, the significant effects of the introduction of the pollution control technologies may be observed in the historical evaluation of the emissions.

When making the energy forecasts, a baseline was determined as a business-as-usual scenario. In fact, in the period of economic transition from a planned economy to a market one, there is no possibility to speak about a business-as-usual trend, but about a traditional way of thinking, when making the forecast. When making the forecast the MEDEE-II model has been used, and was modified by the Hungarian working group. MEDEE-II was developed by the Grenoble University and it was adapted to the International Institute for Applies Systems Analysis (IIASA) energy model. Similarly it was also adapted to the ENPEP model system, as the MAED-1 module. The ENPEP model system was developed by the Argonne National Laboratory and it was sponsored by the International Atomic Energy Agency (IAEA).

The model used is an "if.....then" type model, thus for the baseline scenario selected, the energy consumption has been determined. The exogenous variables of the model have been determined by the traditional way of thinking. Because it is not possible to make a realistic forecast for only two sectors of the national economy, an overall energy forecast had to be developed for all sectors and for all energy carriers, and from this the fossil fuel consumption of the two sectors investigated has been deduced. Of course in the case of the two sectors mentioned the energy forecast developed was very detailed.

It was assumed that after the year 2000 there will be a slight decrease in the population, to about 9,13 million people by the year 2030, and a slight increase in the number of flats to 4,3-4,5 million. In the same period a deterministic share of the aged flats and of the old houses are to be reconstructed, thus the area and the volume of heated space will be higher. The increase in the energy demand for space heating will be caused by the higher heated volume and by the increase in the number of flats. The thermal insulation and the orientation of the new flats and of the reconstructed ones will be better, thus only a slight increase in the energy consumption for space-heating is expected. Practically, the increase in the energy consumption of the residential sector is determined by the new electrical household devices and appliances. In the new flats and houses modern energy-efficient devices are expected. An increase in the share of district heating is not expected because building flats in bulk, in the old style, is no longer practiced. Additionally, district heat supply of the single family house is not presently economical nor will it be in the future.

In the present economic situation the old appliances will only be replaced when they break, and the old fashioned, higher energy-consuming appliances will be bought because of their cheaper prices. The selling of the modern energy-saving devices will increase in the second period of the investigated time horizon.

When forecasting the energy demand of the communal sector it was assumed, as in the case of the residential sector, that the area of the communal sector will increase either because of reconstruction and/or because of the new buildings. The new buildings will be built with better thermal insulation, thus only a relatively slight increase is expected in the energy consumption. New energy-efficient devices and appliances will be installed. The modification of the aged devices will be a long process.

To promote the modification of household and communal fuel and energy use, a more effective and adequate tariff system is needed. This will be introduced shortly. At the time of the writing of this section[11], the plans are public, but the results are confidential. Thus it could not be taken into consideration at the time of the preparation of this project.

It is worth mentioning that the motor fuel demand of the sectors investigated is taken into consideration separately in the so-called transportation module of the model. When simulating motor fuel consumption, the strong cross-dependence between private and mass transportation cannot be taken into account. This is because the dependence is not concentrated, and its forecast is not based on the overall capacity of the transportation sector. In the case of the two sectors investigated, not only the fossil fuel consumption but also the overall energy consumption had to be determined to take into consideration the share of the electrical energy and the district heat in satisfying the energy demand of the sectors. This is very important to know when determining the GHG emissions of the sector, because there are direct GHG emissions which are related to the fossil fuel

[11] 1997

consumption of the sectors, and there are indirect GHG emissions which are related to the electrical and heat energy consumption of the same sectors.

The indirect GHG emissions for the residential and communal sectors are calculated using the emissions connected with the fossil fuel consumption of the heat supply (district heat) and of the electrical energy generation. This requires a detailed background calculation because a part of district heat is produced by individual boilers, while another part is produced by the public power plants together with the electrical energy generation (combined heat and electricity generation). Using the emissions and fuel consumption data of the public power plants the specific emission data have been determined for district heating and for electricity generation. With these values the indirect GHG emissions have been determined for the two sectors investigated.

The energy demand of the industry was forecasted in connection with the evaluation of the GDP. We have taken into consideration that the aged production systems and that the devices cannot be changed immediately, thus at the first period of the time horizon the elasticity had been supposed higher than later. Similarly, the restructuring of the economy needs a longer time horizon than it had been expected earlier. According to the statistical data, the increase of the industrial production started already, thus according to the experts, the economic crisis in Hungary seems to be over.

Because of the lack of resources, a sharp increase of the energy import is also to be expected in the future. In the long-run, the development of the domestic electrical energy production will be based on fossil fired power plants, in accordance with the international practices at present.

In the short run, the aged, coal fired power plants with low efficiencies are to be taken out of operation, and new power plants with lower heat rates are to be put into operation. At the beginning, smaller (140- 150 MW) combined cycle gas-turbines, and a coal(lignite) -fired base-load power plants should be installed (few of the former are already working). The new fossil fuel-fired power plants will be designed with supercritical parameters , i.e. their efficiency will be increased to about 40%, compared to the present 30-33% on average. In spite of Hungary’s lack of domestic energy resources, when making the energy forecast, the international tendencies at present have been taken into consideration. Thus it is considered that there are a few new nuclear power reactors contracted and installed in the future.

When calculating the overall GHG emission in the future and the direct and indirect GHG emission of the sectors investigated, it was assumed that the main chemical- physical characteristics of the fossil fuels consumed remain the same as in the past and in the baseline scenario.

III.4.2. The methodological tool applied: the ENPEP model in brief

The Energy and Power Evaluation Program (ENPEP), a personal computer software package, was developed by the Argonne National Laboratory with the help of the US Department of Energy, the World Bank and the International Atomic Energy Agency (IAEA) in order to provide a user friendly and integrated tool that can be widely applied for calculations and analyses in different examinations of the energy system. The widely used analyzing programs that were developed earlier for high performance computers and the practical experiences of operating those programs were applied in the design of this program.

The program is modular, thus each module required for the directed examinations can be independently operated. As well as improving the perspicuity of the examination, it also makes the whole process easier. In comprehensive examinations or analyses, naturally, individual modules connect automatically to other modules of the ENPEP model system.

Both general examinations of the whole energy system and specific examinations of the electrical energy system can be carried out by means of the ENPEP model. The development of ENPEP was needed because the development of energy systems today can only be achieved if all the relationships of the whole system are considered.

The program package contains nine modules:

For general examinations of the energy system:

Module MACRO simulates the growth of macro-economy

Module DEMAND estimates the long term energy need of the economy

Module BALANCE analyses the balance of energy supply and demand

Module IMPACTS identifies resulted environmental pollution and the economically viable alternatives of reducing them

For detailed examinations of the energy system:

Module PLANTDATA contains typical data of power plants

Module MAED provides detailed estimation of the future electrical energy demand

Module LDC provides estimations for power and load characteristics

Module ELECTRIC analyses the least expensive development strategy

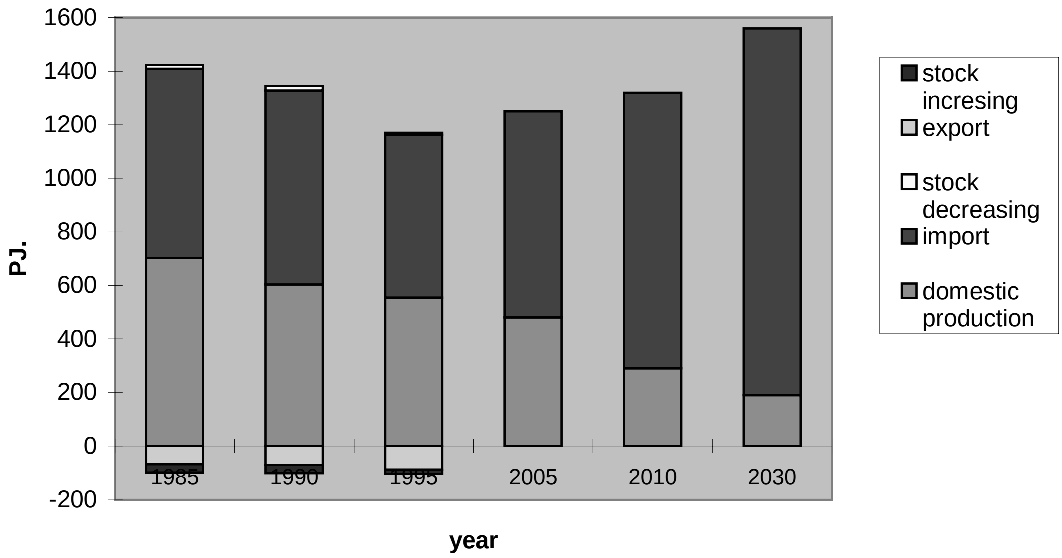
Module ICARUS details the electrical energy system and its costs as well as provides reliability assessments.

For a more detailed description of the ENPEP model, or its individual modules, please refer to the model manual and other program descriptions.

III.4.3. Energy sector baseline projections

Below the total primary energy requirements of the country are shown by fuel type up to the year 2030.

Figure III-C. Total primary energy requirement in Hungary by sources.



In the total primary energy requirement of the earlier period, the fossil fuel consumption and within this, the solid fuel, the coal was dominant. Later on the hydrocarbons play an important role. The structure of the domestic energy production has drastically changed in the last period. Coal production, specially deep-mining, decreased significantly. In the future the hydrocarbon mining will also decrease because of the exhaustion of the domestic reserves. Only the production of lignite from open-pit mining will remain practically together with the renewable energy sources. Thus our energy import should be increased to cover the domestic energy demand. Our dependency on energy import will greatly increase in the future (See Fig III-C above and Table VIII-G in the Appendix I).

The total primary energy requirement in Hungary is fulfilled by coal, oil, natural gas, nuclear power, hydro, imported electricity and fuelwood. In the future we predict an increase of the role of fuelwood and a decrease of the role of imported electricity. The penetration of the nuclear electricity into the HES in Hungary started in the year 1983. Its share in the primary energy consumption in the year 1995 was about 13% , but in the domestic electrical energy production its share is much higher, about 45%. Its effect on environmental pollution, when compared with electrical energy production, may be advantageous.

By the year 2030 public power plants' share of gross electrical energy will be 98% while the other 2 sources, we predict, will only total 2%. In the period between the years 1990 and 1995 electrical energy consumption decreased (Fig. III-E below and Table 3 in Appendix 2), because of the overall economic recession, the transition from a planned to a market economy and the restructuring of industry.

Figure III-D. Total primary energy requirement in Hungary by fuel types.

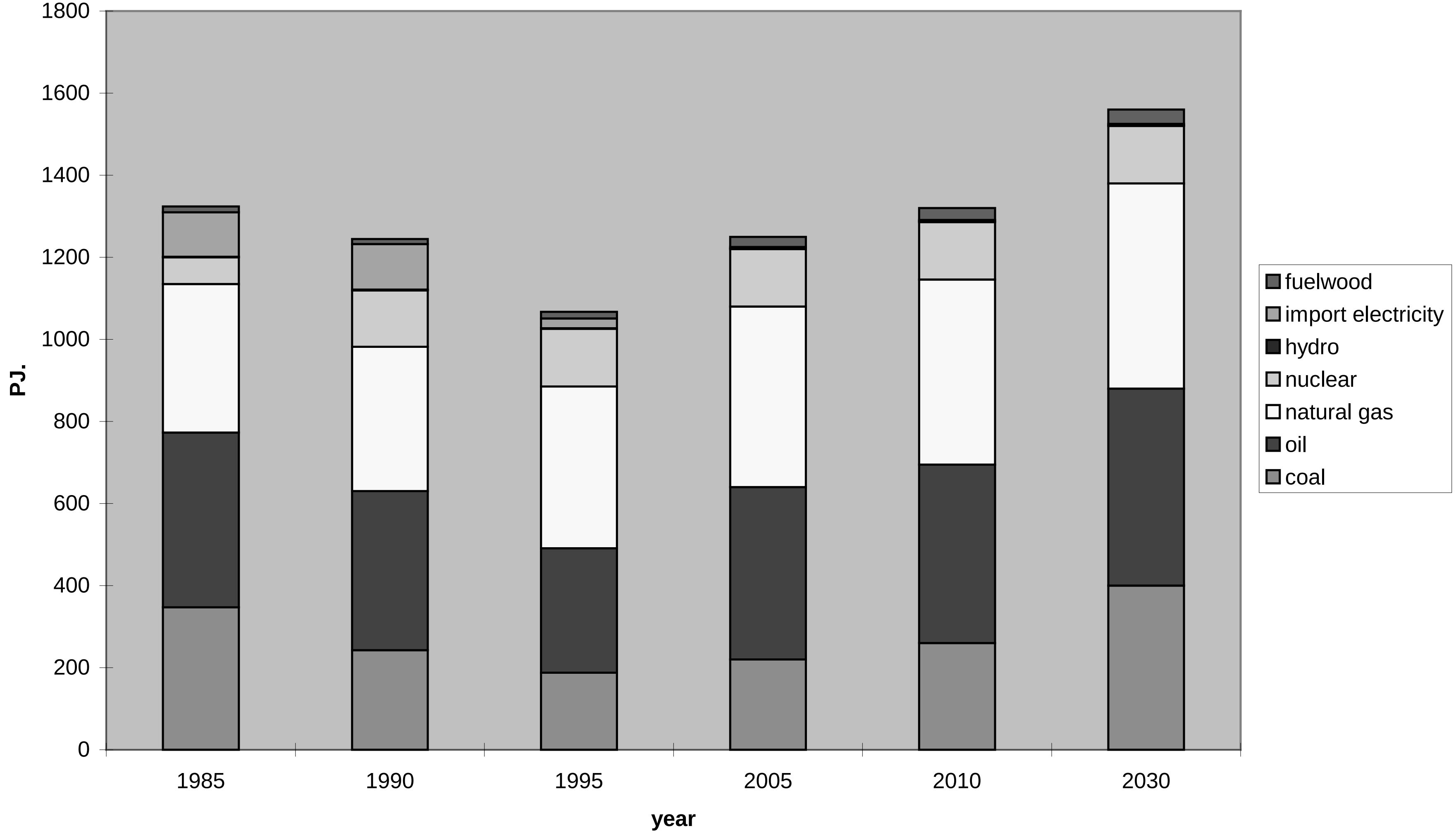
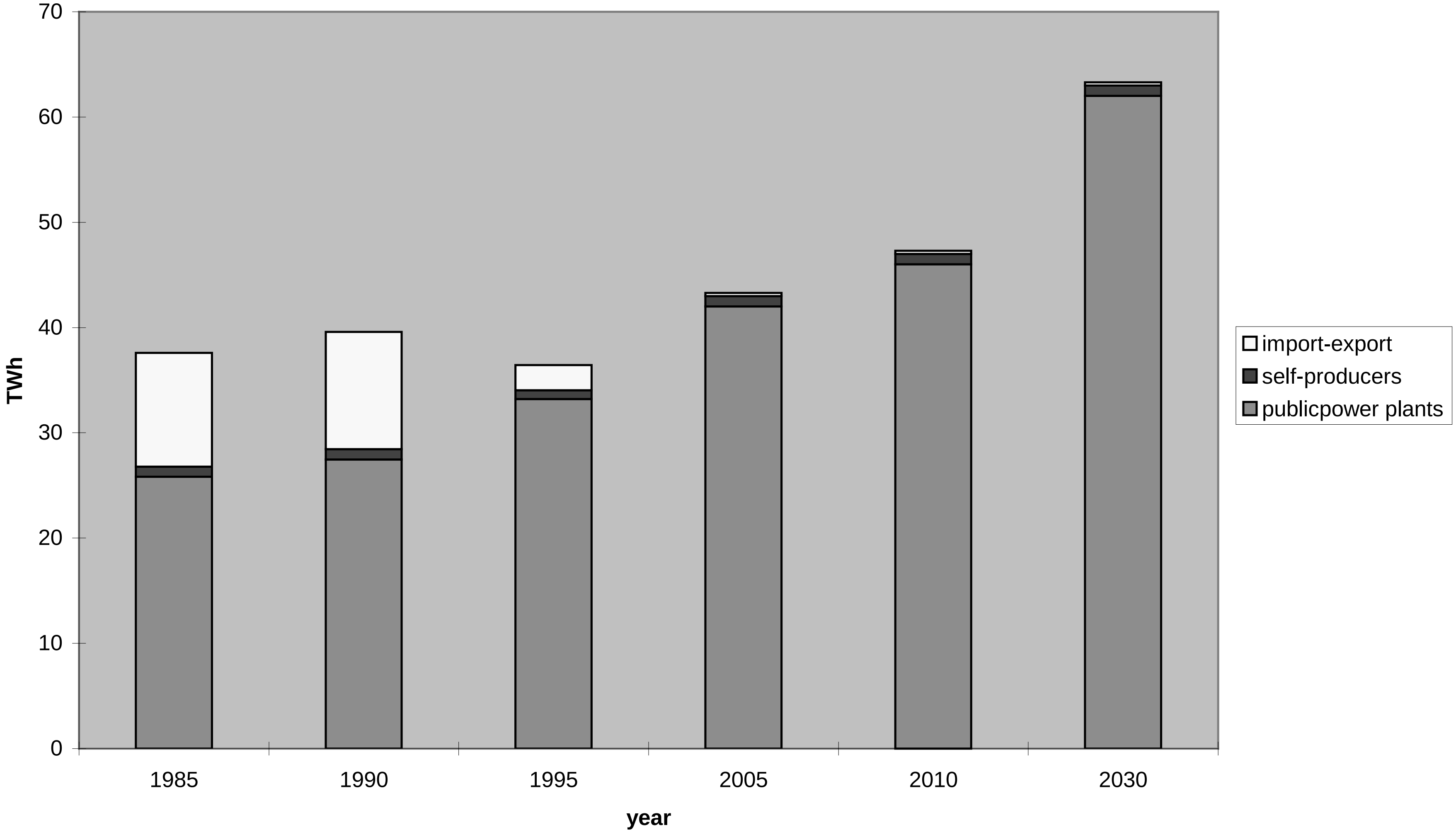
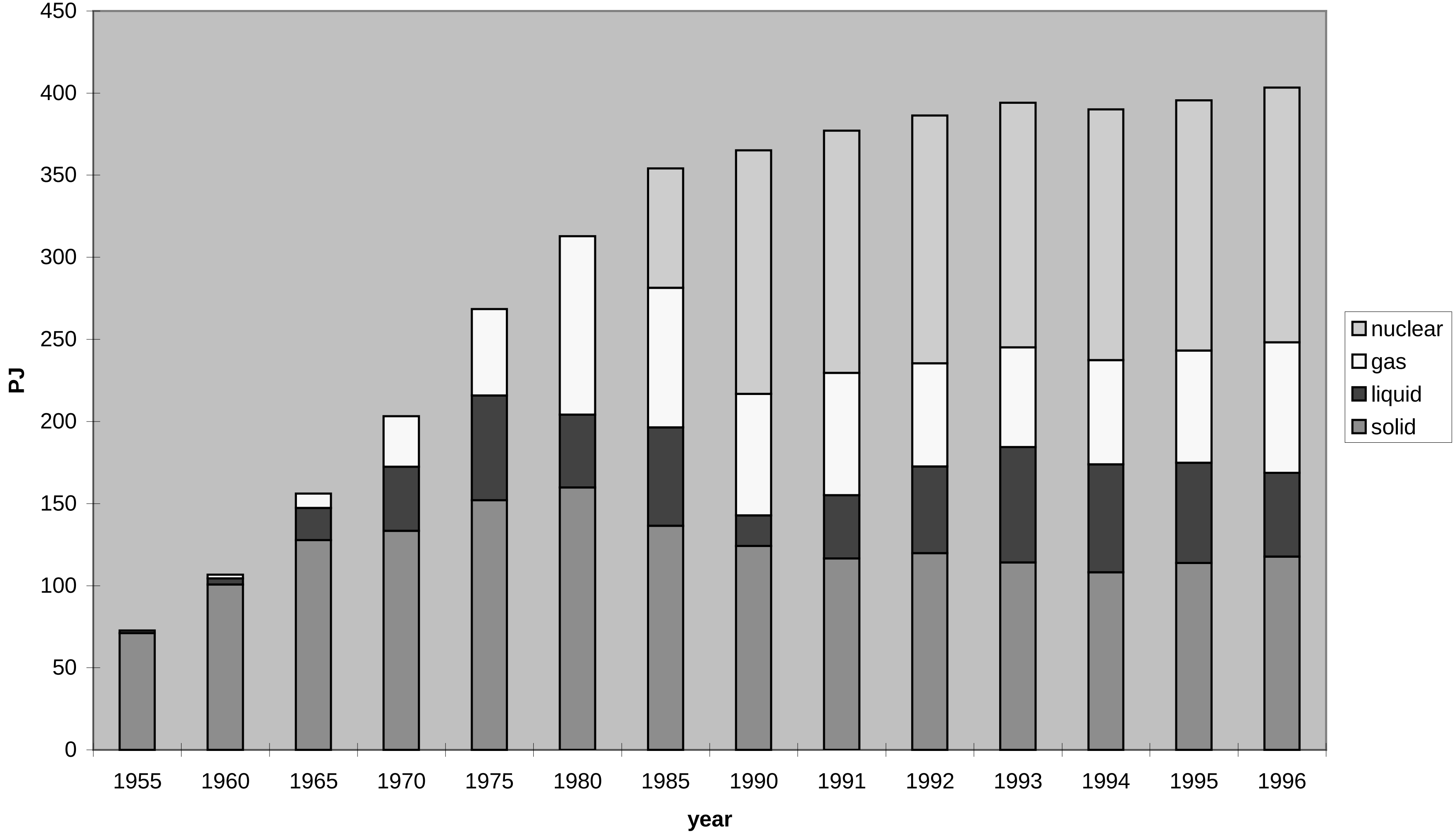


Figure III-E. Gross electrical energy by sources.



However, the electrical energy import decreased even faster, thus the domestic electrical energy production had to be increased. Nowadays on a significantly higher production level, the fossil fuel consumption of public power plants is less than before due to the introduction of nuclear electricity production (Fig. III-F below and Table VIII-J in the Appendix 1). And thus the emissions connected to electrical energy production are more advantageous. While by 1995 solid fuel consumption rates only increased from 100.87 PJ to 133.963, liquid fuel increased from 3.7 PJ to 60.975, and gas from 2.21 PJ to 68.332.

Figure III-F. The fuel consumption of public power plants in Hungary.

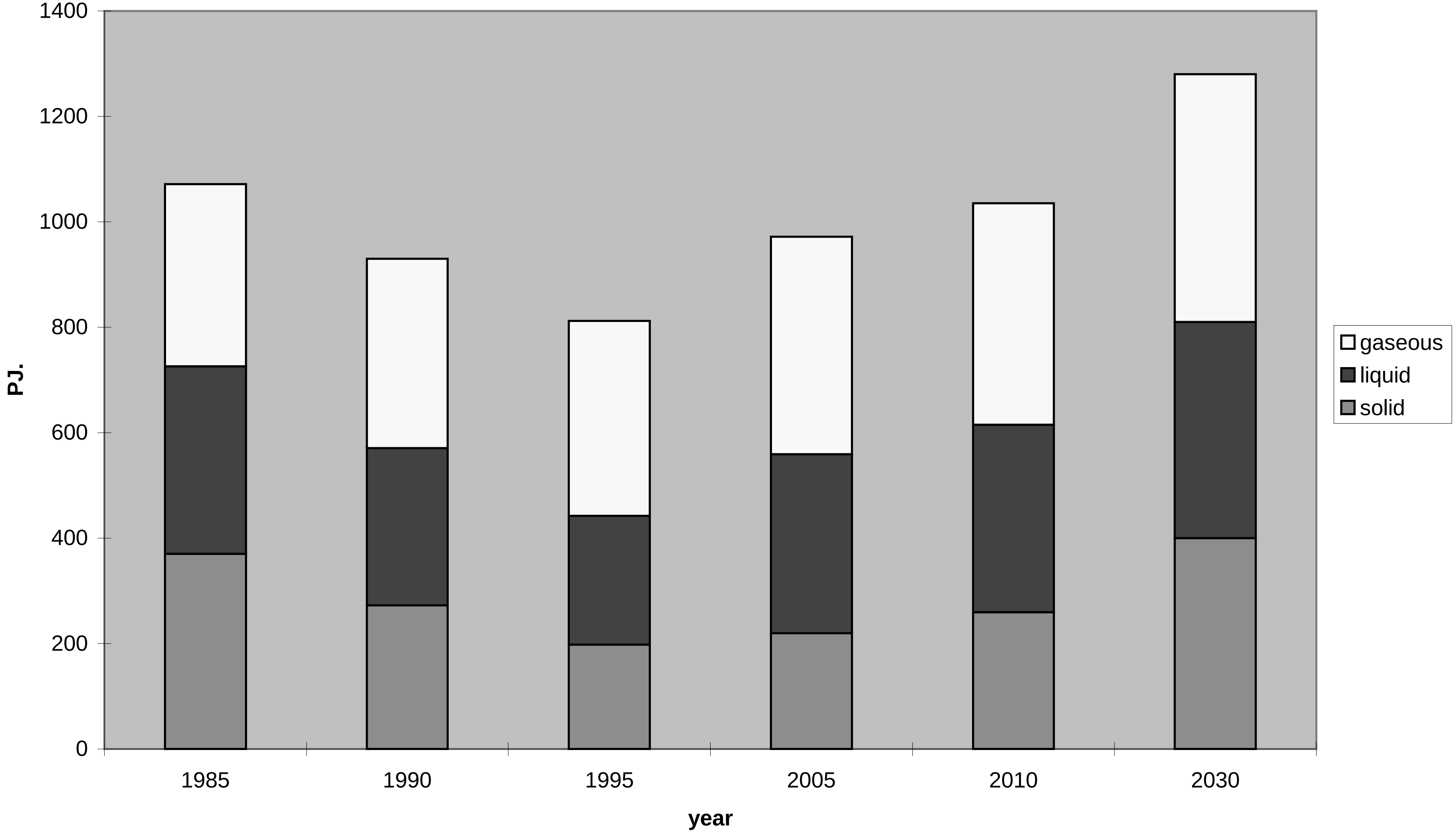


III.4.4. Projections of GHG emissions in Hungary

In the emission factor method, fossil fuel consumption has been selected as the activity level for the energy-related emissions. Fired fossil fuel does not equal to the total fossil fuel consumed, because of exports, of the non-energy use of the fossil fuels (for example, lubricants, paraffins, etc.) and because of the feedstocks (e.g. gasoline for chemistry, natural-gas for ammonia production, bitumen for road-making etc...). Therefore a new data set representing actual GHG emissions had to be designed.

In Fig. III-G below and in Table VIII-L of Appendix 1 the actually fired fossil fuels are shown. Solid fuels in 1985 compose 35% of the total fissil fuel fired in Hungary by fuel types: liquid fuel 33% and gasseous 32,%. By the year 2030, we predict that solid fuel will comprise 31% of the fossil fuel fired in Hungary, liquid fuel 31% and gaseous 37%. Thus the different fuel types will not greatly change their proportion of the total fossil fuel fired, but actual total of all fuels will increase by 208.74 PJ.

Figure III-G. Fossil fuel fired in Hungary by fuel types.

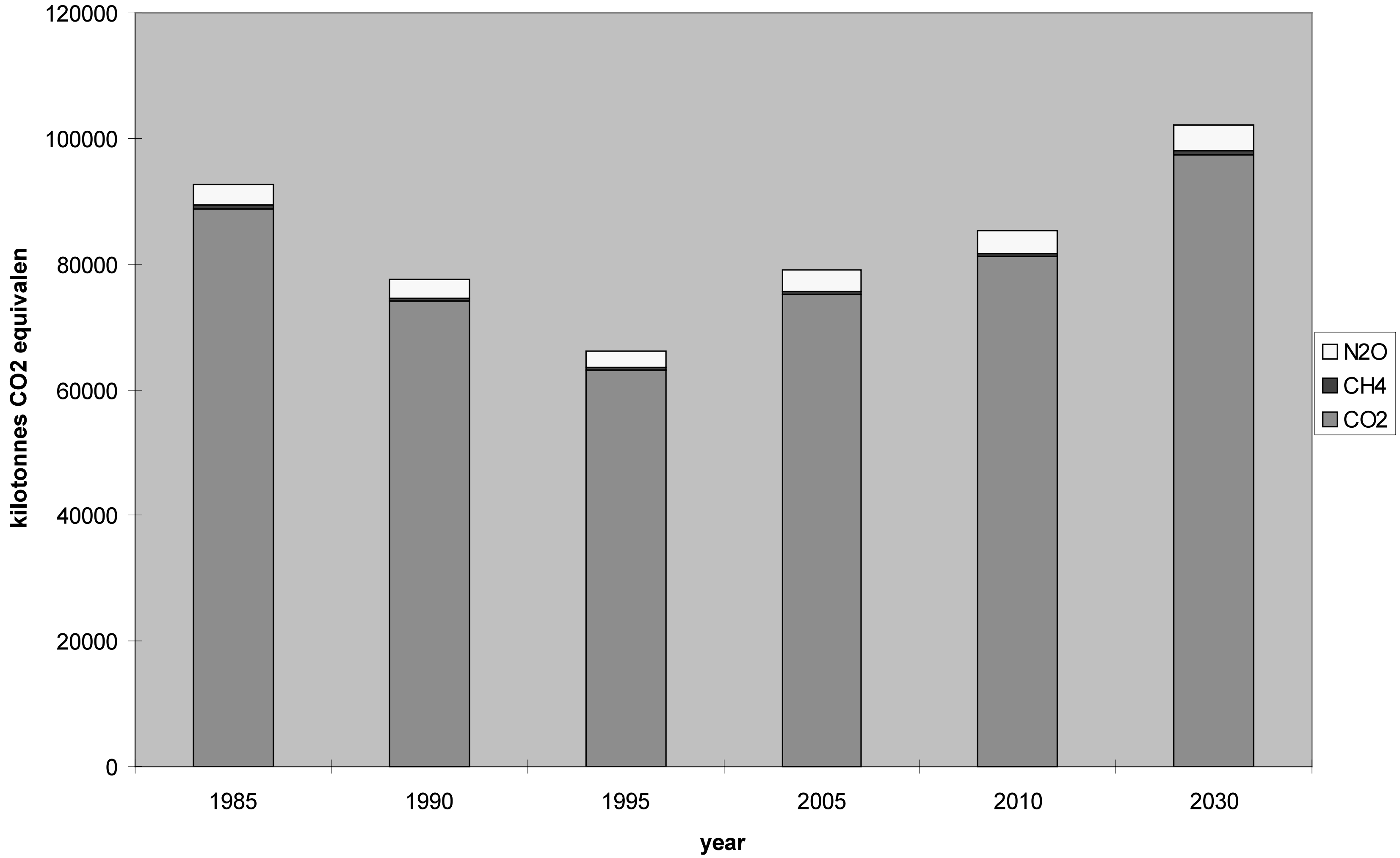


In the Figs. VIII-H, VIII-I and VIII-J the connected GHG emissions (carbon-dioxide, methane, and dinitrogen-oxide) and their projections are seen for the years of 1985 to 2030. All 3 emissions, with the exception of gaseous emissions, experience a temporary drop around the time of the year of 1995.

The emissions and the fossil fuel consumption of the period of the years 1985 to 1990 show the effects caused by the installation of the new nuclear reactor blocks in the Paks Nuclear Power Plant. The changes in the following five year period (1990-1995) have also been the results of the overall economic depression, modification in the economy caused by the transition from the planned economy to the market one, and the restructuring of production. At the same time there was a significant modification in the structure of fossil fuel uses: intensive natural gas programs have been realized which resulted in a sharp decrease of household coal consumption and of the industry. Similarly, there was a decrease in the residential fuel-oil consumption and in the motor-driving fuels because of the multiple price increase.

The direct GHG emissions in Hungary are developed and using the GHG's equivalent Global Warming Potential (GWP), the resulting GWP for the GHGs for a 100 year time horizon is shown in Fig. III-H below and in Table 9 of appendix 2. When calculating the resulting GWP for methane emissions and for the N_2O, factors 21 and 310 have been used respectively. As one can see, with comparison to the GWP of CO_2, the GWP of methane and dinitrogen-oxide may be neglected. Also evident in the graph is a temporary drop in the emissions around the year of 1995.

Figure III-H. Global Warming Potential of the GHGs emitted in Hungary.



III.4.4.1. GHG emissions connected with residential and communal energy use

The forecasted energy consumption of the household sector is shown in Fig. III-I and of the communal sector in Fig. III-J.

Figure III-I. Energy consumption of the residential sector.

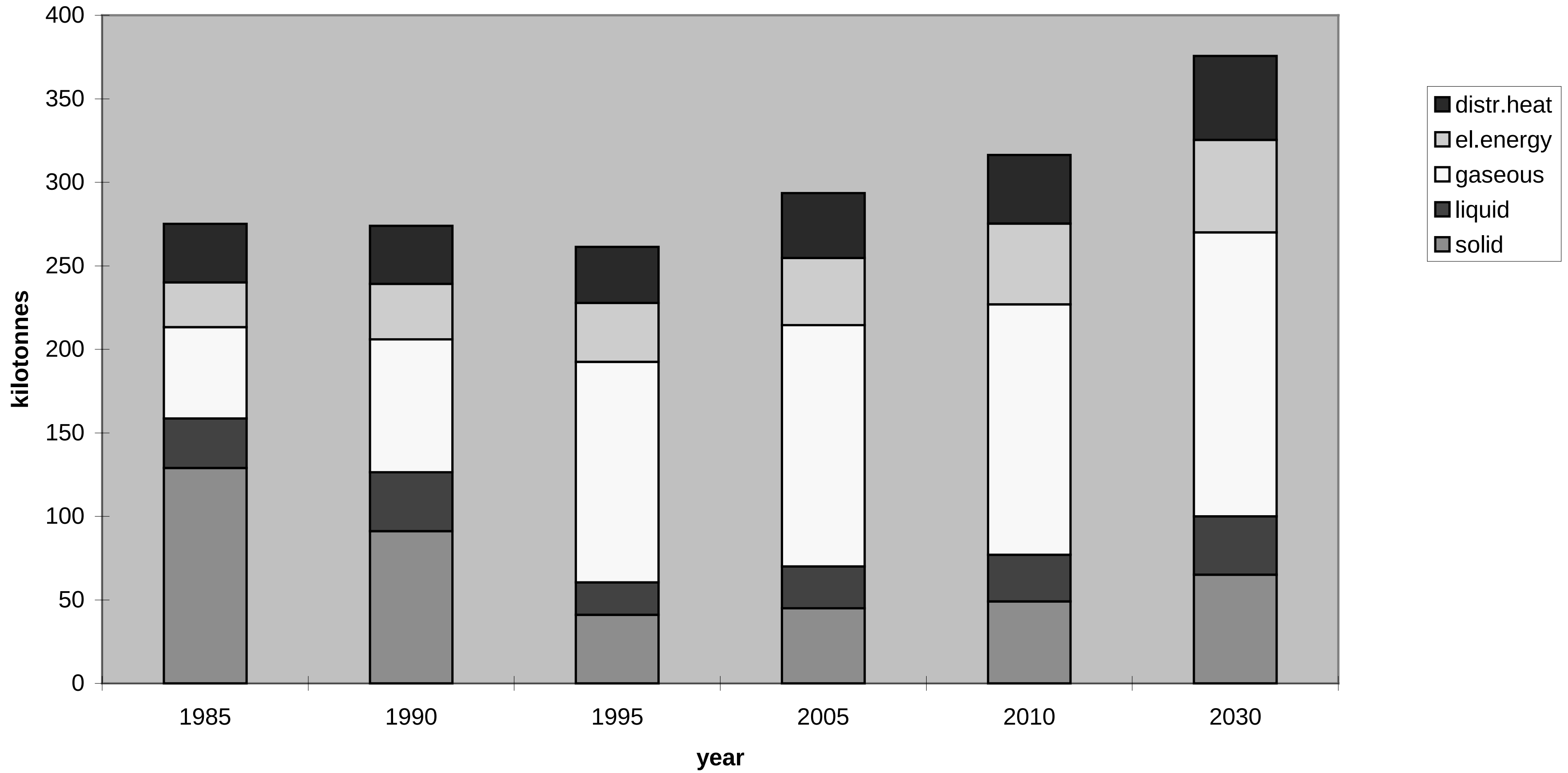
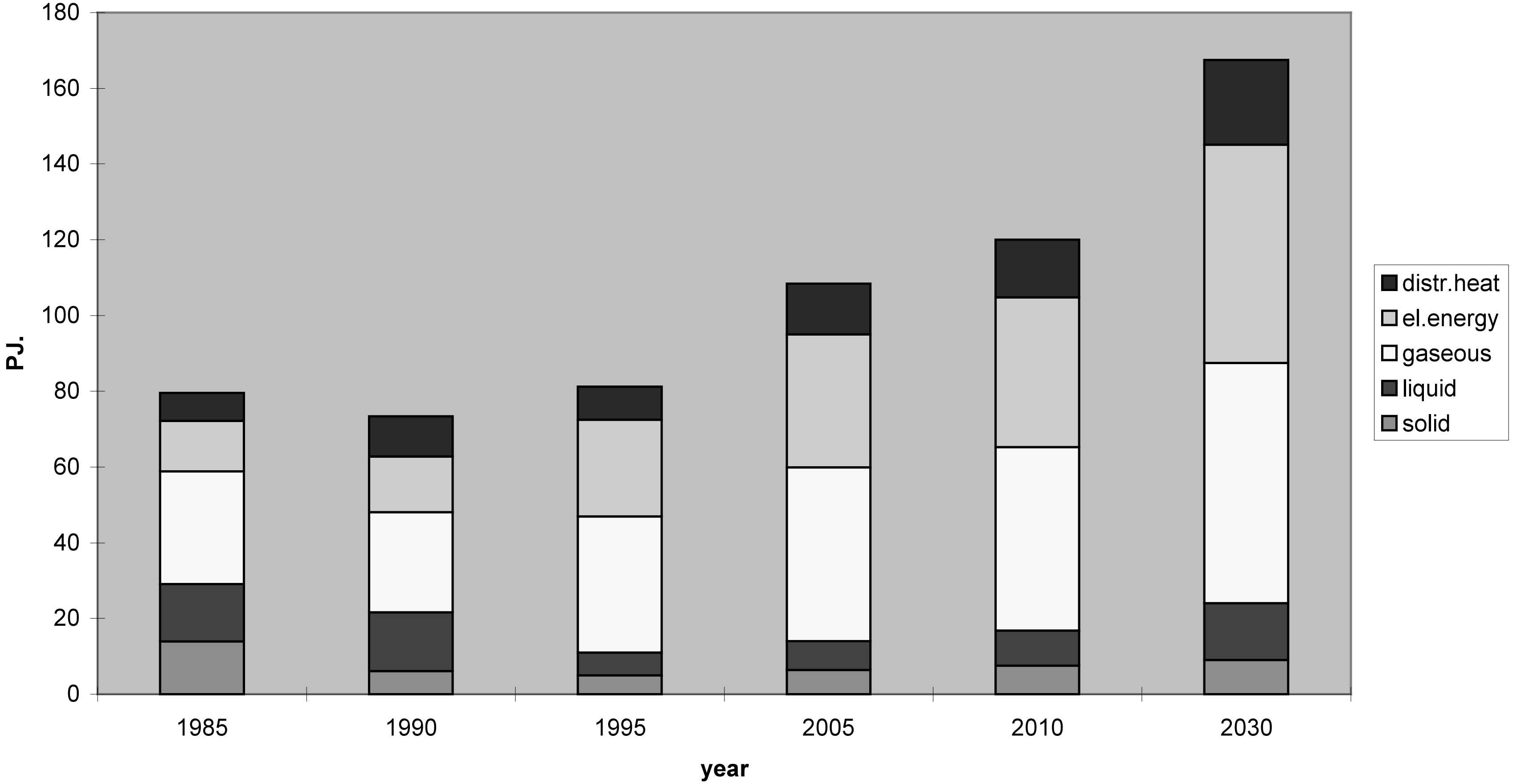


Figure III-J. Energy consumption of the service sector.



The energy consumption of the 2 sectors is made up of district heating, electrical energy, gas, liquid, and solid sources. In the residential sector, there is a drop of the solid energy source and an increase of gaseous. Electrical energy, district heating and liquid sources of energy consumption of the residential sector stay relatively the same. In the communal sector, all sources of energy increase in quantity with the exception of solid fuel.

For the forecast it was assumed that there will be a slight decrease in the Hungarian population, thus an increase in the number of flats is not expected. Aging flats will be demolished and the area of the new flats and the number of rooms per flat will increase. Since the thermal insulation and the orientation of the new flats will be better, only a slight increase in energy consumption for space-heating is expected. The increase in energy consumption of the residential sector is determined by new electrical household devices and appliances. Modern energy efficient devices are expected in the new flats and homes.

When the household and communal (excluding households) energy consumption sectors were determined, motor fuel consumption was not taken into consideration. This was accounted for in the transport sector because private passenger transport cannot be treated independently of mass transportation.

In the forecast of the communal energy demand it was assumed that it is similar to the residential sector. The area of the communal sector will increase either because of reconstruction or because of the new buildings. The new buildings will be built with better thermal insulation, thus only a slight increase is expected in this energy demand. New energy efficient devices and appliances will be installed. The modification of the aged devices will be a long process.

For the two sectors investigated, not only is the fossil fuel consumption illustrated, but so is the overall energy consumption in order to demonstrate the share of the electrical energy and district heat in satisfying the energy demand of the sectors. This is very important to know when determining the GHG emissions of a sector.

Indirect GHG emissions for the residential and communal sectors are calculated from the emissions connected to the fossil fuel consumption of heat supply (district heat) and of electrical energy generation. A detailed background calculation is necessary because a part of district heating is produced by individual boilers, while another part is produced by public power plants together with electrical energy generation (combined heat and electricity generation). Using the emissions and fuel consumption data of public power plants, specific emission data has been determined for district heating and for electricity generation. With these values the indirect GHG emissions have been determined for the two sectors investigated.

When making a long term energy forecast, the results of the domestic energy demand model were taken into consideration, which is based on the former MEDEE-II model. The MEDEE-II model was developed by the Grenoble University. It was adapted by the International Institute for Applies Systems Analysis (IIASA). Similarly it was adapted into the ENPEP model system, as the MAED-1 module. The ENPEP model system was developed by the Argonne National Laboratory and was sponsored by the International Atomic Energy Agency (IAEA).

The energy demand was forecasted with the progress of the GDP in mind. We have taken into consideration the fact that the aged production systems and devices cannot be changed immediately. Thus at the first period of the time horizon, the elasticity had been assumed higher than later. Similarly, the restructuring of the economy needs a longer time horizon than it was expected earlier. When forecasting household energy demand, the long-lasting population decrease predicted by the Central Bureau of Statistic was taken into consideration. Thus the number of flats will not change significantly. The area and thus the volume of the space heated will be higher. Thus the increase in the energy demand for space heating will be caused by the higher volume heated , not by the increase in the number of flats. A part of this increase will be compensated by the increase of the thermal insulation of the new buildings. Because of the recent economic and consumer trends, old appliances will be changed when they break down and the old fashioned, energy inefficient appliances will be bought because of their inexpensive prices. The selling of modern energy saving devices will increase in the second period of the investigated time-horizon.

According to economic forecast the role of the communal sector will increase in the future. This sector will invest in modern, energy-efficient appliances. Thus the modernization of this sector will be realized in a shorter time period.

For the long term forecast of the HES development, the Balance and the Electric (Wasp-III) module of the ENPEP PC model system, sponsored by the International Atomic Energy Agency together with the EFOM-GAMS version, had been used. Because of the Hungarian resource situation discussed earlier, sharp increase of imports is to be expected (Fig 2.) In the future, and in the long-run, the development of the domestic electrical energy production will be based on fossil fired power plants in accordance of the international praxis at present. In the short run, the aged coal fired power plants of low efficiency are to be closed, and the new power plants with lower heat rates should to be put into operation. At the beginning, smaller (140- 150 MW) combined cycle gas-turbines and a coal (lignite)-fired base-load power plant should be installed. Today, few are already put into service.

The model calculation should be redone again when the new regulations on the emissions are introduced because the new emission level will promote the introduction of emission control technologies and a structural change in the fuel consumption of the power system.

III.5. Projections of forestry-related carbon sequestration potentials

III.5.1. Methodology and assumptions

In Hungary there is a long tradition of forest management planning. Detailed forest management plans have been prepared for every forest-covered part of the country for at least three decades. Since the year 1976 this data has been available on magnetic media. Therefore, compilation of forestry statistics is easy. The data is annually updated with new inventories, natural growth processes and with changes monitored and registered by forest inspections.

Using the management plan data and the inventories, changes in the structure of the forested areas can be monitored, and the long term prognoses of future or planned forest structures can be calculated. The results of these prognoses can be used to estimate future specie compositions, growing stock and cuts. There are several methods of converting an arbitrary age class distribution into a classical or decreasing age class distribution. When the target state is reached, the cutting areas and the volume yield of the forest is going to be the same for any successive 10 year periods. Cutting ages or cutting age distributions are determined by analyzing statistics and by investigating the properties of the different species in terms of the optimal life cycle.

Once the specie's composition and the cutting age intervals for the target state are determined, the process of regulation can begin, and the changes of the state characteristics will be simulated with a computer program for several 10 year intervals, until the desired target state is reached. Such computer programs were written at the Department of Forest Management of the Sopron University under the leadership of Professor *László Király*. An analysis made by *Király* (*1994*) from a computation which was based on the forest inventory data of the year 1991 contained:

- the area and volume data of species and age class categories for Hungary for 1991
- statistics on site characteristics and on appropriate forest stands
- data on species composition in the target state
- estimates on the available area for afforestation and their site characteristics
- minimal, average and maximal cutting ages for the different species
- volume/ha data for the target state (*by species and age classes*)
- thinning percentage by species and age classes

The present carbon emissions of the forestry sector were not calculated in the study as there is no life cycle analysis for them and/or relevant models for computing the decomposition processes and time relations of wood products. The surveying of carbon emissions would cause only a little parallel slip in the time relations of our estimations, but would not modify the carbon balance dramatically. Forest carbon emissions could be significant only in those regions, where large scale deforestation is happening, or where wildfires, from time to time, destroy large forested areas. Fortunately, the Hungarian forestry sector is already avoiding deforestation problems by supporting new forests.

The effects of nature conservation policies on forest productivity and carbon sequestration were also not considered in the study. Virgin or old growth forests sequester only a small amounts of carbon, because their composition and decomposition processes are nearly balanced. Since in Hungary, virgin or old growth forests do not exist, this problem potentially interferes with the carbon sequestration capacity of Hungarian forests.

III.5.2. A Description of the baseline scenario

The baseline scenario assumes that there will not be any new afforestation. The baseline scenario is a long-term forestry activity taking place in Hungarian forests. This means that reforestation would follow regulated harvesting processes, but there would not be any afforestation on former arable land (Table III-K). In this scenario the forest-covered area remained as in the year 1991, and changes were assumed in the average volume/ha values. A slight change in the species structure is anticipated, and this change modifies the total growing stock from 292,8 million m^3 to 294,2. In the "*baseline*" scenario there is hardly any change in the total timber volume. The change in the annual harvest is due to the change in the age structure. The increase in growing stock is 1.36 million m^3.

Table III-K "Baseline" scenario for GHG mitigation options of Hungarian forestry

Baseline scenario	**1991**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Forest land (1000 ha)	1 634	1 634	1 634	1 634	1 634	1 634	1 634
Growing stock (above ground volume, $1000m^3$)	292 841	293 036	293 326	293 521	293 716	294 006	294 201
Forest carbon pool (1000 t)	105 310	105 441	105 643	105 774	105 905	106 107	106 238
Vegetation carbon (1000 t)	87 759	87 868	88 036	88 145	88 254	88 422	88 531
Below ground biomass (1000 t)	17 552	17 574	17 607	17 629	17 651	17 684	17 706
Carbon accumulation in living biomass (1000 t)	**0**	**131**	**333**	**464**	**595**	**796**	**927**
Annual area of harvest (1000 ha)	23,1	26,4	30	30,7	28,8	28,1	27,2
Annual allowable harvest, AAC (1000 m^3)	8 831	9 301	10 106	9 939	9 184	9 353	9 349
Total harvested carbon (1000 t)	25 791	52 640	81 002	108 491	134 122	160 115	186 053
Carbon content of raw material (1000 t)	**9 801**	**20 003**	**30 781**	**41 226**	**50 967**	**60 844**	**70 700**
Carbon content of fuel wood (1000 t)	**15 990**	**32 637**	**50 221**	**67 264**	**83 156**	**99 271**	**115 353**
Annual costs of forestation (1000 USD)	37 907	41 978	45 152	44 290	42 121	41 127	39 715
Annual costs of harvesting (1000 USD)	86 209	90 137	96 296	93 909	87 221	88 673	88 559
Annual incomes of harvesting (1000 USD)	146 947	153 956	164 751	160 568	149 280	151 108	150 809
Annual profits (1000 USD)	22 831	21 841	23 303	22 369	19 939	21 308	22 535
Net Present Value (1000 USD)	**19 695**	**33 713**	**44 843**	**52 793**	**58 065**	**62 258**	**65 557**

As a result of the necessary forced sustainable structural changes in the Hungarian forestry sector, some very slow increase in standing volume is predicted uptill the half of the next century. This increase in above ground woody biomass will remove 595 thousand tons of carbon up till the year 2030 (or 927 thousand tons of carbon till the year 2050) and will fix that amount in living trees. This little increase of growing stock is combined with an annual allowable cut (AAC) which will chang between 8.831 million m3 and 10.106 million m3 in the investigated time period. Less than 40% of annually harvested timber will be used as raw material. Wood products (furniture, constructions, etc.) will conserve the carbon for a certain time of between 1-500 years, depending on their life cycle. Wastes of wood processing will be used as wood fuel or natural decomposition processes will take back their carbon into the atmosphere in 1-6 years after harvesting. The carbon content of wood products and industrial wastes is estimated to be 70.7 million tons till the year 2050. Further investigations in the field of life cycle analysis as well as model developments are needed to estimate the total carbon sequestration capacity of the forestry sector and wood industry. More than 60% of the annually harvested wood is supposed to be used as wood fuel, which puts back the sequestered amount of carbon into the atmosphere in 1-3 years after the harvest. It is a large amount of carbon, estimated to be 115.4 million tons by the year 2050. The amounts of carbon fixed in the increasing living stock (see carbon changes in Table III-K) will conserve the sequestered carbon continuously into the far future.

IV. Mitigation scenarios

IV.1. Overview of past energy efficiency initiatives in the residential and communal sectors of Hungary

In the period before the 1989 political changes energy efficiency programs were centrally planned and supervised. They were directly or indirectly (through the regional or local councils) financed from the central budget.

The first energy efficiency programs were organised in 1954 based on the recognition that energy efficiency can be beneficial in solving the country's energy supply problems. It is understood that improving energy efficiency was cheaper than increasing energy production through new mines or imports. Within the scope of these programs projects were implemented primarily in the industrial sector. Later, evaluations of the centrally planned programs revealed that energy saving of several hundred thousand tons of oil per year was achieved. An additional benefit of these programs was that they gave an opportunity for industrial companies to modernise parts of their obsolete technologies. Technology upgrades resulted in reduced production costs, in reduced energy and material use, and, also in some cases, in increased production volumes. These factors were important elements of the evaluation of company leaders.

In the centrally planned era, district heating was as a strategy of energy efficiency. (It was also the cheapest solution for providing space heating for big numbers of pre-fabricated homes.) In the beginning co-generation-based heat sources were built, which provided heat both for residential and industrial consumers. The cogeneration facilities replaced highly obsolete coal-fired individual heating systems.

Later, due to the lack of investment capital, heat-only boiler plants were built to serve as heat sources for district heating schemes. Although these heat sources did not implement the co-generation system, they were meant to be energy efficient solutions when they replaced low efficiency residential space heating equipment.

After the early 1970's national budget sources for energy efficiency programs shrank. This resulted in the slowing down of energy efficiency activities. Hungary did not witness the dramatic price increases of the oil crises therefore strategies for energy conservation were not elaborated. It was believed that the effects of the oil crises will not infiltrate into the Eastern Block countries.

When the introduction of the market economy started in the year 1990, the market, it was declared, should solve the task of increasing energy efficiency. Unfortunately, at that time the basic elements of the market were not functioning. For example, energy market prices were not yet introduced.

In this way energy efficiency activities further slowed down as they were encouraged neither by the central nor by real market forces.

As a consequence of the change of the political system, conditions have changed in the residential and communal sectors, as well. Several tasks, earlier handled by the central or county-level governments, were passed on to the local governments, which do not have any experience in addressing them. Due to the strong belief in market mechanisms, the preparation of a national energy efficiency policy plan was delayed until the year 1994. In the first years of the transition, no major state funds were made available for energy efficiency investments, except for a small soft loan program. The successful operation of this program (called the German Coal Fund) shows that state intervention into energy policy can be highly efficient. Projects implemented by the help of the German Coal Fund have proven that investment in energy efficiency improvement can be more cost-effective than the development of the supply-side infrastructure.

In the transitional period international assistance programs have helped Hungary to launch energy efficiency initiatives. Some of these programs resulted in energy studies, which could serve as inputs to the development of energy policies (national or local). Other programs included demonstrational investments, illustrating concrete possibilities. The US or Dutch assistance programs or the PHARE program can be mentioned as good examples.

The situation can be summarised as follows:

1. *In the centrally planned era, energy efficiency programs were centrally planned and financed. They were probably as efficient, as the centrally planned system itself.*
2. *During the changes of 1989-90, central institutions for energy efficiency improvement were demolished. Market forces were expected to replace these state institutions.*
3. *Between 1990 and 1995 energy efficiency received little attention. The state nearly completely withdrew from this field however the market mechanisms could not take over properly.*
4. *Since the year 1996, the recognition for the need of market mechanisms and state intervention to work together has been strengthening.*

IV.2. Measures/technologies for improving energy efficiency

There is a wide scope of measures that can improve energy efficiency in the residential and communal sectors. Some of the measures can be implemented independently from the others while some are exclusive (e. g. a window can be either upgraded or replaced).

The following is a brief description of the considered measures. Some of them include a number of interrelated small measures. E. g. the term “retrofit of boiler plants” includes all improving interventions in an old, obsolete boiler-house, without the replacement of the main equipment.

All known measures are considered which

- are technically feasible
- have at least a small chance of becoming economically feasible under some circumstances
- may have a more than negligible impact on the national energy balance

“Exotic” technologies such as PV cells, daylighting by lighting shelves, or cogeneration by fuel cells, were not considered.

The measures are applied in our investigation for the existing building stock, although most of them are applicable for new buildings, as well.

Table IV-A

	Description
1	**THERMAL ENERGY**
1.1	**Building envelope**
1.1.1	Post-insulation of roofs, walls, and basement of existing buildings
1.1.2	Closing gaps between prefabricated panels
1.1.3	Heat mirror behind the radiators in existing buildings
1.1.4	Upgrading windows of existing buildings by retrofitting (weather-stripping, fixing of frames, replacement or upgrading of glazing)
1.1.5	Replacement of windows of existing buildings by efficient ones (low emissivity glazing, tight frames)
1.2	**Space heating**
	<u>District heating - supply side</u>
	Heat sources
1.2.1	Utilisation of industrial waste heat for district heating
1.2.2	Energy efficiency retrofit of boiler plants (adjustment/replacement of burners, energy efficient pumps, flue gas heat recovery, better controls, improved thermal insulation, upgraded condensate and steam technology, etc.)
1.2.3	Replacement of boiler-house equipment
1.2.4	Introduction of up-to-date cogeneration into existing heat-only or cogeneration plants
1.2.5	Use of biomass in existing heat sources
1.2.6	Switch from coal/oil to natural gas
	Distribution system
1.2.7	Switch from temperature control to flow control
1.2.8	Improved thermal insulation by new pre-insulated pipelines
	Substations
1.2.9	Improved controls (weather-compensated controls, programming) and other retrofit measures (better thermal insulation, more thorough maintenance, etc.)
1.2.10	Introduction of high-efficiency technologies (high performance heat exchangers, DDC controls, central dispatching, etc.)
	<u>Central heating</u>
	Boilerhouses
1.2.11	Energy efficiency retrofit of boilerhouses (adjustment/replacement of burners, energy-efficient pumps, flue gas heat recovery, better controls, improved thermal insulation, better boiler controls, etc.)
1.2.12	Switch from coal/light fuel oil to natural gas (in small, central heating boiler plants which cannot use heavy fuel oil)
1.2.13	Switch from heavy fuel oil to natural gas (in bigger communal boiler plants which can use heavy fuel oil)
	<u>Secondary systems of centralised heating systems</u>
	Distribution
1.2.14	Introduction of zoned distribution and control
1.2.15	Hydraulic adjustment of individual loops (in order to decrease unevenness of heating)
	Dwellings
1.2.16	Thermostatic valves + cost allocators + converting single-pipe systems by the installation of individual bypasses where necessary

1.2.17	Introduction of individual metering (by switching to horizontal distribution and installing individual substations per dwelling)
	Individual space heating
1.2.18	New, higher efficiency traditional boilers
1.2.19	Installation of condensing boilers, including the replacement of radiators
1.2.20	Programmable thermostats
1.2.21	Thermostatic valves
1.2.22	Upgrading existing combustion equipment by adjustment and better maintenance
	Solar architecture
1.2.23	Solar retrofits (solariums, heat traps)
1.3	**Domestic hot water supply**
1.3.1	Individual metering
1.3.2	Efficient faucets and shower-heads
1.3.3	Active solar DHW (Domestic Hot Water) systems
1.4	**Ventilation**
1.4.1	Heat recovery in forced ventilation systems
1.5	**Awareness development**
1.5.1	Development of public awareness by promotional activities, campaigns, labelling, etc.
2	**ELECTRICITY**
2.1	**Lighting**
2.1.1	More CFLs (Compact florescent lamps) in households and communal buildings
2.1.2	Technology change (replacement of luminaries and controls)
2.2	**DHW**
2.2.1	Switch from electric to gas heaters
2.2.2	Better electric DHW heaters (more efficient thermal insulation)
2.2.3	Flow controllers on faucets and shower-heads
2.3	**Home appliances**
2.3.1	Procurement of new, more efficient appliances
2.4	**Ventilation**
2.4.1	Replacement of common ventilation (in multi-storey buildings) by individual ventilation
2.5	**Awareness development**
2.5.1	Development of public awareness by promotional activities, campaigns, product labelling, etc.

For the purpose of the present study, strategies have been compiled. Each strategy includes measures grouped in such a way that they can be technically implemented (they do not exclude one another). The strategies were compiled according to the following series of steps:

– the parameters of the individual measures were determined (energy saving effect in %, specific micro level investment cost in HUF/capacity unit, application potential in TJ/a)

– the measures were ranked by micro-level cost effectiveness

– it was assumed that the measures are implemented in the above cost-effectiveness order, taking into account that the measures influence one another. For example, demand side measures, such as the insulation of walls, influence supply side ones - low demand buildings need less heat; in this way the cogeneration potential decreases.

For heating and electricity, separate strategies are presented. The “First” strategy includes retrofit type measures, while the “Second” strategy includes technology replacement type measures.

Table IV-B The following tables show the scope of measures considered in the individual strategies.

	The First Heat Strategy (retrofitting)		The Second Heat Strategy (new equipment)	
	Residential	**Communal**	**Residential**	**Communal**
1.1.1			■	■
1.1.2	■	■		
1.1.3	■	■		
1.1.4	■	■		
1.1.5			■	■
1.2.1	■	■	■	■
1.2.2	■	■		
1.2.3			■	■
1.2.4	■	■	■	■
1.2.5			■	■
1.2.6	■	■	■	■
1.2.7	■	■	■	■
1.2.8	■	■	■	■
1.2.9	■	■		
1.2.10			■	■
1.2.11	■	■	■	■
1.2.12	■	■	■	■
1.2.13.		■		■
1.2.14				■
1.2.15	■			
1.2.16.	■			
1.2.17			■	
1.2.18	■			
1.2.19	■		■	
1.2.20	■		■	
1.2.21	■		■	
1.2.22	■		■	
1.2.23	■		■	
1.3.1	■		■	
1.3.2	■	■	■	■
1.3.3	■	■	■	■
1.4.1		■		■
1.5.1	■		■	

	The First Electricity Strategy (retrofitting)		The Second Electricity Strategy (new equipment)	
	Residential	**Communal**	**Residential**	**Communal**
2.1.1	■	■	■	■
2.1.2		■		■
2.2.1			■	
2.2.2	■	■		
2.2.3	■	■	■	■
2.3.1	■		■	
2.4.1	■		■	
2.5.1	■		■	

IV.3. Conservation potential and related costs

Conservation potential and the related costs are summarised in the following eight tables.

The measures are denominated by their code numbers introduced in Table IV-A.

Primary fuel savings calculations take into account the losses of generation/ transmission.

CO_2 savings are calculated on the basis of the present fuel mix of the studied sectors. CO_2 savings related to electricity savings are calculated on the basis of the present fuel mix of the Hungarian power sector.

CO2 conservation potentials and costs are calculated based on the assumption of full adoption, i.e. the achievable, real potentials will probably be somewhat smaller. Since achievable conservation potentials are difficult to calculate and require some historical data on previous measure adaptations, the calculation of achievable potentials are beyond the scope of this study. However, to be as close as the realistic costs as possible, we have considered the costs of implementation. These are marked in the tables.

Micro level energy cost savings are calculated on the basis of the present retail prices, exclusive of VAT (value added tax).

The total investment costs represent the costs the end-users are supposed to pay. No VAT is considered. No subsidies, grants, etc. are taken into account.

The second last column of the following tables shows the part of investment costs justified by energy cost savings. An investment is justifiable if the net return (exclusive of inflation effects) is 9%.

The last column shows the net costs of GHG abatement. The same data are also represented in the so-called “conservation supply curves” in the appendix, where the CO_2 abatements for each measure versus its investment costs are diagonally shown by each strategy.

IV.3.1. The First Heat Strategy - Residential Sector

Measure	Savings			Investment costs		
	In primary fuel	In CO_2	In micro level energy cost	Total investment at micro level	Justified by energy cost savings	To be financed through GHG abatement mecha-nisms)
	PJ	kt	10^9 HUF	10^9 HUF	10^9 HUF	10^9 HUF
1.2.12.	0.07	28.90	1.13	0.45	0.45	0
1.3.1.	3.95	270.49	3.96	2.08	2.08	0
1.5.1.	1.27	85.83	1.28	2.59	0.00	2.592
1.3.2.	7.18	423.06	6.46	14.49	14.49	0
1.2.1.	0.03	19.17	0.19	0.52	0.52	0
1.2.22.	2.28	127.31	1.37	4.33	2.42	1.91
1.2.15.	0.69	46.73	0.43	1.37	0.40	0.97
1.2.21.	4.54	290.39	4.26	16.15	16.15	0.00
1.2.20.	3.67	205.00	3.09	12.99	12.99	0.00
1.1.3.	1.54	101.16	1.61	6.91	6.28	0.64
1.2.7.	0.64	49.95	0.46	2.16	2.16	0.00
1.2.2.	0.12	7.71	0.08	0.41	0.41	0.00
1.2.9.	0.46	34.79	0.31	1.59	1.59	0.00
1.2.16.	7.88	539.79	4.88	32.28	18.98	13.30
1.2.4.	31.38	2998.48	16.60	124.42	124.42	0.00
1.2.11.	0.19	12.04	0.22	2.25	1.80	0.45
1.1.4.	24.13	1578.75	28.78	479.17	232.00	247.18
1.1.2.	0.39	25.85	0.60	14.87	4.81	10.06
1.3.3.	3.16	241.85	4.60	136.60	37.07	99.53
1.2.23.	2.37	155.69	3.29	214.88	33.78	181.09
1.2.18.	3.32	185.32	3.23	216.55	26.06	190.49
1.2.8.	0.61	46.73	0.61	56.82	4.93	51.88
1.2.6.	-2.87	13.27	0.00	4.51	0.00	4.51
Total	96.97	7488.26	87.46	1348.39	543.82	804.61

IV.3.2. The First Heat Strategy - Communal Sector

Measure	Savings			Investment costs		
	In primary fuel	In CO_2	In micro level energy cost	Total investment at micro level	Justified by energy cost savings	To be financed through GHG abatement mecha-nisms)
	PJ	kt	10^9 HUF	10^9 HUF	10^9 HUF	10^9 HUF
1.2.12.	0.16	57.47	2.72	1.08	1.08	0
1.2.1.	0.003	3.23	0.03	0.08	0.08	0.00
1.3.2.	1.54	90.81	1.53	4.73	4.73	0.00
1.2.7.	0.09	7.15	0.07	0.35	0.35	0.00
1.2.2.	0.02	1.34	0.01	0.07	0.07	0.00
1.2.9.	0.06	4.87	0.05	0.25	0.25	0.00
1.1.3.	0.75	45.81	0.63	4.33	2.45	1.88
1.4.1.	0.51	31.39	1.67	11.80	11.80	0.00
1.2.4.	5.20	501.94	2.67	19.99	19.99	0.00
1.2.11.	1.06	62.92	0.90	9.03	7.22	1.81
1.1.4.	13.72	837.56	11.88	235.02	95.73	139.28
1.1.2.	0.14	8.66	0.20	4.63	1.62	3.01
1.2.8.	0.10	7.79	0.10	9.13	0.79	8.34
1.3.3.	1.10	90.44	0.30	44.09	2.44	41.65
1.2.13.	0.24	79.17	0.00	0.58	0.00	0.58
1.2.6.	-0.16	34.19	0.00	0.72	0.00	0.72
Total	24.53	1864.74	22.76	345.88	148.62	197.27

IV.3.3. The First Electricity Strategy - Residential Sector

Measure	Savings			Investment costs		
	In primary fuel	In CO_2	In micro level energy cost	Total investment at micro level	Justified by energy cost savings	To be financed through GHG abatement mechanisms)
	PJ	kt	10^9 HUF	10^9 HUF	10^9 HUF	10^9 HUF
2.5.1.	4.40	347.95	7.25	2.59	0.00	2.592
2.2.3.	4.61	364.27	3.60	4.15	4.15	0
2.4.1.	10.89	720.75	11.20	23.83	23.83	0
2.1.1.	5.00	394.75	9.03	49.23	35.11	14.1
2.3.1.	10.15	799.48	18.87	324.03	152.09	171.9
2.2.2.	1.51	118.60	1.38	63.59	11.14	52.4
Total	36.57	2745.80	51.33	467.42	226.33	241.09

IV.3.4. The First Electricity Strategy - Communal Sector

Measure	Savings			Investment costs		
	In primary fuel	In CO_2	In micro level energy cost	Total investment at micro level	Justified by energy cost savings	To be financed through GHG abatement mechanisms)
	PJ	kt	10^9 HUF	10^9 HUF	10^9 HUF	10^9 HUF
2.2.3.	0.91	72.85	0.37	0.56	0.56	0
2.1.1.	2.34	186.97	1.63	5.29	5.29	0.00
2.1.2.	19.21	1536.34	13.58	141.08	109.46	31.61
2.2.2.	0.17	13.63	0.08	3.23	0.64	2.59
Total	22.63	1809.78	15.66	150.15	115.95	34.20

IV.3.5. The Second Heat Strategy - Residential Sector

Measure	Savings			Investment costs		
	In primary fuel	In CO_2	In micro level energy cost	Total investment at micro level	ustified by energy cost savings	To be financed through GHG abatement mecha-nisms)
	PJ	kt	10^9 HUF	10^9 HUF	10^9 HUF	10^9 HUF
1.2.12.	0.07	28.90	1.13	0.45	0.45	0.00
1.3.1.	3.95	270.49	3.96	2.08	2.08	0.00
1.5.1.	1.27	85.83	1.28	2.59	0.00	2.59
1.3.2.	7.18	423.06	6.46	14.49	14.49	0.00
1.2.1.	0.03	19.17	0.19	0.52	0.52	0.00
1.2.22.	2.28	127.31	1.37	4.33	2.42	1.91
1.2.21.	4.55	291.06	4.26	16.15	16.15	0.00
1.2.20.	3.68	205.57	3.09	12.99	12.99	0.00
1.2.7.	0.64	50.26	0.46	2.16	2.16	0.00
1.2.4.	32.58	3111.97	16.60	124.42	124.42	0.00
1.2.3.	0.21	13.67	0.16	1.32	1.32	0.00
1.2.5.	1.88	291.94	3.09	25.17	25.17	0.00
1.2.11.	0.19	12.17	0.22	2.25	1.80	0.45
1.1.1.	45.68	2937.55	52.93	969.41	543.82	425.59
1.1.5.	21.15	1367.60	31.81	669.44	326.82	342.62
1.2.10.	0.63	44.96	0.85	24.52	6.88	17.64
1.3.3.	2.70	206.91	4.60	136.60	37.07	99.53
1.2.17.	0.09	5.79	10.24	316.10	82.58	233.52
1.2.19.	6.71	374.35	7.85	471.00	50.39	420.61
1.2.23.	1.80	118.97	3.29	214.88	33.78	181.09
1.2.8.	0.42	30.17	0.61	56.82	4.93	51.88
1.2.6.	-1.72	54.73	0.05	4.51	0.00	4.50
Total	135.95	10072.43	154.52	3072.19	1290.60	1781.95

IV.3.6. The Second Heat Strategy - Communal Sector

Measure	Savings			Investment costs		
	In primary fuel	In CO_2	In micro level energy cost	Total investment at micro level	Justified by energy cost savings	To be financed through GHG abatement mechanisms)
	PJ	kt	10^9 HUF	10^9 HUF	10^9 HUF	10^9 HUF
1.2.12.	0.16	14.76	2.72	1.08	1.08	0.00
1.2.1.	0.00	3.23	0.03	0.08	0.08	0.00
1.3.2.	1.54	90.81	1.53	4.73	4.73	0.00
1.2.14.	0.44	26.40	0.35	1.44	1.44	0.00
1.2.7.	0.09	7.13	0.07	0.35	0.35	0.00
1.4.1.	0.51	31.49	1.67	11.80	11.80	0.00
1.2.4.	5.21	502.80	2.67	19.99	19.99	0.00
1.2.3.	0.04	2.67	0.03	0.26	0.26	0.00
1.2.5.	0.07	45.56	0.50	4.04	4.04	0.00
1.2.11.	1.06	62.68	0.90	9.03	7.22	1.81
1.1.1.	18.51	1119.16	16.09	267.96	165.31	102.66
1.1.5.	16.47	1007.67	17.58	340.47	180.61	159.86
1.2.10.	0.11	8.33	0.14	3.94	1.11	2.83
1.2.8.	0.08	5.91	0.10	9.13	0.79	8.34
1.3.3.	0.96	79.88	0.30	44.09	2.44	41.65
1.2.13.	0.72	100.15	0.01	0.58	0.00	0.58
1.2.6.	0.15	47.74	0.01	0.72	0.00	0.73
Total	46.10	3156.38	44.69	719.70	401.36	318.45

IV.3.7. The Second Electricity Strategy - Residential Sector

Measure	Savings			Investment costs		
	In primary fuel	In CO_2	In micro level energy cost	Total investment at micro level	Justified by energy cost savings	To be financed through GHG abatement mechanisms)
	PJ	kt	10^9 HUF	10^9 HUF	10^9 HUF	10^9 HUF
2.5.1.	4.40	347.95	7.25	2.59	0.00	2.59
2.2.3.	4.61	364.27	3.60	4.15	4.15	0.00
2.4.1.	10.89	720.75	11.20	23.83	23.83	0.00
2.1.1.	5.00	394.75	9.03	49.23	35.11	14.11
2.2.1.	3.12	343.12	2.85	37.10	22.99	14.11
2.3.1.	9.78	766.63	18.87	324.03	152.09	171.94
2.2.2.	1.46	113.84	1.38	63.59	11.14	52.45
Total	39.26	3051.31	54.18	504.52	249.33	255.20

IV.3.8. The Second Electricity Strategy - Communal Sector

Measure	Savings			Investment costs		
	In primary fuel	In CO_2	In micro level energy cost	Total investment at micro level	Justified by energy cost savings	To be financed through GHG abatement mechanisms)
	PJ	kt	10^9 HUF	10^9 HUF	10^9 HUF	10^9 HUF
2.2.3.	0.43	34.26	0.37167	0.56	0.56	0
2.1.1.	1.11	87.92	1.63181	5.29	5.29	0
2.1.2.	9.15	722.48	13.5801	141.08	109.46	31.6121
2.2.2.	0.08	6.41	0.07903	3.23	0.64	2.5894
Total	10.78	851.07	15.66	150.15	115.95	34.20

IV.4. Selected measures in details

In this section, we detail the assumptions for the measures which have been analysed in detail. The following chosen measures were taken into consideration when producing the so-called “cost curves” in the following sections.

IV.4.1. (1.1.1) The supplementary insulation of roofs, walls and basements in existing buildings

Field of application: heating

The energy saving of roofs (ceilings), walls and foundations defined in % can be calculated using the following formula:

$$\Delta Q_i = \frac{(k_{r,i} - k_{u,i})F_i}{\sum kF},$$

ΔQ_i the % of energy saving

$k_{r,i}$ the original heat transmission of the examined structural element i.e. roof, wall, foundation

$k_{u,i}$ the heat transmission of the examined structural element i.e. roof, wall, foundation, after the application of heat insulation

F_i the surface of the examined structural element i.e. roof, wall, foundation

$\sum kF$ the product of heat transmission factor and the surface of all the structural elements of the building

To be able to calculate the savings on the national level, the following pieces of information are necessary

- information concerning heat transmission, surface and the number of buildings on a national level
- the heating necessities of buildings on a national level divided into groups of energy sources

The first study contains a comprehensive, nation-wide survey on buildings. The survey was administered in 1993, therefore the changes that have taken place ever since concerning the conditions of the buildings are neglected. In order to more easily handle the data, the concerned buildings have been put into categories each described by the so-called model building. The data of the model buildings contains information on their surface, heat transmission factors and the need for energy for heating. The categories are the following:

I. Detached houses

II. Non-adjacent, multi-storey buildings built with traditional technology

III. Multi-storey, terraced-like houses built with traditional technology

IV. Panel buildings built with industrialised technology

In each of the categories three sub-groups have been distinguished:

1. poor quality heat insulation
2. medium quality heat insulation
3. high quality heat insulation

The following combination of categories have been excluded from the study:

- I.3. satisfactory heat insulation
- I.1. neglected and decaying buildings to be demolished
- II.3. satisfactory heat insulation
- III.2. neglected buildings who's heterogeneity is not manageable,
- IV.1. there is no building of this kind

Category IV.3. has not been excluded from the study since its heat insulation, especially of doors and windows can be improved.

The following chart presents information on the number of the buildings divided into the above-mentioned categories and the heating energy consumption for the residential sphere:

Table IV-C

Category	Number of houses		Energy consumption of heating (TJ/yr)		
	in thsd	%	Total	District heating	Non-district heating
I.1.	1492.0	37.9	89170		89170
I.2.	350.0	8.9	25094		25094
II.2.	433.3	11.0	11775	30	11744
III.1.	157.3	4.0	6027	717	5310
IV.2	635.4	16.1	22356	18108	4249
IV.3.	158.9	4.0	4090	4090	0
Sub-total	3226.9	81.9	158512	22945	135567
Not studied	711.7	18.1	21013	405	20608
Total	3938.6	100.0	179524	23350	156174

The buildings of the communal sphere, in order to match the requirements of the models, have also been categorised. The following chart presents the above-mentioned data of the three most characteristic groups:

Table IV-D

Category	Number of houses		Energy consumption of heating (TJ/yr)		
	in thsd	%	Total	District heating	Non-district heating
III.1.	1411	80.0	40274	1182	39092
IV.2	198	11.2	6401	2943	3458
IV.3.	155	8.8	3918	3918	0
Total	1763	100.0	50594	8044	42550

The original heat transmission factors in the dimension of W/m^2K and divided into categories of buildings are as it follows:

Table IV-E

	I.1.	I.2.	II.2	III.1	IV.2	IV.3
Walls	1.4	1	1	1.2	0.8	0.8
Ceilings	0.643	0.5	0.7	0.643	0.6	0.6
Basements	0.236	0.236	0.236	0.23	0.23	0.23

After having applied heat insulation, heat transmission factors can be presented in each of the categories:

Walls 0.42 W/m^2K

Ceilings 0.3 W/m^2K

Basements 0.15 W/m^2K

The following chart shows the savings indicated in % and in natural measures:

Table IV-F

Category	Savings in % for the structural elements				Decrease of heating in residential sphere		Decrease of heating in communal sphere	
	Ceilings	Walls	Foundation	Total	Non-district heating	District heating	Non-district heating	District heating
	%	%	%	%	TJ/yr	TJ/yr	TJ/yr	TJ/yr
I.1	8.3	35.4	1.5	41.7	37205	0		
I.2	6.4	21.2	2.2	27.8	6977	0		
II.2	8.0	22.9	3.1	31.2	3668	9		
III.1	5.2	24.6	2.2	30.1	1600	216	11779	356
IV.2	3.2	15.9	1.6	19.9	844	3597	687	585
IV.3	3.2	21.5	2.2	25.6	0	1047	0	1003
Total.					50295	4870	12466	1944

The savings of certain heating energy sources could be defined by the figures of their nation-wide distribution. As a result of the energy saving measures, a nation-wide decrease of energy consumption can be anticipated, as can be seen in the following chart:

Table IV-G

Energy source	Residential sector	Communal sector
	TJ/yr	TJ/yr
Solid fuel	13204	1465
Domestic heating fuel	6248	813
Heating fuel	0	813
Natural gas	30032	9375
Electric power	812	0
District heating	4870	1944
Total	55164	14410

The cost of the investments for the taking of the described measures has been concluded from the following figures:

Attic floor heat insulation	1100	HUF/m2	I.1, I.2,II.2,III.1
Roof heat insulation	2000	HUF/m2	IV.1,IV.2
Wall insulation without scaffold	3000	HUF/m2	I.1, I.2,II.2,III.1
Wall insulation with scaffold	6000	HUF/m2	IV.1,IV.2
Basement ceiling insulation	2000	HUF/m2	all categories

Table IV-H Generated costs of category investments in HUF billions:

Category	Residential sector	Communal sector
I.1	528.8	
I.2	147.3	
II.2	105.4	
III.1	23.8	213.1
IV.2	98.9	30.8
IV.3	24.7	24.1
Total	**928.8**	**268.0**

The savings on energy costs have been regarded in the light of the prices of certain energy sources as well as on their share in the whole heating energy sector:

Residential sphere with non-district heating:	1042	HUF/GJ
Residential sphere with district heating:	744	HUF/GJ
Communal sphere with non-district heating:	816	HUF/GJ
Communal sphere with district heating:	744	HUF/GJ

The following chart presents the total savings in HUF billions and the simple payback time, i.e. years, of cost recovery:

Table IV-I

Category	Saving of energy costs HUF/billions/year		Simple payback time years	
	Residential sphere	Communal sphere	Residential sphere	Communal sphere
I.1	38.8	0.0	13.6	
I.2	7.3	0.0	20.3	
II.2	3.8	0.0	27.5	
III.1	1.8	9.9	13.0	21.6
IV.2	3.6	1.0	27.8	30.9
IV.3	0.8	0.7	31.7	32.3
Total	56.0	11.6	16.6	23.1

The life span of the investment is 30 years. The cost-saving operation or additional costs cannot be reported. Since in this study the goal was the maximisation of CO2 abatement, some of the measures have long payback times. However, since the measures are ranked by cost effectiveness, any payback time limit can be chosen for policy-making, and the rest of the measures can simply be ignored.

IV.4.2. (1.1.5) Changing windows in existing buildings

Field of application: heating

The applied method and the compound of the studied buildings are identical to the methods of the 1.1.1. measures, however the difference is that only one structural element has been studied, namely the windows. The heat transmission of the windows presently available is as follows:

Category I.1, III, IV.2: 5.5 W/m^2K

Category I.2,II.2: 4.5 W/m^2K

Category IV.3 : 2.8 W/m^2K

After the windows have been changed, the heat transmission factor, ‘k‘, of the new heat insulating windows is a constant of 1.5 W/m^2K.

The following chart shows the realisable savings in % and in natural measures after the application of the energy saving measures:

Table IV-J

Category	Savings in %	Decrease of heating in residential sphere		Decrease of heating in communal sphere	
		Non-district heating	District heating	Non-district heating	District heating
	%	TJ/year	TJ/year	TJ/year	TJ/year
I.1	13.0	11582	0		
I.2	18.7	4690	0		
II.2	25.9	3046	8		
III.1	31.4	1665	225	12257	371
IV.2	38.6	1638	6982	1333	1135
IV.3	16.9	0	693	0	664
Total		22621	7907	13591	2169

The savings of certain energy sources for heating are defined by the nation-wide division of heat energy sources. As a result of the measures taken, a decrease can be expected in the use of energy sources as seen in the following chart:

Table IV-K

Energy source	Residential sphere	Communal sphere
	TJ/year	TJ/year
Solid fuel	5939	1597
Domestic heating fuel	2810	886
Heating fuel	0	886
Natural gas	13507	10221
Electric power	365	0
District heating	7907	2169
Total	30528	15760

The investment costs of implementing the described measure have been specified from the chart below.

The cost of the heat insulated glass window is 25,000 HUF/m^2 .

The following chart shows the generated investment costs in HUF billions:

Table IV-L

Category	Residential sphere	Communal sphere
I.1	277.9	
I.2	130.8	
II.2	126.3	
III.1	32.9	295.4
IV.2	81.2	25.3
IV.3	20.3	19.8
Total	**669.4**	**340.5**

The energy savings have been calculated using the same energy prices as for measure 1.1.1.

The following chart has more total savings in billions of HUF and linear time of recovering the costs presented in years:

Table IV-M

Category	Saving of energy costs HUF/billions/year		Simple payback time year	
	Residential sphere	Communal sphere	Residential sphere	Communal sphere
I.1	12.1	0	23.0	
I.2	4.9	0	26.8	
II.2	3.2	0	39.7	
III.1	1.9	10.3	17.3	28.7
IV.2	6.9	1.9	11.8	13.1
IV.3	0.5	0.5	39.4	40.1
Total	29.4	12.7	22.7	26.8

The life span of the investment is 30 years. The cost-saving operation or additional costs cannot be reported.

IV.4.3. (1.3.2.) Low-flow faucets and shower-heads

Field of application: consumption of hot water

This study is looking at hot water savings after having applied certain plumbing devices. The anticipation is that by the application of these devices 30% of hot water can be saved. As a result of this, the same proportion of energy can also be saved. Firstly, a look must be taken at the amount of running hot water that is used in the residential and the communal spheres. According to the Waterworks of Budapest (Fõvárosi Vízmûvek), the consumption of running hot-water e.g. taking a shower, washing hands and bathing, makes up approximately 59% of the total consumption of hot water. Therefore, 30% of this proportion can be saved and this particular hot water consumption can be reduced to 16.6%.

For the communal sphere, on the basis of the data provided by the district heating service, heat consumption was divided into groups of production, one for heating and the other for direct utilisation of hot water. As a result of this, in this sphere hot water is mainly consumed for cleaning, i.e. washing, showering. Consequently, the presumed saving of 30% was calculated for this sector in the light of the entire hot water consumption.

The following chart illustrates the realisable savings of energy sources and the energy costs after the measures have been taken.

Table IV-N

Type of fuel	**Residential sphere**		**Communal sphere**	
	TJ/year	**Billion HUF/year**	**TJ/year**	**Billion HUF/year**
Solid fuel	0.0	0.0	0.0	0.0
Domestic heating fuel	0.0	0.0	0.1	0.2
Heating fuel	0.0	0.0	0.1	0.0
Natural gas + PB gas	5.0	3.8	1.2	0.8
Electric power	1.9	5.7	0.3	0.9
District heating	1.7	2.0	0.2	0.2
Total	8.6	11.5	1.8	2.1

The cost of investment is different for the residential and communal spheres. For the residential sector it is enough to take smaller measures such as installing devices that block the flow of water. The costs of these devices make up an average of 2,000 HUF for each tap. For every household, bearing in mind an average of 3 taps per household, the cost of the installation is 6,000 HUF. According to the statistics, there are 3938.6 thousand households in Hungary, out of which 78.9% have running water. Therefore the cost of the installation of such devices in the residential sphere is 18.6 billion HUF.

For the communal sphere the more expensive but at the same time, longer lasting devices have been taken into consideration. These devices can be controlled by the means of timers, photoelectric cells or by certain other ways. The costs of devices of this kind is an average of 10,000 HUF per piece. The number of taps in the communal sphere has been deduced from two pieces of information, from the number of households characterised by the ‘model buildings’ of the communal sphere and from the assumption that there is one tenth of the number of taps in the communal sphere compared to the residential sphere. Consequently, 529 thousand taps have been taken into consideration which means a 5.3 billion HUF worth of investment in the communal sphere is necessary. The life span of these measures is approximately 5 years and the cost of maintenance can be neglected.

IV.4.4. (2.1.2.) Replacement of luminaries and instalment of lighting controls in communal buildings

Field of application: lighting

Here we examine the replacement of armatures of old strip-lights otherwise so typical in communal institutions with more efficient mirror armatures.

The buildings of communal institutions have been characterised with the numbers of model buildings described in section 1.1.1. Ten armatures are assumed to be in a building. Thus the number of armatures goes as follows:

Category III.1	14108 in thousand
Category IV.2	1979 in thousand
Category IV.3	1548 in thousand
Total	17635 in thousand

It is further assumed that 80% of the armatures are to be replaced. Consequently, a total number of 14,108 thousand armatures need replacement.

The electrical power savings achieved by the better light efficiency of the new armature is approximately 33%. Communal institutions consume the electric power of about 12,100 TJ a year for lighting. The consumption is divided among bulbs and strip-lights. The energy consumption of bulbs can be estimated from the above-mentioned categorisation, i.e. considering 1,760 thousand 60 W bulbs with 1,500 hours of operation, in other words it is approximately 570 TJ a year. As a consequence of this, the energy saving of 3,040 TJ a year can be realised. By this installation 10.86 billion HUF can be saved.

The cost of installation is 10,000 HUF per armature, which means that a 141 billion HUF investment is required. The life span of the investment is 15 years. The cost of operation cannot be calculated.

IV.4.5. (2.4.1.) The replacement of shared ventilation systems by individual systems in multi-story buildings

Field of application: heating and electrical power consumption for different purposes.

The ventilation of bathrooms, toilets and kitchens in blocks of flats is provided by the means of roof fans and communal air channels 24 hours a day. Saving can be realised if the ventilation works only when it is really needed. This can be achieved by installing individual fans in the air channels.

According to the building categories described in section 1.1.1 and based on reference (7), there are 794.3 thousand panel buildings. Each roof fan provides air to an average of 11 flats. The performance of the engine of the roof fan is 370 kW. The 24 hour operation of the total number of roof fans means the electric power consumption of 843 TJ for a year. The constant ventilation provided by the fans increases the need for heating in the heating season. Considering an indoor and outdoor average heat difference of 18.5

degrees Celsius during the heating season and the 105 m^3 per hour necessary air refreshment, an excessive heating of 9664 TJ per year is needed.

If the daily needed operation of the fan is 5 hours, by installing two fans with the performance of 28 W each, the total electrical power need can be reduced to 292 TJ per year and the total need of heating can be reduced to 2,013 TJ per year.

Consequently, savings of 550 TJ a year concerning electric power and savings of 7,651 TJ a year concerning heating energy can be expected. The following chart shows the shares of different energy sources. However, in the case of block of flats only natural gas and certain energy sources used by district heating plants can be considered:

Table IV-O

Type of energy	Savings (TJ/year)	Cost savings (Billion/HUF/year)
Electric power	550	2.2
District heating	6795	5.1
Natural gas	1007	0.8
Total	8352	8.1

The cost of applying this measure is 23.8 billion HUF bearing in mind 15,000 HUF for a single appliance. The cost of maintenance cannot be calculated. The life span of the investment is 15 years.

IV.4.6. (1.2.20.) Programmable space heating control

End-users: residential sector, individual space heating systems

The programmable control systems are first of all advisable for individual space heating systems with up-to-date natural gas fired wall-mounted boilers or for small central heating systems, further referred to as 'modern' space heating systems. Firstly, based on the technical literature and secondly, the data of the buildings listed under section 1.1.1, the number and energy consumption of households with individual modern space heating systems are as follows:

Table IV-P

Building type	**Households with up-to-date space heating systems**	
	Number ['000 pieces]	Energy consumption TJ/year]
I.1	0	0
I.2	324	22211
II.2	319,1	8288
III.1	56,2	2018
IV.2	166,9	3358
IV.3	0	0
Total	866	**35876**

The savings from the programmable space heating controls is due to the reduced heating. Heating can be reduced during the nights, and within those longer periods of the day or week when nobody is at home. Although heating can be also manually reduced with the 'traditional' room thermostat, the inconvenience of cold room during the heating up must then be tolerated. Because of the discomfort, only few people use these methods. The programmable thermostat gives the opportunity to its user to set the start and the end of the reduced heating period according to a weekly schedule. Therefore the required room temperature will be reached at the set time (e.g. on arrival home, in the morning).

Under the Hungarian circumstances 1°C lower room temperature results in 6% energy savings. The room temperature during the reduced heating period can be practically 5° C less than otherwise. The saving's potential of the households with modern space heating systems were determined on the basis of the following assumptions:

1. In 50% of the households all the family members work or study. Therefore it is possible to reduce heating both during nights and weekdays. The estimated time for heating reduction is 12 hours per day. The yearly energy savings are 15%.
2. In the other 50% of the households somebody is at home during the day. Therefore the reduced heating is only acceptable during the nights. The yearly energy savings are 7.5%.

Consequently the average yearly space heating savings amount to 11.5%, which is equivalent to 4036 TJ natural gas savings per year, i.e. 3.1 x 10^9 HUF per year of energy cost savings.

The price of a programmable thermostat is around 15,000 HUF; thus the total investment cost is 13 x 10^9 HUF for 866,000 households. The lifetime of the intervention is 15 years and there are no foreseen maintenance costs.

IV.4.7. (1.2.22.) *Efficiency improvement of existing natural gas fired equipment (adjustment of the burners and maintenance)*

End-users: residential sector, individual heating

The involved consumers are the same as those in section 1.2.20, i.e. the number of households in question is 866,000, who's natural gas consumption used for space heating is 35,876 TJ per year.

Efficiency-related maintenance includes two basic areas:

1. The adjustment of the combustion-air / fuel mixture ratio of the burner: the high combustion-air content unnecessarily increases the amount of the flue gas. Low combustion-air content, on the other hand, causes incomplete consumption. Both cases cause a combustion efficiency decrease.
2. Regular cleaning of the boilers' heat transfer surfaces: fouled heat transfer surfaces reduce the rate of heat transfer between the flue gases and the water, which also leads to the reduction of efficiency.

The fuel savings achievable by regular maintenance are estimated to be about 5%. Therefore the total natural gas savings for the investigated group of households amounts to 1794 TJ/year, that is 1.4×10^9 HUF per year of fuel cost savings.

The estimated cost of regular maintenance is 5,000 HUF per unit. It is advisable to repeat the cleaning process every two years, so as to guarantee the efficient operation.

IV.4.8. (1.3.1.) *Individual metering of the domestic hot water consumption*

End-users: the residential sector, district heating generation and domestic hot water (DHW) .

This measure is only applicable for district heating generated DHW, because this is the only area where the lump sum price is still often used. District heated DHW in the commercial sector is generally invoiced on a metering basis, therefore our investigation deals with the residential sector only.

According to reference (4), the energy supplied to residential consumers by district heating systems is 10,475 TJ per year, which is divided among 595,136 households. Other data indicates that the share of those households who still pay lump-sum for their heating energy is 50%[12]. Thus the energy used for DHW generation by these 297,568 consumers is 5,238 TJ per year.

[12] Remarks: the source contains data from 1996. It is likely that since that time the number of households with energy metering are increased. The just passed District Heating Bill obliges the district heating companies to switch to invoicing based on metering within the next 4 years.

The district heating companies' measurements and experience shows that switching to metering-based tariffs results in drastic changes in consumer behaviour because

- the district heating prices are very high compared to other fuel prices,
- therefore DHW savings result in significant cost savings for the family budget.

According to the general experience, on the average, district heating savings are 50%, i.e. 2,619 TJ per year for the sector involved. The possible cost savings are 4 x 10^9 HUF per year. The estimated investment cost is 7,000 HUF per household, which represents a total 2.1 x 10^9 HUF investment costs for the whole country.

The meters need to be replaced every five years, therefore the lifetime of the project is five years. During that period there is no need for additional maintenance costs.

IV.4.9. (1.3.3.) Solar domestic hot water production systems (solar panels)

End-users:

- Residential sector: DHW production based on electric heaters
- Commercial sector: DHW consumption

Due to the high capital cost involved and the low price of natural gas as a possible fuel, this measure is viable in case of those households where electricity is used for DHW production. The users with the biggest potential are the family houses, for which complete solar panel systems are available. These include an electrical heater for supplementary DHW generation.

In the commercial sector the heat production is centralised, therefore using solar energy as a supplementary heat source could be much cheaper than in the residential sector. Therefore in this sector the investigation was not focused on only the electrical DHW generation.

The number of consumers was determined with the following assumptions:

The number of households with electric heaters according to MVM's (The Hungarian Electrical Company) Statistical Yearbook is 1,413,119 which is 36% of the total. Solar panels are possible for family houses and small apartment buildings with few flats in them. Based on reference (1) and the historical data of the buildings in section 1.1.1 such households are found in category I. and II. buildings. It is likely that only a part of old, obsolete family buildings (I.1 type buildings) are suitable for this technology while the big old apartment buildings are entirely unsuitable. Therefore only half of the I.1 category buildings were taken into account and II.1 category buildings were excluded. Buildings without South-facing roofs were also excluded, because this feature is necessary for the efficient operation of the solar panels. Our estimation shows that this is true for half of the family house group. In the light of the above, the number of buildings suitable for the implementation of this measure is calculated in the table below.

Table IV-Q Number of buildings suitable for solar panels [In thousand pieces]

Type of building	Total number of households	Of this considerable	Of this installed with electric boilers	Of which has South-facing roofs
I.1.	1865	932.5	335	167
I.2.	350	350	125	63
I.3.	150	150	54	27
I. Total	**2.365**	**1432.5**	**504**	**257**
II.1.	58	0	0	
II.2.	433	433	155	
II.3.	87	87	31	
II. Total	**578**	**520**	**186**	

FIORENTINI HUNGARY Kft., one of the prominent Hungarian solar panel supplier made a market survey of exclusively family houses. It was found that about 200,000 family houses are suitable for mounting solar panels.

In the residential sector the electricity used for DHW production is 11,643 TJ per year, of which 3,655 TJ per year is the electric energy consumption of those households which are suitable for solar panel mounting.

In the commercial sector, the DHW production uses 5,581 TJ electricity per year (see section 1.3.2.) It is worthwhile to use solar panels on those commercial buildings who's DHW consumption is high, such as hospitals, dormitories, hotels, etc. The estimated energy consumption of the DHW production is around 10% of total usage, that is 558 TJ per year.

FIORENTINI HUNGARY's experience shows that with the installation of a solar panel 60% of the energy used for DHW production can be saved.

Based on the above the energy and cost saving data of this measure are summarised in the following table.

Table IV-R

Fuel	Residential		Commercial	
	TJ/year	10^9 HUF/year	TJ/year	10^9 HUF/year
Coal	0	0.0	0	0.0
Light fuel oil	0	0.0	19	0.06
Heavy fuel oil	0	0.0	22	0.01
Natural gas + LPG	0	0.0	234	0.16
Electricity	2193	6,5	35	0.10
District heating	0	0.0	25	0.03
Total	2193	6,5	335	0.36

The investment cost of the implementation of the measure in the case of family houses is 350,000 HUF per unit, and in the case of multi-flat buildings is 250,000 HUF per flat. Therefore the investment needed of the residential sector is 136.6 x 10^9 HUF, and 44.1 x 10^9 HUF in the commercial sector.

The lifetime of the investment is 15 years. The additional maintenance cost is 1.5 x 10^9 HUF in the residential sector and 0.5 x 10^9 HUF in the commercial sector.

IV.4.10. (2.1.1.) More compact fluorescent lamps

End-use: lighting.

The only difference between CFLs and standard linear fluorescent lamps is that the CFLs incorporate all the components (lamp and ballast combined or separate) and have a screw fit (threaded) base. Therefore a CFL can easily replace incandescent lamps. This shows that it makes no sense to replace existing standard linear fluorescent lamps with CFLs. Energy can only be saved by replacing incandescent lamps.

Most homes in the residential sector are lit by incandescent lamps. The estimated average number of incandescent lamps in a household is 10. Because CFLs are expensive and because frequent switching on and off sharply decreases their lifetime, only those incandescent lamps are worthwhile to replace which are often used for long periods. This is true for half of the incandescent lamps in any given household. Therefore, 5 lamps per household, means a replacement of 19.7 x 10^6 lamps in the whole country. The estimated electricity consumption for residential lighting is around 4,000 TJ per year. Living rooms and kitchens are among those rooms which are used steadily. These comprise 70% of the total lighting energy consumption. So, the total energy consumption of the replaceable incandescent lamps in the residential sector is around 2800 TJ per year.

In the commercial sector the linear fluorescent lamps are the most wide-spread lights. Incandescent lamps are used in rooms of little importance (WC, closets, etc.). The lighting energy consumption of the commercial sector is around 12,100 TJ per year, of which incandescent lamps take around 570 TJ/year. If on average 60 W lamps are installed and working for 1,500 working hours, then the number of replaceable incandescent lamps in the communal sector can be estimated at 1.763 million.

The luminous efficacy of CFLs is about five times higher than the incandescent lamps, so the electricity savings are approximately 80%.

The following table contains electricity and cost savings of the replacement of incandescent lamps with CFLs.

Table IV-S

	Residential		Commercial	
	TJ/year	**10^9 HUF/year**	**TJ/year**	**10^9 HUF/year**
Electricity	2240	6.6	456	1.3

The average investment cost in the residential sector is 2,500 HUF and 3,000 HUF per piece in the commercial sector. In the latter case, the commercial sector, a theft-proof socket is necessary, which makes the whole investment more expensive. The total investment cost in the residential sector are 49.2 x 10^9 HUF and in the commercial sector are 5.3 x 10^9 HUF.

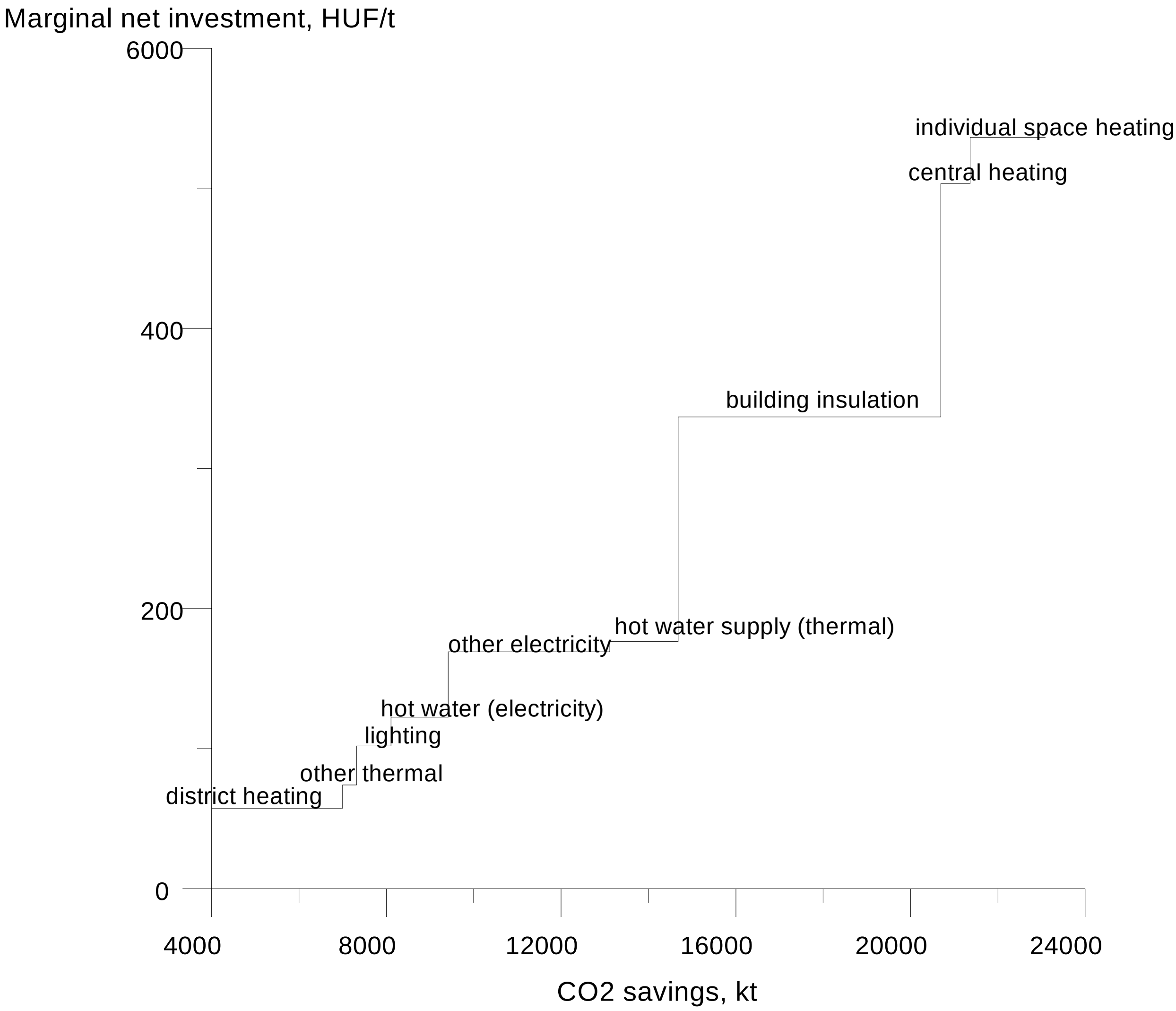
The lifetime of a CFL is around 8,000 hours, which means that assuming an annual average of 1,500-1,600 hours of operation, the total lifetime of a CFL is five years. There are no maintenance costs incurred during this period.

IV.4.11. Summary of Marginal Cost Curves

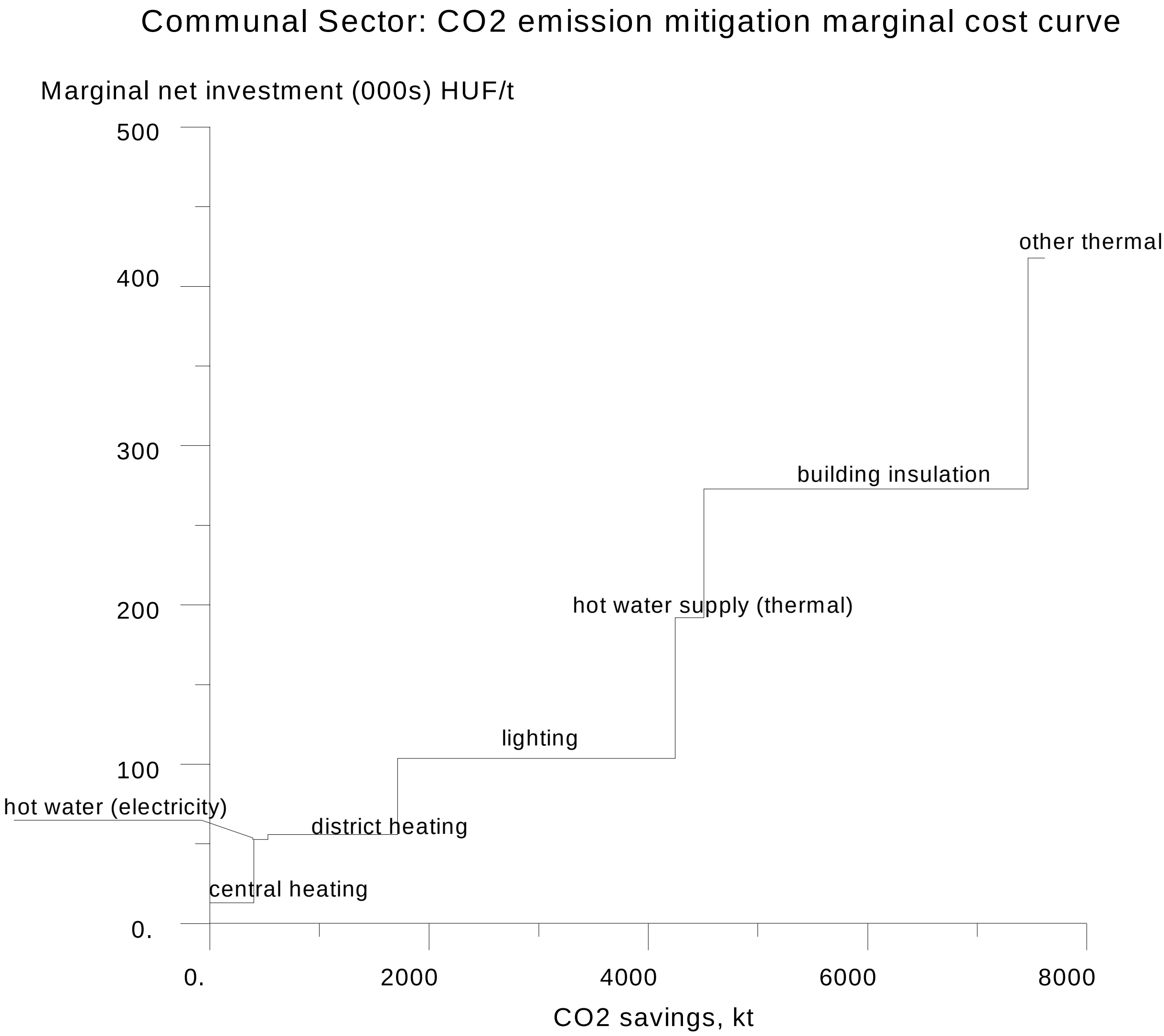
In summary we will discuss the CO_2 emission mitigation cost curves (See graphs below). In the following graphs we can see the marginal net investment of each measure examined and the CO_2 savings. The space that each measure takes up on the x-axis is the amount of CO_2 savings it accomplishes. As we run along the x-axis from left to right we can see the total CO_2 savings.

Investment in building insulation and district heating would generate the highest CO_2 savings in the residential sector. In the graph below we can also see that district heating in fact requires the lowest marginal net investments clearly making it a very cost-efficient measure. For a total marginal net investment of 393,869 HUF/t, investments in both measures would result in CO_2 savings of 13,002.88 kt. Other mitigation strategies that play major roles in emission reduction in this specific sector are investments in electricity and hot water supply. The maximum CO_2 savings possible in the residential sector could be as high as 23,087.31 kt. Marginal net investment, however, is as high as 225,000 HUF/t.

Residential Sector: CO2 emission mitigation marginal cost curve



While the overall potential emission reductions are lower in the communal sector (maximum CO_2 savings equal to 7,618.96 kt) the marginal net investments are not much lower than in the residential sector (179,000 HUF/t). In the communal sector investments in building insulation and lighting have the greatest potential for emission savings (5,489.56 CO_2 savings, kt). The marginal net investment of these, however, is 375,207 HUF/t. When we compare this to the highest CO_2 savings in the residential sector, it becomes clear that marginal met investments there result in more CO_2 savings then in the communal sector. Similarly to the residential sector, district heating investments in the communal sector are relatively more cost-efficient than other measures.



Therefore the reduction measures that we looked at for the residential sector are more cost efficient than the investment in the CO_2 reduction measures of the communal sector. For comparable marginal net investments, a great deal more of CO_2 savings can be accomplished in the residential sector.

IV.5. Carbon mitigation potentials in the forestry sector

IV.5.1. Introduction to carbon sequestration by forestry activities

The role of forests and forest soils as carbon sinks have been already investigated by several authors (*Dixon, 1994; Kolchugina and Vinson, 1993 and others*). The potential change in yield and distribution of the Earth's crops under a warmed climate were also investigated (*Mátyás, 1996; Leemans and Solomon, 1993 and others*). After the oceans, the forest ecosystems are the most important natural carbon sinks. Global forests and forest soils contain and conserve a large amount of carbon, comparable to the annual human carbon emission. A forest ecosystem is not a static carbon storage. Stored quantity of carbon in a forest ecosystem is a result of a dynamic balance mainly between the photosynthetic and respiration activities, modified by several ecological aspects as well as human management and disturbances. It is well known that removed and extinct virgin forests (*mainly in South American, African and Asian tropical regions, as well as in Canada and Russia*) are a major source of carbon content presently in the atmosphere. Additionally, natural forest fires, *as well as wood energy combustion,* are also sources of CO_2. Fortunately, the carbon sequestration capacity of managed forests and forest plantations is higher than that of virgin forests.

The dynamic processes in forest growth and productivity and their relations to the global carbon cycle should be regarded as a bases for modelling the potentials of the forestry sector in greenhouse gas mitigation. The method of greenhouse gas mitigation assessment was developed and a guidebook was published by the Lawrence Berkeley National Laboratory. The guidebook included a chapter on mitigation assessment for the forestry sector. Forestry mitigation options refer to measures and policies that can lead to a greenhouse gas emission reductions from the forestry sector and/or increases of the forest's carbon sequestration capacity (*Sathaye, J. and Meyers, S., 1995*).

Not only the carbon fixation of the forest is worth consideration as a potential carbon sink. So is wood biomass as well as wood-for-energy plantations. Carbon neutral energy resources also could play a significant role in carbon mitigation options. Several authors investigated the biomass production and potential use of short rotation coppice plantations (Zsuffa et al., 1979; Aravanapoulos and Zsuffa, 1993; Kenney, Gambles and Zsuffa, 1993; Weisgeber, 1993; Szendrõdi, 1993; Christenson, Sennerby-Forsse and Zsuffa, 1993; Szendrõdi, 1995; ETSU, 1996 etc.) as well as wood fuel combustion and technical concerns of using wood as a fuel (Jonas and Görtler, 1988; Kovács and Marosvölgyi, 1990; Burch, 1993; NREL, 1993a; NREL, 1993b; Foster, 1993)

Thus, sequestered carbon by forests is beneficial in combating global warming. However first we must distinguish among three types of wood carbon sinks. The best carbon sink is the living wood and forest biomass, which fixes the accounted measure of carbon continuously for long periods of time. It is a real carbon sequestration, because it removes the carbon from the atmosphere and conserves it. However, the carbon content of fuelwood and wood-for-energy plantations will be put back into the atmosphere in 1 to 6 years after harvesting. These would reduce only the exponential carbon increase caused by fossils without removing and fixing the aerial carbon for a long time. Raw material and wood constructions would fix the carbon for a 3 to 500 year period depending on the life cycle of the products.

Raw materials and wood products conserve carbon temporarily. Their contribution to combating global warming by delaying the carbon increase in the atmosphere must also be emphasised. We are allowed to count them as carbon neutral energy or as material resources even if sometimes their life cycle is short. This is because trees remove the same amounts of carbon from air by photosynthetic activities that they will emit by being burned or by the decomposing processes. This point is very important because the continuous carbon increase in the atmosphere is more of a dangerous problem than the present carbon content.

IV.5.2. Methodology and Assumptions

For an introduction into our methodology and our assumptions made in the forest modelling, please refer to the methodology description of the Baseline Scenario. The simulations for the mitigation options were done with two different specie compositions and the average cutting ages for the target state. The "*yield-maximising*" scenario supports the fast growing tree species and intensive technologies, while the "*close-to-nature*" scenario is based on slow growing native tree species and extensive technologies. The specie composition is not very different between the two scenarios. The main difference is the higher average cutting ages in the "*close-to-nature*" management scenario. The main goal in the "*Yield maximising*" scenario is to gain the possible largest wood production in the future supported by fast growing tree species and plantations. The "*Close-to-nature*" scenario, based on nature conservation consideration, supports slow growing ancient species instead of bred clones and invasive exotic species. In both scenarios it was assumed that there are 800 thousand ha of former agricultural land for afforestation. It was also assumed that this area is going to be afforested up till the year 2030. This afforestation would be the main driving factor in the sequestering of carbon.

There are no absolutely free-choice decisions for policy makers as it is really the site conditions that limit possible species. Thus the expected structure of future forests is mainly determined by site characteristics.

The output data of the simulation provides information in the form of species/age class tables for every ten year period on the following characteristics:

- forested area
- growing stock
- area of final cuttings
- volume of final cuttings
- volume of thinnings
- volume of yield
- average volume/ha

IV.5.3. Carbon mitigation potentials by mitigation scenarios

The results of the simulation show that the growing stock of the "*close-to-nature*" scenario is higher by 20 million m^3 after 50 years, which can be associated with a higher carbon storage capacity, and the amount of the possible harvest being higher by 8 million m^3 for a 10 year period.

In the "*yield maximising*" scenario the timber volume increases from 292.8 million to 438.5 million m^3. The average per hectare volumes have the most significant change in the case of conifers, from 164 to 235 m^3/ha. The annual harvesting nearly doubles, from 8.8 million m^3 to 15.0 million m^3.

According to the carbon balance calculations the sequestrated additional carbon fixed in the increasing living biomass is around 43 million tons.

In the "*close-to-nature*" scenario the timber volumes are considerably higher with a somewhat lower level of annual harvest. Higher rotation ages make a higher level of accumulation possible. The additional carbon sequestration fixed in the increasing living biomass is around 52 million tons of carbon.

The growing wood stock would increase up to 439 million m^3 by the year 2050 from the present 293 million m^3 by the "*Yield maximising*" scenario (Table IV-T). In addition, the annual allowable harvest (*AAC*) would increase to 15 million m^3 up by the year 2050 from the present 8.8 million m^3, which includes also a large amount of carbon. The industrially used timber and wastes will contain approximately 90.6 million tons of carbon, while the carbon content of the wood fuel will be 147.8 million tons. The "*Yield maximising*" scenario would fix 25.580 million tons of carbon in above ground living woody biomass by the year 2030, which will accumulate to 43.512 million tons of carbon by the year 2050. This weighty increase appears because of completion of the 800 thousand ha afforestation program by the year 2030. To accomplish this huge afforestation program it is necessary to plant new forests on 152 thousand ha in the 1st decade as well as 304 thousand ha in the 2nd, 200 thousand ha in the 3rd and 144 thousand ha in the 4th decades. The annual rates of afforestation are the same in the "*Close-to-nature*" scenario but the preferred tree species are different.

Table IV-T "Yield maximising" scenario for GHG mitigation options of Hungarian forestry

Yield maximising scenario	**1991**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Forest land (1000 ha)	1 634	1 786	2 090	2 290	2 434	2 434	2 434
Growing stock (aboveground volume, 1000 m3)	292 841	309 711	331 114	353 286	383 470	420 468	438 515
Forest carbon pool (100 t)	105 310	109 811	115 451	121 497	130 891	142 536	148 822
Vegetation carbon (1000 t)	87 759	91 510	96 209	101 247	109 075	118 780	124 018
Below ground biomass (1000 t)	17 552	18 302	19 242	20 249	21 815	23 756	24 804
Carbon accumulation in living biomass (1000 t)	**0**	**4 501**	**10 141**	**16 187**	**25 580**	**37 226**	**43 512**
Annual area of harvest (1000 ha)	23	27,9	35,2	39	40,1	42,3	42,5
Annual allowable harvest, AAC (1000 m3)	8 815	9 843	11 961	12 777	12 816	14 420	14 996
Total harvested carbon (1000 t)	25 747	54 097	87 641	122 797	158 200	197 545	238 396
Carbon content of raw material (1000 t)	**9 784**	**20 557**	**33 304**	**46 663**	**60 116**	**75 067**	**90 590**
Carbon content of fuelwood (1000 t)	**15 963**	**33 540**	**54 337**	**76 134**	**98 084**	**122 4780**	**147 805**
Annual costs of forestation (1000 USD)	55 818	84 977	80 591	77 947	57 761	60 427	60 568
Annual costs of harvesting (1000 USD)	86 058	95 283	113 952	120 417	121 029	135 380	140 696
Annual incomes of harvesting (1000 USD)	146 686	162 574	194 678	205 355	206 730	229 507	238 156
Annual profits (1000 USD)	4 809	-17 685	135	6 991	27 939	33 700	36 892
Net Present Value (1000 USD)	**4 149**	**-7 203**	**-7 138**	**-4 654**	**2 734**	**9 365**	**14 767**

The growing stock would increase up to 456 million m^3 by the year 2050 from the present 293 million m3 in the "*Close-to-nature*" scenario (Table IV-U). This huge increase of living biomass will remove 51.5 million tons of carbon from the atmosphere and will continually fix those for a long time.

Additionally, the annual allowable harvest (*AAC*) would increase up to 14.1 million m^3 by the year 2050 from the present 7.9 million m^3. The raw material and industrial wastes will contain 85.3 million tons of carbon all together up till 2050. The carbon content of fuelwood will take 139.1 million tons by the year 2050.

While the main goal of its forest policy is to prefer slow growing ancient tree species instead of bred clones, the "*Close-to-nature*" scenario would result in the highest carbon fixation in living biomass. Practically this does not mean the highest sequestration capacity of the forestry sector for the investigated five decades, because the annual allowable cut (*AAC*) is less than that in the "*Yield maximising*" scenario. The difference of total sequestered carbon between these two scenarios is 5.9 million tons on the side of the "*Yield maximising*" scenario.

We have not yet had a well developed model for the estimation of the real carbon sequestration and conservation capacity of wood products and fuel wood. We suspect that the rational use of higher amounts of wood as raw material and energy resource would increase the total carbon sequestration capacity of the forestry sector. However, we have no data about decomposition (*and carbon emission*) of formerly cut and processed wood. Therefore, our investigation contains some uncertainties. There is a newly launched joint research project entitled: COST Action E9 *"Life cycle assessment for forestry and forest products*" in the frame of European Co-operation in the Field of Science and Technical Research (*DGXII, Brussels*). New research on this issue will result in better approaches to estimating the carbon sequestration and carbon conservation of the forestry sector and the wood industry.

Table IV-U “Close-to-Nature” scenario for GHG mitigation options of Hungarian forestry

Close-to-Nature scenario	**1991**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Forest land (1000 ha)	1 634	1 786	2 090	2 290	2 434	2 434	2 434
Growing stock (aboveground volume, 1000 m3)	292 841	319 580	346 339	372 373	404 201	439 479	456 200
Forest carbon pool (1000 t)	105 310	113 767	121 994	129 714	139 704	150 889	156 835
Vegetation carbon (1000 t)	87 759	94 805	101 662	108 095	116 420	125 741	130 696
Below ground biomass (1000 t)	17 552	18 961	20 332	21 619	23 284	25 148	26 139
Carbon accumulation in living biomass (1000 t)	**0**	**8 456**	**16 684**	**24 404**	**34 394**	**45 579**	**51 525**
Annual area of harvest (1000 ha)	18,9	24,3	31,4	34,4	35,6	38,3	38,3
Annual allowable harvest, AAC (1000 m3)	7 882	9 114	11 087	12 043	12 100	13 679	14 144
Total harvested carbon (1000 t)	22 675	48 668	79 960	113 668	147 531	185 373	224 469
Carbon content of raw material (1000 t)	**8 617**	**18 494**	**30 385**	**43 194**	**56 062**	**70 442**	**85 298**
Carbon content of fuelwood (1000 t)	**14 059**	**30 174**	**49 575**	**70 474**	**91 469**	**114 931**	**139 171**
Annual costs of forestation (1000 USD)	51 138	81 368	77 103	73 423	52 669	56 650	56 790
Annual costs of harvesting (1000 USD)	76 242	87 705	106 060	114 735	115 223	129 469	133 823
Annual incomes of harvesting (1000 USD)	130 121	149 718	180 824	194 736	196 007	219 388	226 608
Annual profits (1000 USD)	2 741	-19 355	-2 340	6 577	28 115	33 269	35 995
Net Present Value (1000 USD)	2 364	-10 059	-11 177	-8 839	-1 404	5 142	10 412

The final results of the financial investigation of the baseline scenario and two mitigation options are not surprising for foresters. It is well known that *close-to-nature* technologies of forestry require more investments and result in less profits. The only surprise is that carbon fixation in living biomass by the “*Close-to-nature*” scenario is higher by about 1 million tons over the fixation of “*Yield maximising*” scenario. Modelling effects the life cycle assessments of wood products and therefore the carbon sequestration capacity of the forestry sector may change in this situation, because of larger harvested (*and used*) amounts of timber in the “*Yield maximising*” scenario.

IV.5.4. Carbon mitigation options by short rotation forestry practices

IV.5.4.1. Wood-for-energy plantations

Because of the existing forest biofuel capacity, there is a chance to establish new and very short rotation forest plantations specifically for woodchip production. However, more than one million hectares of surplus arable land are reported. This is because the food market in the European Community is overcrowded, and all the member countries are trying to reduce their agricultural production. In the near future, as Hungary continues on the road to EU accession there will be a new agricultural support policy conforming to EU practices. We think, that all kind of bioenergy resource development should be encouraged and subsidised in Hungary because of their environmental benefits, rural job opportunities and other social advantages as well as the dwindling fossil energy resources.

Methods for estimating biomass production of plantations require site parameters as input data. We have a long term climatic database but, unfortunately, there is no relevant database for soils available for establishing new wood-for-energy plantations. Therefore, we cannot make an exact prognosis to estimate the potential energy from this resource. From regional agricultural authorities, we received some information and data about estimated surplus land in the region. We think that most of the surplus arable land would be appropriate for energy plantations, but not all. All the necessary information about establishment, cultivation and harvesting processes of short rotation coppice is available for farmers both in Hungarian and in English. However, fragmented little groups of farmers cannot organise this activity. The woodfuel market needs some management activities from the user (consumer) side as well as theoretical support from the Forestry Experts.

Climate, soil and hydrological conditions are suitable for several kinds of tree species everywhere in the Northern part of Transdanubian region, but their productivity depends on site conditions. We suppose that the usually poor quality soil will be available for forest plantations, but sometimes mid or high quality soil will also appear. We estimated the potential wood biomass energy resource by using poor, medium and good site categories. We supposed that the annual oven-dry above-ground wood biomass that can be produced in wood-for-energy plantations amounted to 8 t/ha on poor soil, 14 t/ha on medium quality soil and 20 t/ha on good soil. These quantities would be easily produced with several kinds of fast growing tree species such as Hybrid Poplar, Hybrid Willow, Black Locust etc. based on the Hungarian site conditions and without any treatments. Irrigation and/or fertilisation can improve site productivity in some regions, but we did not take them into account because of certain environmental and economical considerations.

IV.5.4.2. Carbon sequestration capacity of short rotation forestry

Available surplus land is supposed to be used as wood-for-energy plantations on a total of 300 thousand ha of former arable land. The annual rate of afforestation is 15 thousand ha, and the starting point of the model estimation is the year 1990. That way the program would have been completed by the year 2010. Hybrid Poplar is supposed to be used in the program as it is the only fast growing species and as there is no information available about the site conditions of the available land.

Experts suppose that the usually poor land is available for producing energy crops, and agricultural practices would be continued on fertile soils. But according to our proposals, some mid level and a few highly productive soils will also be available for the program because of the regional differences and continuous structural changes in the Hungarian society. By estimation, the productivity will be low (8 oven dry tons per year) on about half of the available land. About 35% of the land will be of average fertility (14 oven tons a year) and 15% will be fertile (20 oven dry tons a year). The model estimation is based on the low cost technology described earlier. Five times of four year rotations are calculated. The total rotation age is 20 years per plantation. Multipliers 1.50 for the 2nd and 1.25 for the 3rd rotation are used for yield estimation because of the coppice vigour. The multiplier for the last rotation is 0.80 because of the decreasing productivity and expected decays. Table IV-V shows the final results.

Table IV-V Annual carbon sequestration capacity and cost relations of short rotation energy plantations in Hungary

Wood-for-Energy plantations	**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Plantations' total area (1000 ha)	0	150	300	300	300	300	300
Annual living biomass (1000 oven dry t)	0	5132	9907	9907	9907	9907	9907
Fixed carbon in living biomass (1000 ton)	0	2215	4854	4854	4854	4854	4854
Annual harvest (1000 oven dry ton)	0	2454	3963	3963	3963	3963	3963
Heating value of annual harvest * (GJ)	0	42793	69107	69107	69107	69107	69107
Annually harvested carbon (1000 t)	0	1093	1942	1942	1942	1942	1942
Total harvest (1000 oven dry ton)	0	10487	43109	82739	122369	161999	201629
Total heating value * (GJ)	0	18258	751735	1442803	2133871	2824939	3516007
Carbon sequestration by harvest (1000 t)	0	5138	21123	40543	59963	79383	98803
Total carbon sequestration (1000 t)	0	7653	25977	45397	64817	84237	103657
Forestation costs (1000 USD)	3786	29229	47335	47335	47335	47335	47335

* Heating value of Hybrid Poplar 17.438 GJ/oven dry ton (*Kovács and Marosvölgyi, 1990*)

The model expresses that a 300 thousand ha wood-for-energy plantation program would produce continuously about 9.9 million oven dry tons of total living biomass at the end of the growing seasons. This large amount of wood would contain about 4.8 million tons of carbon. Although this is a considerable measure, not only the amount of carbon fixed in the living biomass is beneficial in this program. Annually available harvest wood take nearly 4 million oven dry tons of woodchip in the dormant seasons, which contain 1.942 million tons of carbon. The heating value of the annual harvest is estimated to be more than 69 thousand GJ. Using this nature friendly, renewable energy resource about 201.6 million oven dry tons of woodchip would be available as wood fuel in the frame of the program by the year 2050. The total accumulated heating value is estimated to be more than 3.51 million GJ, and 98.8 million tons of fossil carbon would be replaced with biomass carbon. Although the biomass carbon is put back to the air annually, because of the internal carbon cycle, it really results in a valuable reduction of atmospheric carbon uptake caused by fossil energy resources.

The carbon content of living biomass and the accumulated carbon content of woodchip would sequestrate more than 100 million tons of carbon by the year 2050. The costs of this program are reasonable, and some additional benefits, such as rural development as well as the strengthening of social relations, are also worth considering.

IV.6. Summary of GHG mitigation potentials

Different modification in technologies and in devices and appliances have been taken into consideration when investigating the mitigation in GHG emissions of the residential and service sectors. The mitigation options elaborated have been used as constraints in our model investigation mentioned ahead briefly.

The direct and indirect effects of both the mitigation options in the GHG emissions of the residential and the service sectors have been determined. The indirect mitigation in the GHG emissions have been induced by the decrease in the electricity and district heat demand of these sectors. When investigating the effects mentioned, the energy demand of the other sectors remained the same as in the base line scenario.

When calculating the mitigation in the direct and indirect emissions, it was assumed that the main chemical- physical characteristic data of the fossil fuels consumed are the same as in the base line scenario. After the year 2005 it was assumed that significant improvements will occur in the efficiencies of the newly invested fossil-fuelled power plants (over 40%), mainly because of their operation in the supercritical region of the steam-parameters. In spite of this, the introduction of control technologies for carbon-dioxide will be necessary to reduce the carbon-dioxide emissions of the fossil fuel-based power plants according to the international and regional expectations. But such cheap and advanced technologies don’t exist on a commercial scale at present and probably will not in the near future.

The energy conservation possibilities in the residential and service (communal) sectors known at present will be utilised till the end of the first decade of the next century, afterwards they will be exhausted, thus the mitigation scenario is effective in the mid-term period of the time interval investigated only. According to the model investigation in the long-term period either new energy sources and mainly renewable and non-carbon based energy system or drastic modification in the final energy consumption of the residential and communal consumers are needed to fulfil the requirements of the Kyoto protocol. Also it is to be investigated in the future, how the penetration of the clean fuels and control technologies which are based not only on the traditional fossil-fuels should be promoted and realised.

The result of the model calculations are presented in the case of the GHG emission of the residential sector, and the communal consumers in Section IV-3 and IV-4.

Summarising the results of the model calculation one may see that the effects of the non-CO_2 GHGs may be neglected compared with the carbon-dioxide emissions. In the case of the carbon-dioxide the reductions induced by the direct and indirect emissions are in the same range, thus it is very important to deal not only with the reducing of the primary energy sources of the final consumers, but with their secondary energy consumption at the same time.

The effect of the mitigation options is about 10% reduction in the carbon-dioxide emissions in medium-term. Their possibilities are exhausted in this time-period, and there is no other reduction possibilities in the long-term induced by them. In the long-term, new reduction options are to be elaborated. It is to be dealt not only with the reduction of their final primary energy demand, but it is necessary to reduce their final secondary energy demand too, and there is a need, in the long term, to investigate the possibility to introduce a new, non carbon-based electrical energy system. If this is not realised, it seems at least from our present perspective, then to fulfil the Kyoto protocol may not be possible.

As a summary of the results of the carbon mitigation scenarios in the forestry sector, the amount of carbon that could be sequestered in an intensive afforestation program and fixed in living biomass by the year 2050 is in the order of magnitude of 40 to 50 million tons. The Hungarian Forestry Sector has a large carbon sequestration capacity based on 1 634 000 ha existing forest stand in 1991. The carbon sequestration capacity of the Forestry Sector would be easily improved by 800 000 ha afforestation program and/or 300 000 ha of a short rotation forestry program by establishing new forests and wood-for-energy plantations. Table IV–23 below shows the final results of four scenarios by two different afforestation policies.

Existing and future forests would necessarily be managed by sustainable methods of silvicultural practices in all scenarios. No afforestation activities would be proposed by the baseline scenario. Forest stand would be renewed soon after cutting. Forest management and stand improvement would result in an increase of 927 thousand tons of carbon accumulated in living biomass. The total fuelwood harvested till 2050 would contain a cumulated sum of 115 353 000 tons of carbon. The industrially used part of the round wood would contain total 70 700 000 tons of carbon until 2050 by the baseline scenario. Total carbon sequestration would take 186 980 000 tons till 2050.

The “*Yield maximising*” scenario supports fast growing trees and plantations on 800 000 ha newly established forest stand. The carbon content of living biomass would increase by 43 512 000 tons till 2050 to the basic year of 1991. The carbon content of raw material would take 90 590 000 tons of carbon, while harvested fuelwood would contain a total of 147 805 000 tons of carbon by the year 2050. The total carbon sequestration by the “*Yield maximising*” scenario would take 281 908 000 tons till 2050.

The “*Close-to-nature*” scenario prefers slow growing native tree species (*e.g. Oaks, etc*.) to clones (*e.g. Hybrid Poplar*) or fast growing improved species (*e.g. Black Locust*) in the frame of 800 000 ha afforestation program. Carbon increase would take 51 525 000 tons by the year 2050 fixed in living woody biomass of forests. Harvested raw material would contain 85 298 000 tons of carbon, and fuelwood would contain 139 171 000 tons of carbon by the year 2050. The carbon sequestration capacity of the Hungarian Forestry Sector would take a total of 275 994 000 tons by this scenario. The short rotation forestry plantations would fix 4 854 000 tons of carbon continuously in living biomass in the frame of 300 000 ha wood-for-energy program. The carbon content of woodfuel produced in SRF plantations would take 98 803 000 tons till 2050.

A summary of the carbon sequestration capacity of the Hungarian forestry sector broken down by the scenarios discussed in this document is included in the table below. By comparing the amount of carbon that could be sequestered in an intensive afforestation program and fixed in living biomass by the year 2050 to the annual carbon emission of Hungary, one can conclude that carbon fixation in the living biomass of the forestry sector can offset about 4.0-4.7% of the total carbon emission of the country (*this complies with Somogyi's (1996) estimations*).

Table IV-W Carbon sequestration capacity of the Hungarian Forestry Sector

Cumulated carbon sequestration capacity of the forestry sector by different scenarios							
	1991	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
1. Baseline scenario							
Forest land (1000 ha)	1 634	1 634	1 634	1 634	1 634	1 634	1 634
Growing stock (aboveground, 1000 m3)	292 841	293 036	293 326	293 521	293 716	294 006	294 201
Carbon increase in living biomass (1000 t)	**0**	**131**	**333**	**464**	**595**	**796**	**927**
Carbon content of raw material (1000 t)	**9 801**	**20 003**	**30 781**	**41 226**	**50 967**	**60 844**	**70 700**
Carbon content of fuel wood (1000 t)	**15 990**	**32 637**	**50 221**	**67 264**	**83 156**	**99 271**	**115 353**
2. Yield maximising scenario							
Forest land (1000 ha)	1 634	1 786	2 090	2 290	2 434	2 434	2 434
Growing stock (aboveground, 1000 m^3)	292 841	309 711	331 114	353 286	383 470	420 468	438 515
Carbon increase in living biomass (1000 t)	**0**	**4 501**	**10 141**	**16 187**	**25 580**	**37 226**	**43 512**
Carbon content of raw material (1000 t)	**9 784**	**20 557**	**33 304**	**46 663**	**60 116**	**75 067**	**90 590**
Carbon content of fuelwood (1000 t)	**15 963**	**33 540**	**54 337**	**76 134**	**98 084**	**122 478**	**147 805**
3. Close-to-nature scenario							
Forest land (1000 ha)	1 634	1 786	2 090	2 290	2 434	2 434	2 434
Growing stock (aboveground, 1000 m^3)	292 841	319 580	346 339	372 373	404 201	439 479	456 200
Carbon increase in living biomass (1000t)	**0**	**8 456**	**16 684**	**24 404**	**34 394**	**45 579**	**51 525**
Carbon content of raw material (1000 t)	**8 617**	**18 494**	**30 385**	**43 194**	**56 062**	**70 442**	**85 298**
Carbon content of fuelwood (1000 t)	**14 059**	**30 174**	**49 575**	**70 474**	**91 469**	**114 931**	**139 171**
4. Wood-for-Energy plantations							
Total area of energy plantations (1000 ha)	0	150	300	300	300	300	300
Annual living biomass (1000 oven dry t)	0	5132	9907	9907	9907	9907	9907
Fixed carbon in living biomass (1000 ton)	**0**	**2215**	**4854**	**4854**	**4854**	**4854**	**4854**
Carbon sequestration by harvest (1000 t)	**0**	**5138**	**21123**	**40543**	**59963**	**79383**	**98803**

IV.7. Marginal cost curves of GHG mitigation options in Hungary

IV.7.1. Methodology of cost curves

The first step during the study has been the selection of projects to be included in the analyses. This was based on the GHG reduction potential of different mitigation options. In order to achieve a significant reduction in GHG emissions at the national level we have picked projects with the largest GHG reduction potential. A general overview of the economic implications of alternative emission reduction targets is also needed. For this reason we included a couple of projects with smaller GHG reduction potentials but with significant low or high costs of saving potentials (e.g. replacement of bulbs results in a significant negative marginal cost). All the options taken concern demand side management problems.

We consider the supply of different services or goods constant. The costs of providing the services are estimated. Most of the projects can be regarded as marginal without significant impact on the factor market. The only exemption from this is the afforestation project which would result in a noteworthy change in the land use pattern.

The following cost factors are calculated for each mitigation and baseline options: investment costs (levelled costs, free of taxes such as VAT), operating costs including labour, energy or fuel costs, administrative costs of the implementation and others.

IV.7.2. Assumptions

In the study we worked with the social discount rate rather than using other discount rates. The social discount rate reflects the future growth potential of the country and a pure time preference factor of the society. In the short and the medium run, the GDP of Hungary is expected to grow by about 4% annually. In the longer run this very high rate of growth cannot be maintained. A 2% growth rate seems to be more realistic. There are different suggestions for the determination of the time preference factor. Most of the authors suggest the use of a rate of time preference rate between 0.5 and 1.5- [13].

We decided to use a medium to high social discount rate. Sensitivity analysis was carried out to show the effect of the choice of discount rates. Based on the above mentioned considerations two different discount rates were used for the purpose of calculation: 3% and 5%.

The theoretical maximum of GHG reduction potential has been estimated by earlier phases of the project. In our calculations, however, we assumed that only 25% of the changes will be carried out by the year 2010 and 50% by 2030. A less or more radical assumption (e.g. the project effects about 20% of households) would not cause much change in the marginal cost), but it would radically decrease or increase the GHG reduction possibilities.

During the calculation of the marginal cost curves we had to neglect the question of feasibility. The feasibility of the projects as well as the rationally expectable level of implementation is discussed under the title "implementation". In the later analyses and for the purpose of policy advice, feasibility will be taken into consideration.

The energy cost is not heavily subsidised in Hungary, thus we could rely on the use of market prices in calculating the costs of different projects.

In case of certain projects the reference case costs are missing as these projects rely on the installation of some kind of supplementary devices which do not involve the change of the basic technology (e.g. supplementary insulation). In these cases the cost of the base technology can be regarded as “sunk cost” and the marginal cost is calculated only for the instalment of the supplementary device.

The cost of technology was assumed to be fixed and based on currently known prices.

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[13] Kula (1987) suggested rates of 1,2 for the UK while Ray (1984) suggested the rate as high as 2-5%. See: Project and ploicy appraisal, integrating Economics and the environment, OECD documents, 1994.

IV.7.3. Sensitivity of marginal cost curves

A sensitivity analysis was carried out to analyse the impact of the discount rate on the ranking of the projects. It shows that the choice of the discount rate has more impact on options with high initial investment costs and less impact on those with low initial investments. Generally, changing the discount rate has not caused major changes in the ranking of the projects. Examples of marginal and average cost curves relating to the projects selected are shown in the Appendix.

IV.7.4. The effect of economic instruments on the shape of marginal cost curves

Marginal cost curves can be used to decide about the GHG policy of a country. After this there is a need for another environmental policy tool decision that would help in the implementation of the GHG policy. The shape of the marginal cost curve however might be influenced by the economic instrument. If the externalities of global warming are internalised through the use of some kind of fuel or carbon tax this would reduce the marginal costs of the energy efficiency projects.

IV.7.5. Cross-cutting sectoral assessment

In the first phase of the analysis the impact of the mitigation projects on the energy system, and thus on the carbon intensity of the emission from the substituted electricity production, was neglected. Therefore the draft marginal cost curves did not reflect this impact. In the later analysis the summarised impact of the projects on the energy sector has been assessed([14]) and the marginal cost curves were modified to include this impact.

IV.7.6. A short description of the cost implications of energy-related mitigation projects

IV.7.6.1. Supplementary insulation of roofs, walls and basements in existing buildings

Energy performance of buildings in Hungary differs to a great extent. With buildings well over 100 years of age, concrete blocks of flats built during the socialist regime and new family houses using state-of-the-art insulation techniques it is not easy to determine the possible energy savings of such a project. Even though it saves the most GHG emissions among all the projects analysed (about 2,4 million tons of CO2 equivalent), this project's implementation is not without problems. Though the calculations show that such a GHG mitigation is possible, lack of financial means may hinder the implementation. This project has a very long lifetime (30 years) and thus benefits arising from the project reach out far into the future. This, combined with a high initial investment costs, make the project's net present value negative at higher discount rates (5 and 7%). Thus government intervention is definitely needed even though the privatisation of formerly state owned

[14] This analyses was carried out by Klara Staub and Tihamér Tajthy

residential and communal buildings brought about open-market changes in the management and attitude with which these buildings are handled.

IV.7.6.2. Change of windows in existing buildings

Basically, similar problems arise in the case of this project as with the insulation of the already existing buildings. A question still unresolved is whether a change to energy efficient windows or the construction of new buildings combined with the insulation of still remaining windows is more feasible. This has to be answered before state intervention can begin. (This problems also arises in the previous case: costs of insulation are so high that it might be more feasible in the long term to tear down old buildings and build new ones.)

Raising awareness and information dissemination alone would not have a significant effect in this case without readily available financial means because of the positive costs arising during the whole lifetime of the project.

IV.7.6.3. Individual ventilation systems instead of shared ventilation systems

This project has a relatively long lifetime (15 years) but its negative marginal cost at all discount rates calculated show that it is financially as well as environmentally feasible. The project also has a relatively high impact on GHG emissions (a saving of almost 400,000 tons of CO2 equivalent can be expected on the long run). This means that such a project could be carried out by the owners of concrete block flats where such devices are mostly used if information is provided to the owners. An initial soft loan or tax reduction would also be needed for these types of houses which usually accommodate households with smaller incomes.

IV.7.6.4. Water-saving device installed on taps

This project is characterised by negative marginal costs and a relatively short payback period (2 years in the residential sector and 3 years in the communal sector). The largest part of the costs should be born by the institutions and persons effected. An education campaign for citizens about the advantages should be an integral part of the policy. In the case of governmental institutions the expansion of use is a question of decision-making and funding. Financial incentives are required to make the project widespread. In a short or medium run it is unrealistic to expect more than 25% of households to join the program. The initial investment of 6000 HUF might be a problem in many cases because of the limited household financial resources. In the longer run widespread use is quite likely as both the price of energy and the water rises steeply. Installing equipment also gives other advantages than that of energy saving, e.g. water saving. This fact makes the option more profitable even in the case of private households than it is showed in our simplified example.

IV.7.6.5. Installation of compact fluorescent lamps

Ten 60 Watt lamps per household were taken into consideration and a 1500h/year operation was assumed. The efficient bulbs can save about 80%

of energy used. They also have a longer lifetime. In the residential sector there are a large number of bulbs. In the communal sector, however, the use of bulbs is more marginal while fluorescent lamps are more common. In the communal sector the replacement of maximum 1763000 bulbs was assumed.

Citizens have already started to buy more efficient bulbs. Problems might occur because of very high initial investment costs. Efficient bulbs cost about 20-30 times more compared to traditional ones. This means that in the short run we cannot expect a quick dispersion of compact bulbs. Longer daily use makes the efficient bulbs pay back faster. In areas with longer hours of use the efficient bulbs are expected to be more profitable (e.g. in offices with 8-10 hours of daily use or in the communal sector). A lack of available financial resources is likely to hinder the fast spread of these bulbs.

IV.7.6.6. Luminaires

This mitigation project involves the replacement of conventional armatures with those with mirrors in their casing so that the efficiency of lighting increases. Maximum 14,100,000 armatures can be replaced. The latter is about 3 times more expensive but saves about 33% of the energy and pays back in a relatively short period of time.

IV.7.6.7. Low-flow faucets and shower-heads

By avoiding the useless flow of hot water from taps during showers, hand washes etc. about 16% savings can be achieved in the residential sector and about 30% savings in the communal sector. The initial investment cost is not high (about 2000 HUF per tap). Higher energy and water prices are likely to work towards the spread of these devices.

IV.7.7. Cost implications of forestry-related mitigation scenarios

IV.7.7.1. Introduction

Among the possible mitigation measures, afforestation must be recommended as far as economics are concerned. Quite naturally, investment costs are high, and benefits balance costs only after a few decades. However, the costs of carbon sequestration by forestry means are usually low, and these costs are estimated low in the afforestation programs analysed in this study. They are comparable to the costs in the tropics (8 USD/tC). Those in the OECD countries (excluding USA) are 28 USD/tC (U.S. Support, 1995 and Somogyi, 1996). Actually, the carbon mitigation investments by afforestation are very low compared to the proposed carbon tax as 100-350 USD/tC, recommended by Rubin et al. (1992). These costs are even lower if non-timber benefits, not quantified here, such as job creation, rural development, enhanced land use, other environmental and nature protection benefits of afforestation etc., are also taken into account.

Finally, it must also be stressed that forestry may well be the only economic sector that can actively remove carbon from the air (Somogyi, 1996). Even if emission rates could be decreased abruptly and dramatically, removal of excess carbon would still be needed and forests are indispensable in this respect. This further underlines the necessity to support afforestation in Hungary. This is proved in the following cost-benefit analyses.

IV.7.7.2. Assumptions and methodology

Costs of forest tending in general are influenced, besides species and site characteristics, by short term changes in weather (*dry periods*), casual damages and the applied system of regeneration. The annual costs of forest tending in the cost structure of the forestry companies are also the function of the above mentioned factors. This means that some of the cost factors appear only in some cases (*the cost of the protection against biotic and abiotic damages*), and the other part of the costs can be influenced by management (*according to the regeneration system applied*). However the overwhelming part of the costs is a function of site and species. The analysis therefore is based on the latter two factors, and the 1993 cost levels (*Marosi et.al. 1993*).

The compilation of the different regeneration systems applied in the case of different tree species was based on a database collected for several years using the method developed by the Department of Economics of the Forest Research Institute. This method makes it possible to show the different phases of the regeneration process on the same cost level. With the completion of the minimally required operation, regeneration can be considered successful with a high probability.

Among the costs we only show the direct costs (*materials, energy, wages and their additional costs such as social insurance, etc.*). The overhead costs vary from company to company, but 40% is a good acceptable average number. A detailed calculation was performed to determine the direct costs by species. Based on this detailed data, an aggregated estimate is given by species group. The weight numbers of the completion of the regeneration were also taken into account.

The basis of the cost analysis is the "*Sopron series analysis*" method developed at the Department of Forest Utilisation. The method for benefit analysis is based on the sortiment group planning method developed by the Forest Research Institute (*Rumpf et al, 1993*).

The normative direct costs were calculated based on standard quality, the applied harvesting system and the amount of operations within them (proportion of long and short sortiments, the amount of wood to be barked etc.), the required number of people for each operation and the hourly cost of the machines used. The hourly costs were assigned to the operations depending on the machine used and the required personnel using the averages of the forest management companies in 1993. The calculation of specific direct costs was done by net and gross m^3 of the wood in the proportion of the harvesting operation done by the company (28%). In the case of harvesting done by independent entrepreneurs (72%) the cost of hiring them was taken into consideration.

The benefits were calculated based on species data, breast height diameters, quality characteristics and sortiment structure, the proportion of woodchip and the prices of the different sortiments. The sortiment structure by species (*which also represents the average quality*) was given based on forest company's statistics in the year 1993. The specific average income was calculated from the average price data and the sortiment structure. Further in the analysis we accounted the profitability of the harvesting operations in the case of state owned forest companies (*Héjj B. 1993*). Using the data of the above analyses, simplified and weighted average numbers for selling prices, direct costs and cover were calculated for the three species groups.

The prices and the costs (*both direct and indirect*) have considerably changed compared to the price and cost levels of 1993 due to the inflation effects and structural changes of the Hungarian economy and society. We could not follow the effects of these changes in detail, but as a good orientation we give the annual changes of the price index.

Methods of determining the interest rates for net present values do not provide acceptable results in Hungary due to the changes in the real economic processes. Because of the substantial structural changes of the economy, similar values from stabilised countries (*e.g. Austria*) cannot be applied. In this situation we have to get back to the much debated "*forestry interest rate*" which was set to 3%.

In the analysis we used not only net present value but also unchanged costs and benefits, because, as shown earlier, the interest rates are rapidly changing in Hungary, and their suitability for long term analyses are limited.

For the analysis by unchanged costs and benefits two different approaches can be used:

- summing the costs of the afforestation of the planned 800 thousand ha and calculating the amount required to sequestrate 1 t of carbon
- calculating the profit loss of the forestry sector compared to the baseline scenario, and assuming that this loss is due to the afforestation, and indirectly to the sequestration of carbon.

IV.7.7.3. Cost-benefit analysis of the GHG mitigation options of traditional forestry practices

According to the first approach described above, the total investment costs of the afforestation of 800 thousand ha are 798.6 million US$ in the "*close-to-nature*", and 738.5 million US$ in the "*yield maximising*" scenario. These costs were calculated using the costs of afforestation per hectare in each species group. Based on the data of the prognosis by 2030, i.e. by completing the afforestation, the growing stock increases to 404.2 million m^3 in the "*close-to-nature*" scenario and 383.5 million m^3 in the "*yield maximising*" scenario mainly due to the afforestation. The respective carbon sequestration are 34.4 million and 25.58 millions tons of carbon. This means, that the specific investment costs of carbon sequestration are 23.16 US$/ton (*close-to-nature*) and 28.87 US$/ton (*yield maximising*).

This amount can slightly be reduced by the income of the final cuttings in the plantations established by fast growing trees. Increasing factors are the maintenance and tending costs of the new forests. In this analysis it was assumed that these costs and benefits balance each other, so they were not taken into consideration.

It has to be stressed that we cannot expect considerable benefits from the newly planted forests for a long time because of their age structure. The amount of sequestrated carbon steadily increases, and reaches 51.5 million tons in the “close-to-nature” and 43.5 in the “yield maximising” scenario by the year 2051. The specific investments of carbon sequestration are then 15.50 US$/ton in the “close-to-nature” and 16.98 US$/ton in the “yield maximising” scenario respectively.

In the second analysis the total profits in the three scenarios were calculated. The total profits were 1,315,910 thousand US$ in the “*baseline*”, 490,070 thousand US$ in the “*close-to-nature*” and 558,890 thousand US$ in the “*yield maximising”* scenario for the period 1991-2050. Losses are 825,840 thousand US$ in the “*close-to-nature*” and 757,020 thousand US$ in the “*yield maximising*“ scenario. Thus, the specific costs are 16.02 and 17.40 US$/t carbon in the respective scenarios. However, the Hungarian Forestry Sector would be financially unbalanced without subsidisation for decades because of the costs of the large afforestation program, although a higher profit rate will happen in the far future.

IV.7.7.4. Cost-benefit analysis of the GHG mitigation options of short-rotation forestry practices

IV.7.7.4.1. Cost analyses of Energy Plantations by different site conditions and technologies

The most significant challenge in commercialising energy crop production for the biofuel industry is that success will depend on the individual decisions of thousands of landowners who together comprise the agricultural industry in the country. Every producer has to be convinced that a profit can be made from energy crops. Profit in the early stages of electric power or heating plant development is usually marginal. Several American studies indicate that success or failure will be closely linked to agricultural crop programs and policy decisions. Analyses also proved that valuing environmental and socio-economic externalities could be important in the economic viability of energy crops.

It is well known that site conditions, soil fertility, cultivated species and used technology (*and even the annual meteorological conditions*) determine the quantity and quality of the yield, as well as modify costs and benefits in all types of agricultural crop production. Limits are the same for all the energy crops including Hybrid Poplar and Willow plantations. An American economic analysis of energy crop development on 1992 data (*NREL, 1993*) reported, that highly productive sites require less cost for energy crop and thermal unit. The tendency is similar even in Hungarian ecological and economical conditions.

There are numerous variations in Hungary by soil type and fertility, fast growing tree species and used technology. We constructed two versions for the purpose of cost analyses by soil fertility and technology. There are many varieties by species, productivity and technology which we cannot analyse in the frame of this study. More details are available in relevant American, Canadian, Swedish and German literature.

Version A means good soil conditions and low-cost technology, which would result in low costs and a high profit rate. ***Version B*** means poor soil conditions combined with high-cost technology, which would result in high prices and very low profit rate, or (*maybe*) the crop would be sold at loss sometimes. Results of cost-benefit analyses of these two versions appear as lower and upper limits of costs and prices of the wood fuel produced in short rotation energy plantations. The real situation will probably be somewhere between this lower and upper limit depending mainly on local conditions and the grower's experience. Costs were estimated on basic prices of the year of 1996 at *Kisalföldi Forestry Ltd*. disregarding inflation and/or potential price changes during the cycle. Upon direct cost of work, energy and used material, an overhead of 42.71% of the firm must be added to get the total cost of production.

This technology and cost analysis is a suitable basis for further economical analyses made by Economists. As agricultural policy should be changed in the near future, subsidisation would encourage establishment of short rotation energy plantations and would increase the potential profit rates. As bioenergy programs have so many additional environmental and social advantages, we hope, subsidisation policy will be realised as soon as possible. A little increase in the subsidy by area or crop would dramatically change the cost and benefit conditions. Even a low-level subsidised woodfuel would be competitive with all the fossils in the future.

The cost analysis comprises the necessary and potentially appropriate activity during a 20-year system (*5 times 4-year-long rotation*) coppice plantation of Hybrid Poplar. High productivity combined with low cost technology result in a very competitive cost for wood chip in our model investigation. The first rotation usually has the highest cost because of the primer costs of investments. The second and third rotations are the cheapest, because the plantation needs less maintenance and the productivity is increased by coppice vigour. After the fifth rotation the energy plantations must be re-established because of health problems and decreased growth of the trees. Costs of ***Version A*** are available under Hungarian ecological and economical conditions, but considering the productivity of the potentially available land these costs may represent the lower limit, and not the average cost.

IV.7.7.4.2. Cost analyses for short rotation forestry practices

There are big differences among the costs of Version A and B IV-X. Version A is the best situation and Version B will result in the lowest productivity and will have high costs of applied technology. These two versions show the recent lower and upper limit for cost effectiveness of wood-for-energy plantations under Hungarian ecological and economical conditions in 1996. These high differences are normal in agriculture. The lower costs are competitive with all of the fossil energy resources, while high unit costs would be too big for realising any production profit. That is why growers usually hesitate to change traditional agricultural activity into energy crop production.

The lower profit rate in the first rotation due to the relatively high investment costs is also worth considering. The minimal size of the plantation should fit the rotation age focused on the annual income. Only few growers accept the low profit rate in the first rotation, although profit increase later on.

Table IV-X Cost analyses of wood-for-energy plantation

	Total cost	**Biofuel ***	**Cost per crop unit**	**Heating value**	**Cost per energy unit**
	HUF	t/ha	HUF/t	GJ/ha	HUF/GJ
Low cost technology, good site conditions (*Version A*)					
1st rotation	295410	100	2954	1440	205
2nd rotation	156980	150	1047	2160	73
3rd rotation	156980	125	1256	1800	87
4th rotation	156980	100	1570	1440	109
5th rotation	156980	80	1962	1152	136
Total	**923330**	**555**	**1664**	**7992**	**115**
High cost technology, poor site conditions (*Version B*)					
1st rotation	786330	40	19660	576	1365
2nd rotation	385320	60	6420	864	446
3rd rotation	385320	50	7700	720	535
4th rotation	385320	40	9630	576	669
5th rotation	385320	32	12040	461	836
Total	**2327610**	**222**	**10485**	**3197**	**728**

** water content w=20%*

Average prices of woodchip would be on the margin of profitability without considering additional environmental and social benefits. Although short rotation wood-for-energy plantation system would be profitable on most of Hungarian arable lands, data on environmental and economic factors would be critical for focusing crop development research on those regions and species that are likely to provide the greatest returns to the research investment. This data would also be valuable for local and national-level policy makers, who can have a major effect on determining the economic viability of energy crop production. However, not only costs delay spreading of energy crop production. The responsibility for agricultural policy and subsidisation rests with governmental bodies, while organisation of the regional energy crop market would be a task for the local authorities or the consumers.

V. Macro-economic effects of the mitigation scenario

V.1. Effects on energy consumption and GHG emissions

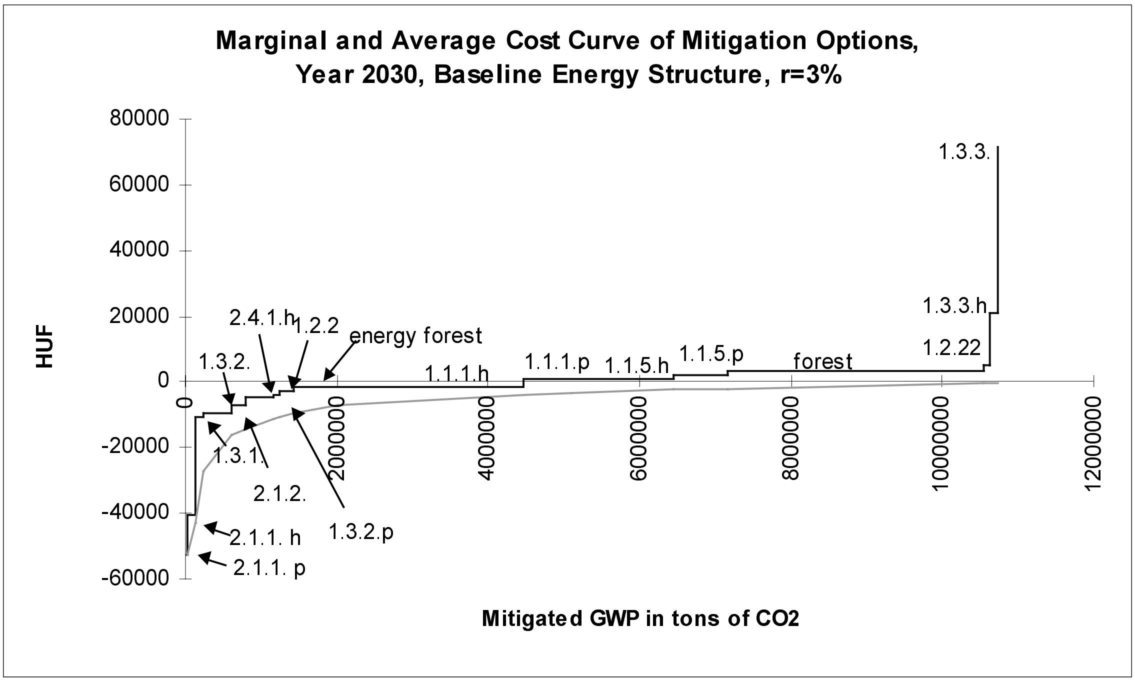
When we add up energy consumption on the demand side, the two sectors in Hungary are expected to emit about 48% of the total CO_2 emissions by the year 2030.

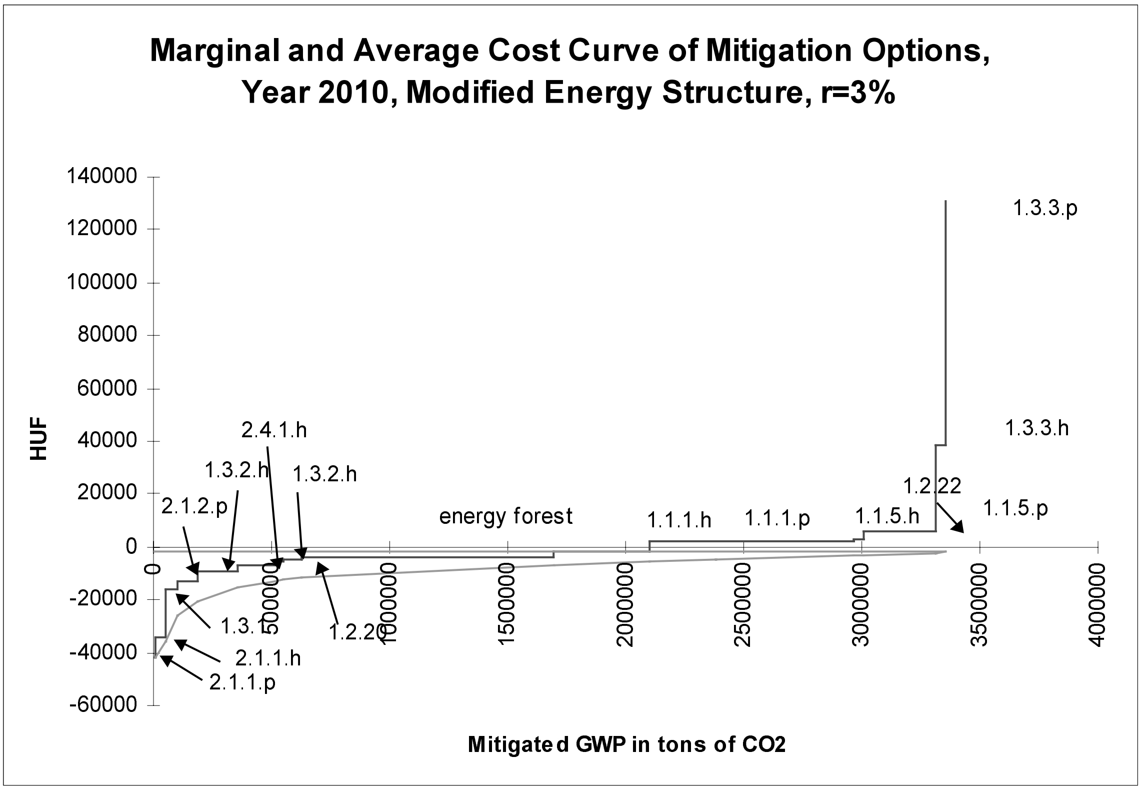
By 2030 the mitigation scenario would result in a decrease of 6348 kt of CO_2 equivalent in GWP with all mitigation projects implemented. This equals to a decrease of 19% compared to the baseline. In the public sector these values are equivalent to 1362 kt of CO_2 or 8%. The mitigation scenario in the two economic sectors would reduce the GWP of the Hungarian economy by 7%. Without the mitigation scenario the GWP of Hungary would increase from 66359 kt of CO_2 in 1995 (92909 kt in 1985) to 102323 kt in 2030. With mitigation projects implemented, the GWP would increase to only 94613 kt of CO_2. This is a significant change considered that only two sectors were regarded and the implementation level of the projects is not more than 50%.

By the year 2010, the GWP of Hungary would increase to the equivalent of 85403 kt of CO_2 according to the baseline case. The reduction due to the mitigation projects equals to the equivalent of 3444 kt of CO_2 in the residential sector and 762 kt in the public sector. The reduction due to the mitigation options is about 5% for the whole country compared to the baseline scenario. In the residential sector the mitigated GWP is 12% while in the public sector the subsequent value is almost 7%.

V.2. Change in the energy structure

It has been assumed that a change in the energy structure would occur as a result of the implementation of the selected mitigation options. This change would then in turn change the marginal cost of mitigation options (see graphs below).


Marginal and Average Cost Curve of Mitigation Options,
Year 2030, Baseline Energy Structure, r=3%
80000
60000
40000
20000
0
-20000
-40000
-60000
HUF
1.3.3.
1.3.3.h
1.2.22
2.4.1.h
1.2.2
energy forest
1.3.2.
1.1.1.h
1.1.1.p
1.1.5.h
1.1.5.p
forest
1.3.1.
2.1.2.
2.1.1. h
2.1.1. p
1.3.2.p
0
2000000
4000000
6000000
8000000
10000000
12000000
Mitigated GWP in tons of CO2


Marginal and Average Cost Curve of Mitigation Options,
Year 2010, Modified Energy Structure, r=3%
140000
120000
100000
80000
60000
40000
20000
0
-20000
-40000
-60000
HUF
1.3.3.p
1.3.3.h
2.4.1.h
1.3.2.h
1.3.2.h
2.1.2.p
1.2.22
energy forest
1.1.1.h
1.1.1.p
1.1.5.h
1.1.5.p
1.3.1.
1.2.20
2.1.1.h
2.1.1.p
0
500000
1000000
1500000
2000000
2500000
3000000
3500000
4000000
Mitigated GWP in tons of CO2

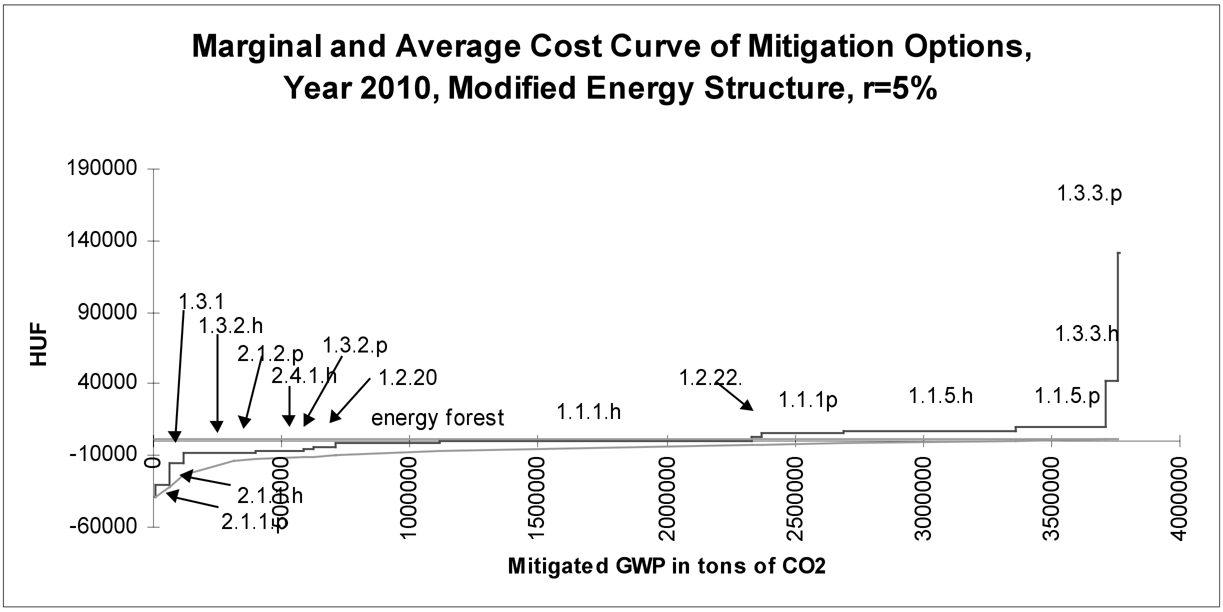


Table V-A Key to project numbers in Marginal Cost Curves (k:communal sector, l: residential sector)

1	2.1.1 k More CFLs in public buildings
2	2.1.1 l More CFLs in households
3	1.3.1 Individual metering of hot water consumption
4	1.3.2.l Efficient faucets and shower-heads in the residential sector
5	2.1.2 Technology change in lighting (replacement of luminaries and controls)
6	2.4.1 l Replacement of common ventilation (in multi-storey buildings) by individual ventilation
7	1.3.2 k Efficient faucets and shower-heads in the public sector
8	1.2.20 Programmable thermostats
9	1.1.1.l Post-insulation of roofs, walls, and basement of existing buildings, residential sector
10	1.1.1.k Post-insulation of roofs, walls, and basement of existing buildings, public sector
11	1.1.5.l Replacement of windows of existing buildings by efficient ones (low emissivity glazing, tight frames), residential sector
12	1.1.5.k Replacement of windows of existing buildings by efficient ones (low emissivity glazing, tight frames), public sector
13	1.2.22 Upgrading existing combustion equipment by adjustment and better maintenance
14	1.3.3.l Active solar DHW system, residential sector
15	1.3.3.k Active solar DHW system, public sector

A simulation has been run to determine the GWP of the modified energy structure and to make comparison with the baseline energy structure possible.

Due to these effects we experience a fall in the GWP/TJ energy consumption throughout the two sectors and the whole economy. The GWP/energy consumption ratio falls to 77 tCO2/TJ by the year 2010, compared with the baseline value of 88 in the residential sector and to 71.7 by the year 2030 (the baseline value is 88.6). Similar changes are expected in the residential sector (93 tCO2/TJ vs. 86,9 tCO2/TJ in 2010 and 85,7 TCO2 vs. 93,8 tCO2/TJ in 2030). The economic impact of this shift is a steeper shape of the marginal cost curve: the no-regret options become even more profitable while the options involving positive marginal costs become more expensive.

The following tables show the annual energy consumption of the household and residential sectors and the change in GWPs of GHG emissions in these sectors.

Table V-B

	1985	1990	1995	2005	2010	2030
Energy consumption of the household sector, TJ	275,17	273,94	261,4	293,5	316,3	375,7
GWP of the GHG emission of the res. sector, kt CO2 equiv.- baseline energy structure	26910	25678	22743	25551	27892	33272
GWP of the GHG emission of the res. sector, kt CO2 equiv.- modified energy structure	26910	25678	22743	23019	24448	26923
GWP/energy cons. kt./TJ - household sector - baseline	97,79	93,73	87,00	87,05	88,18	88,56
GWP/energy cons. kt./TJ - household sector - modified	97,79	93,73	87,00	78,42	77,29	71,66
Energy consumption of the service sector, TJ	79,6	73,4	81,2	108,4	120	167,5
GWP of the GHG emission of the service sector, kt CO2 equiv.- baseline energy structure	7270	6419	7471	10035	11187	15717
GWP of the GHG emission of the service sector, kt CO2 equiv.- modified energy structure	7270	6419	7471	9439	10425	14355
GWP/energy cons. kt./TJ - service sector - baseline	91,33	87,45	92,00	92,57	93,22	93,83
GWP/energy cons. kt./TJ - service sector - modified	91,33	87,45	92,00	87,07	86,87	85,70

These tables reflect that a modified energy structure - with a more environmentally oriented operation - could lead to a less polluting energy production. As a result, GWP/energy conserved ratios fall by about 10% in the public sector and by as much as 20% in the household sector.

Mitigation options have a direct influence on energy use i.e. the same options have different effects on the GWP emitted in the case of the baseline and modified energy structures. Because the GWP/energy conserved ratios are smaller in the modified case, no-regret options tend to result in higher savings taking into account the change in the energy sector. Inn the case of positive cost options, these have a even higher cost compared to the baseline energy structure. This phenomena is shown in the following two figures.

Macro-economic effects of energy saved by the installation of energy saving equipment are widespread. A more ecologically oriented use of resources is very important in Hungary because the country has to import more than half of its gross energy requirements from abroad.

Another aspect of saving energy is the environmental benefit. This may include the elimination of a need for a new power plant and or the obstratction of several other air pollutants from reaching the atmosphere.

The following table shows the energy savings of some mitigation options in the household sector in the year 2010.

Table V-C

Mitigation option	Energy savings in 2010, TJ
1.1.1.	13792
1.1.5.	7632
1.2.20.	1014
1.2.22.	449
1.3.1.	655
1.3.3.	549

These energy savings occur in the case of the medium term scenario which aims at a 25% implementation rate of the mitigation projects by 2010. It can be seen that these figures represent an important share in the total energy consumption of the household sector. However, it has to be noted that it is not possible to sum up these energy savings because they have an impact on each other. E.g. in the case of projects 1.1.1. (Insulation of buildings) and 1.1.5. (Installation of new windows), if insulation occurs first then the installation of new windows could only have a limited effect on energy savings compared to the calculated figures.

Taking the most effective mitigation project (1.1.1. Insulation of buildings) into account it would be possible to save a 600-700 MW power station (calculating with an average 5500-6000 hours of operation). This in turn has a number of effects on the economy and the environment of the country. With such measures, imports could be reduced or, taking into account the decreasing amount of domestic energy resources, at least kept at the same level. Also there are far more environmental effects then CO2 reductions alone as it can be seen in the following table.

Table V-D Emissions of a 600 MW combined cycle power station, comparison of different technologies

	CO_2 g/kWh	SO_2 mg/kWh	NO_2 mg/kWh	ash g/kWh	gypsum g/kWh	heat MJ/kWh
traditional coal fired	830	600	600	34	20	4,3
combined gas-coal fired	810	585	585	62 (mix of ash and gypsum)		3,6
gas-steam power station, gas fired	380		350			2,6

Source: Ulrich Föstner: Környezetvédelmi technika, Springer Hungarica, 1991

V.3. Total cost of the project for the society

About half of the projects are non-regret options with negative marginal costs. Thus the average cost curve is in the negative region throughout the whole range of the CO2 reduction axis. This means that the mitigation scenario has none or only minor costs when it is regarded as a complete package of mitigation options. The allocation of benefits and costs might still be uneven. The scenario may seriously effect certain sectors or social groups in either a positive or negative way. Moreover, not all the projects included in the mitigation scenario shall necessarily be implemented. There are high cost options (e.g. the active solar DHW system) that should be replaced by cheaper options not included in the mitigation scenario.

The projects are marginal and do not have significant effect on the market factors apart from the energy sector and the impact on certain industries. The following will give details of these exceptions.

V.4. Total annual investment cost of the mitigation scenario

One of the important issues determining the feasibility of the mitigation options is that of the initial investment costs. Most of the projects require a higher initial investment in the first 5-10 years of implementation or even longer in case of the long term scenario. The following table shows the total annual amount of investment cost for each of the mitigation options for the starting years.

Table V-E

Project (public sector)	Incremental capital cost in 2000 Billion HUF	Cost per "flat" HUF
More CFLs in public buildings	0.255	2900
Efficient faucets and shower-heads in the public sector	0.240	10000
Technology change in lighting (replacement of luminaries and controls)	2.820	100000
Active solar DHW system, public sector	1.100	250000
Post-insulation of roofs, walls, and basement of existing buildings, public sector	6.700	152000
Replacement of windows of existing buildings by more efficient ones (low emissivity glazing, tight frames), public sector	8.510	193136
Total	19.625	708036

Table V-F

Project (residential sector)	Incremental capital cost in 2000 Billion 97 HUF	Cost per household 97 HUF
Efficient faucets and shower-heads in the residential sector	0.725	6000
More CFLs in households	1.420	7200
Replacement of common ventilation (in multi-story buildings) by individual ventilation	0.600	30000
Active solar DHW system, residential sector	3.420	300000
Individual metering of hot water consumption	0.110	7000
Upgrading existing combustion equipment by adjustment and better maintenance	0.220	250000
Post-insulation of roofs, walls, and basement of existing buildings, residential sector	23.200	288000
Replacement of windows of existing buildings by efficient ones (low emissivity glazing, tight frames), residential sector	16.740	204900
Programmable thermostats	0.330	15000
Total	46.765	1108100

The program would require an annual investment of 66,4 Billion HUF in the first couple of years. (The implementation period differs from project to project, changing from 5 to 10 years).

V.5. Sectoral effects

In this section we are going to analyze the potential sectoral effects of the implementation of the mitigation scenario.

The following industries are significantly influenced by the mitigation projects:

The manufacture of electric lamps and lighting equipment produced a sales value of about 49,6 billion HUF in 1995. The annual investments in luminaries and CFLs would result in a 4,495 billion HUF increase in demand in the mitigation scenario for the products of the lighting industry as the efficient bulbs and luminaries are much more expensive than the conventional ones. This substantial increase of 10% of the demand is significant and would also change the structure of the supply of lighting devices. The industry employs about 12400 employees. The increase in sales would be the consequence of the higher price of the efficient equipment, but the number of bulbs sold would decrease. It means that no positive employment effects can be expected. Efficient CFLs are either produced in Hungary or imported from abroad.

There is no significant effective demand for active solar DHW systems at this moment. The scenarios thus would come along with the birth of a completely new industry. The marginal cost of this project is, however, very high. It means that this project is not amongst the most favored ones.

The manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes produced 9,245 billion HUF value in 1995. The expansion of individual metering of hot water consumption would cause about a 1% increase of the demand in this sector. The project would also result in significant water saving.

The manufacture of glass and glass products has a production value of 23,897 billion HUF. The replacement of windows with its 25,25 billion 97 HUF value would mean a huge boom for the industry. (Of course the value of the glass is only a part of the value of the windows or doors). In this respect the program seems to be somewhat over-ambitious.

V.5.1. Burden on the residential and public sectors

The household consumption of fuel and power took altogether 209,853 Billion HUF in 1996 in Hungary. This means a 5.5% in the consumption of households. This is, however, one of the fastest growing items in the consumption structure. The index per capita consumption at 1996 prices for different groups of goods and services is illustrated in the following table:

Table V-G

Year	Food	Beverages and tobacco	Clothing and foot-wear	Fuel and power	Durable goods	Other consumer goods	Goods total	Services total	Actual domes-tic con-sump-tion
1970	89,3	68,1	93,4	56,0	65,8	49,6	75,8	62,7	72,5
1980	100	100	100	100	100	100	100	100	100
1985	105,4	105,5	94,8	120,3	117,9	104,9	106	116	108,4
1990	101,1	94,1	68,7	139,1	160,4	116,5	105,3	125,9	110,6
1995	88,5	75,5	56,3	114,9	164,9	98,7	91,2	120	99,4

Households spent an average of 40599 HUF per capita on the maintenance of dwellings (24044 HUF in the lowest decile of the population and 62709 HUF in the highest decile). The annual spending of a four person household with average income was about HUF 160 000 on the average. The investment cost of the program has to be compared to this expenditure in order to see how much the households are able to finance the mitigation program.

The impacts of the mitigation projects are serious mainly during the first years of the implementation. Later, the expected growth of GDP and the structural changes in the economy might ease the burden of the initial investment cost impact for the society.

The expected growth of the GDP by 2010 and 2030, 1998 =100%

Table V-H

Assumed annual growth rate	2010	2030
2%	27%	88%
3%	42%	157%
4%	60%	250%

VI. Implementation of climate change mitigation options in Hungary

VI.1. Introduction

In the previous chapters of this document, a baseline scenario has been worked out for the future trends in the residential and public sectors in Hungary. Also a set of mitigation scenarios has been identified and analysed which could serve as specific means of greenhouse gas (GHG) emission reduction scenarios. GHG mitigation potentials and major cost-components of the scenarios have been determined as well in the communal and residential areas. The objective of this chapter is to investigate which policies and programs should be applied or are already in place for the implementation of the discussed mitigation options; which barriers are present in the Hungarian economy, and thus what is the feasibility of the scenarios developed.

VI.1.1. Economic policy instruments of GHG mitigation in Hungary

According to a 1994 meeting of UNEP (United Nations Environmental Programme)[15] economic instruments can be classified into seven categories: "property rights, including ownership rights, use rights, and development rights; market creation, including tradable emission permits, tradable catch quotas, tradable development quotas, tradable water shares, tradable resource shares, tradable land permits, and tradable offsets/credits; fiscal instruments, including pollution taxes, input taxes, product taxes, export taxes, import tariffs, tax differentiation, royalties and resource taxes, land-use taxes, investment tax credits, accelerated depreciation, and subsidies; charge systems, including pollution charges, user charges, betterment charges, impact fees, access fees, road tolls, and administrative charges; financial instruments, including financial subsidies, soft loans, grants, location/relocation incentives, subsidised interest, hard currency at below equilibrium exchange rate, revolving funds, sectoral funds, ecofunds/environmental funds, and green funds; liability instruments, including legal liability, natural resource damage liability, liability insurance, and enforcement incentives; and performance binds and deposit refund systems, including environmental performance bonds, land reclamation bonds, waste delivery bonds, environmental accident bonds, deposit refund systems and deposit refund shares". Some of this wide array of economic instruments are used all over the developed world while some are merely concepts. In Hungary several types of environmental regulations and sanctions have been used to protect the environment which mostly fall in the least market conform group of environmental charges but other types of measures have been introduced as well. To give a comprehensive analysis of

[15] The use and application of economic instruments for environmental management and sustainable development, Report of the Meeting, Nairobi, 10-12 August, 1994, UNEP, Environment and Economics Unit

all of the regulatory instruments is impossible here but an overview of the most important types of regulations will be given in the followings. Environmental taxes are left out of the discussion because the so called energy/carbon tax has already been discussed in another paper.

VI.1.1.1. Property rights

According to Coase (1960)[16] in a society with accurately defined property rights environmental degradation is kept to an optimum by the interest of the owners of environmental amenities.

With privatisation in Hungary property rights have changed from state property to private property throughout the economy. This already has its effect on resource use and a less wasting practice is developing day by day. At the same time as state monopolies are abolished subsidies in the energy sector have been decreased and state guaranteed prices have been replaced by market prices. Among the Central and Eastern-European countries, Hungary has the least subsidised energy price system which also helps in the development of a more energy efficient economy. Although near market prices in the energy sector external costs' of production and use are usually not taken into account when determining prices although there is a certain tax content built in. For example in petrol prices there is a tax built in to cover costs of the infrastructure.

In the residential and public sectors this translates to a higher level of energy prices and renting of buildings is gradually changing to ownership. This has an incentive effect on building restoration including. There are incentives to use energy saving equipment and to practice energy saving in households and public buildings.

VI.1.1.2. Market creation

The principles of market creations are of those of the property rights approach: companies would acquire a certain amount of rights which they can use to pollute the environment or to sell them to other enterprises. This regulatory instrument has not yet been introduced in Hungary but some results have been achieved in the USA. Market creation is considered by economists an efficient, market conform means of regulation because emission mitigation would occur where it can be achieved at the least cost. At the same it is a good incentive for businesses to further improve their environmental performance as technology improves and emission mitigation gets cheaper. One of the drawback of such a system is to make it work in practice. Although it is highly unlikely that such a system would be installed in Hungary there are initiatives on the international level to implement a CO2 emission rights market to which Hungary could join in the future.

One of the newly emerging ideas in the international scene have been international emission offsets which means that a developing country would be allowed to offset its CO2 emissions by an environmental investment (e.g. afforestation project) in a less developed country). Although debate still

[16] Ronald Coase, The problem of social cost, Journal of law and Economics, October, 1960

surrounds this notion it is likely that such measures will be seen in the near future.

The market creation approach is basically aimed at the regulation of corporate sector emissions thus we are not going in more detail concerning this policy instrument here.

VI.1.1.3. Subsidies and tax incentives

Apart from the popular notion of energy taxes discussed in a separate paper several other measures are available relating to the tax system.

An often used means is a tax refund or subsidy on environmental investments. This may take a form of accelerated depreciation of assets with a better than average environmental performance. Soft loans for environmental investments are also readily available in several developed countries. This might be a form of subsidising environmental investments in both the public and household sectors, where a lack of capital may often pose an important constraint to such measures.

An example of an environmental subsidy in the residential and public sectors is the case of compact fluorescent light bulbs in Poland where a significant price subsidy helps households and other sectors of the economy to change energy wasting conventional light bulbs for new, energy efficient bulbs.

Another possibility discussed in the literature of greenhouse gas policy is an environmental tax reform. This means a shift from personal income tax and corporate taxation to an environmentally oriented tax system. Hungary’s general tax system has taken no environmental considerations into account up to now - apart from the introduction of the product fee , but as development starts, a change in the types and rates of taxes is inevitable. At this point the notion of a more environmentally oriented tax system should be considered.

VI.1.1.4. Limits on emission and fines

Emission limits have been the most important factors in Hungary’s environmental legislation in the last decades. The fines were calculated by the amount of emissions of polluting materials beyond the limit value. Unfortunately the rates of pollution fines have not been significant enough to influence decisions. Also effluent charges basically aim at the corporate sector and thus we will not pay attention to this kind of environmental regulation in this paper.

VI.1.1.5. Raising awareness for the efficient use of energy

One of the most important and efficient types of environmental policy measures is the raising of awareness of the population in the direction of energy efficient practices. Such programs have been introduced in several developed countries just like in Hungary.

Starting in the middle of the 1980’s several energy saving programs have already been introduced in Hungary. Most of these programs unfortunately lacked financial resources and thus they effected the thinking of the population only to a limited extent. Therefore an energy savings program should be implemented which aims at the residential and public sectors and has the proper financial resources to make a significant impact on the population, specially on young children.

VI.1.1.6. Policy considerations of individual mitigation options

Three types of mitigation options have been analysed during this study in both the residential and public sectors: mitigation options concerning heating and warm water generation and the electricity use of households and public buildings. Some of these options require a large amount of invested capital while others could be carried with smaller funds. There is a difference in the net present value of projects as well. No-regret alternatives have been also identified which are feasible considering only financial gains. The basic constraints of the implementation of these mitigation options are the initial investment requirement and the lack of information among interested parties, both producers and consumers of such products, concerning energy efficiency measures. The most important policy means in this case is raising environmental awareness which can be coupled by a soft loan or tax subsidy to maximise benefits of the project. This type of state investment would then be recovered from lower energy bills, the improvement of energy intensity of the economy paralleled by a lower, or in case of economic development, a stable GHG emission as required by the international treaties.

A different approach has to be taken in the case of mitigation options which do not recover their initial investment costs during their lifetime. In this case information dissemination would not be enough to initiate the use of such kind of measures. A tax incentive or soft loan would definitely be required in these instances because most households and public organisations are not able to finance an additional investment if it has negative financial impacts. With economy gradually improving, a slight change in this direction can be expected, but this basically does not change the situation: environmental considerations alone are in most cases not yet enough to start an investment without any financial benefits.

For the supply side of the market environmental standards may improve the environmental performance of companies and result in more energy efficient products reaching the market. Raising environmental awareness of consumers also directly effects the product lines of manufacturing companies (through environmental labelling, for example) and enhances energy efficiency.

VI.2. Strategic frameworks of measures to improve the energy-efficiency of the demand side: implementation of integrated environmental and energy policies

VI.2.1. Target areas of measures leading to emission limitations

The direct goal of the Hungarian climate protection strategy is to implement a package of measures which can be introduced and implemented (financed) as well as to support the rational production and use of energy.

The indirect effects (environmental, employment, regional development, incentives for businesses, etc.) are also significant. The measures have to serve the reduction of energy intensity and a more substantial use of renewable energies. The common activity to promote the achievement of the outlined goals, whose elements are present in the National Energy Saving Action Program and the National Environmental Program, has to cover the following main measures:

– An incentive system to improve energy-efficiency: The existing financing mechanisms are to be improved (The Energy Saving Credit Program, Central Environmental Fund, German Coal Assistance Tender, international credits and aids, etc.) including the conditions necessary for funding by a third party. In accordance with the EU Directive the energy savings labels on household appliances are to be introduced and the development of energy management consulting firms and services are to be encouraged. (These latter businesses manage the whole process of revealing, planning, permitting, funding, investment, construction, operation, follow-up consultation of energy rationalisation investments on the consumer side. Their profit comes from the price of saved energy).

– Macro economic instruments to moderate energy demand: The possibility to introduce energy (eco) tax, an energy/carbon product fee and tradable emission quota system as alternatives is to be examined with special regard to phasing out hidden subsidies, preference for renewable energy sources and the analysis of impacts on the energy sector, environment, budget, employment, etc.

– Replacement of fuel: the renewable energy program: The framework of the program, self funding in the long run, which is aimed at the use of solar cells, biomass and geothermal energy just as at the development of energy forests with special regard to the establishment of the necessary stakes and incentives and to the analysis of indirect social/economic effects (e.g. budgetary, employment, regional development, etc.) will to be elaborated on.

– Influencing consumer behaviour and increasing social participation: A significant task is to familiarise a wide circle of the society with the possibility of environmentally friendly, energy-saving and economic use of energy. Favourable change in consumer behaviour will be reflected in the business strategy of energy producers and services. This in the long run will lead to healthy competition. The press and electronic media should pay greater attention to publicising economic energy consumption. Energy-aware behaviour developed in a school education, the activity of non-profit consulting services and voluntary agreement among the players in the energy market have outstanding roles.

VI.2.2. Measures on the consumer side: improving energy-efficiency among the residential and communal sectors

On the basis of the energy concept adopted by the National Assembly in 1993 a National Energy-saving and Energy-efficiency Improvement Program was elaborated in 1994. On the basis of that program the

Government adopted an action program in 1995. The Energy-saving Action Program includes the following main measure packages:

- promoting the use of renewable energy sources
- improving energy-efficiency
- energy saving “labelling” of household appliances
- raising energy awareness, promoting technical development

VI.2.3. Funding the improvement of energy-efficiency

The improvement of the energy management of municipalities is an outstanding target area in the Energy-saving Action Program. These measures have to serve the elaboration and practical application of the energy concepts of municipalities and the exchange of knowledge and information necessary for rational energy management. There has been some progress regarding the energy-efficiency of the population. In the production sector increasingly more businesses recognise the relationship between energy wasting and a decrease in profits. The growing economy provides favourable conditions in the cost sensitive sectors and thus resource and energy consumption saving have become an integral part of economic planning. Several multinational companies based on their own will have shown significant progress in improving energy-efficiency.

VI.2.3.1. Overview of current financial aid schemes

Funding energy-efficiency should meet both the interests and the needs of the producers, services and the different end users. The German coal assistance Program, the Energy- saving Credit Program and the so-called “panel” (i.e. block of flats) credit can be listed among the assistance and credit systems. Certain energy rationalising projects of the Air Protection Intersectoral Program are funded by the Central Environmental Fund. The Energy-efficiency Guarantee Fund, realised with the support of the World Bank, which provides coverage for funding by third party, has recently begun its operation.

Table VI-A Overview of the different energy-efficiency assistance systems

Credit program	Hungarian contribution (million HUF)		Foreign assistance (million USD)	
	central budget	commercial banks	source	amount
German coal assistance	-	-	German government	30
Energy saving credit program	80	800	-	-
PHARE	-	-	PHARE, EBRD, EIB	6.8
Energy-efficiency circulating fund				
Housing estate credit	300	-	-	-
Guarantee Fund	-	-	GEF	4.25

VI.2.3.1.1. Energy-efficiency funding policy and instruments of implementation

The measures promoting energy-efficiency funding can be put into two categories:

– development of institutional background and

– measures shifting the current cash flow towards energy-efficiency

Resulting from problems related to project development, management and funding, the existing financial resources, promoting energy-efficiency, are not distributed efficiently. The development of the institutional background might provide a solution for this problem and might help create a business environment which attracts foreign investors and enable the transfer of technology. Possible ways to develop the **institutional background** are the following:

– the establishment of energy-efficiency centres which would strengthen or replace the existing EU Energy Centres. These new institutions would become the focal points of market evaluation, further training, exchange of information and publicity, demonstration projects and elaboration of financing schemes. A regional “virtual centre” through the Internet could help the work of these centres and could create relationship among actual institutions and would provide connection points to other energy-technology, investment and institutional development web pages of the Internet;

– raising the energy and environmental awareness of the population;

– elaboration of further training accreditation and qualification along with other countries in the region (in several institutional forms; for example bilateral, among local universities, through professional associations, etc.);

– support for energy management consulting firms. Special instruments are: signing service contracts with the authorities; adoption of a general energy saving measurement; elaboration of the general form of contracts to be signed with the authorities and their funding conditions;

– co-operation with international development banks to provide new concession funding possibilities for the consulting firms and in this way the firms could intermediate the bank and private capital into the energy-efficiency sector. In the countries where establishment of consulting firms based on private capital is difficult state owned firms may be established and they might be privatised in the future.

A part of the private investments aimed at energy production, with adequate measures, might also be shifted towards financing the improvement of energy-efficiency. These measures have increasingly greater significance since private investments have greater and greater roles. Governmental and other aids would not further increase therefore their efficient use should be improved. The current capital flow could be redirected in the following ways:

- The parties in the Framework Convention on Climate Change, as the shareholders, managers or the borrowers of international development banks may encourage the credit institutions to take steps to reduce the emission of greenhouse gases. They may urge the banks in the same way to study the possibilities of promoting energy-efficiency; to offer common or concession funding for energy-efficiency; to provide Intersectoral advice; to carry out background institution development; and to apply investment-evaluation techniques which take externalities caused by greenhouse gases into account. The development banks should actively promote local financial institutes to be able to efficiently intermediate credits for projects.
- The OECD member states should urge the Export Credit and Credit Guarantee Commission of the OECD that export credit agencies receiving project support to take environmental criteria into account and they should provide information on the environmental impacts of the projects they support.
- The lack of a government guarantee for the main energy-efficiency projects is a significant financing obstacle. However, at the same time the governments provide a high level guarantee for private capital investments of the electric energy production. The governments should consider their guarantee for energy efficient projects and therefore, in this way, they would promote the division of investor risk, the renewal of credit or of increasing the equitable participation of energy management consulting firms which have financial muscle.
- The public procurement programs may create markets for energy efficient solutions. Governments, bilateral assistance offices and international development banks may promote the establishment of consumer associations in the private sector. Incorporation of energy-efficiency investments into greater transactions will decrease costs and make energy efficient technologies and services more attractive for energy producers.

VI.2.3.2. Main obstacles to the implementation of the measures

A significant emission reduction may be realised just by grasping the potential in economic and achievable energy-efficiency. Additionally, in this case investment costs can be recovered through saving costs on energy. In the case of energy saving investments, in the category of “economic” and “achievable” energy-efficiency potential, the internal savings rate is 12% or in some cases even higher. The exploitation of the energy savings potential is hindered not only by the insignificant number of cost-effective energy saving projects but by the development, management and funding difficulties of these projects.

The price of energy significantly influences the achievable efficiency potential. The rising price of energy raises the value of saving, improves the pay-back period of investments and increases the number of cost-effective projects. Although an indirect state subsidy, especially in district heating areas, still exists other energy prices approximate market price level. (In several cases, for example for industrial users, the prices of some energy sources are higher than in certain OECD countries). Capital scarcity for energy-efficiency investments, lack of information, unpaid energy bills, or uncertainty regarding ownership are all factors which contribute to the under-utilisation of the energy-efficiency potential. Raising energy prices itself will not solve this problem.

Table VI-B The obstacles of implementation and their possible solutions

Obstacles:	**Possible solutions**
1. Macroeconomic environment: • high inflation and fluctuating currency • political and sector political uncertainty • indebtedness, breach of contract and frequency of barter trade	• increasing economic performance • project guarantees • long term loans by international development financial institutes to local banks • elaboration of conditions for the implementation of experimental projects supporting the joint enforcement of the Framework Convention on Climate Change[17](e.g. monitoring, accreditation) • blending aids and preferential credits with credits of market interest to reduce medium term interests • establishment of energy-efficiency funds
2. Lack of information and experience • lack of information regarding energy-efficiency	• Information programs, advertisement campaigns, energy-efficiency trademark
• lack of meters • no uniform measurement stipulation for savings	• installing meters and bills with more information • adoption of uniform stipulation on efficiency savings
• lack of business and risk management experiences	• training financial and technical experts, managers, etc. with the assistance of the EU energy-efficiency centres or with multinational companies
• investors and project managers are not familiar with possibilities	• increasing the role of the project preparation in matching the projects and the investors
3. Inadequate administration of creditworthiness and past credits of the borrower • businesses, municipalities and other borrowing organisations do not handle their past credits adequately • lack of cash flow	• leasing funding; and/or municipal bond funding, signing service contracts through energy management consulting firms, experimental projects and joint businesses for the common implementation of the Framework Convention on Climate Change • expanding and developing the local bank network • connecting energy-efficiency investments and other modernisation investments for long term feasibility (e.g. housing construction)
4. Institutional system/ownership • "historical" traditions of central planning policy • sate owned energy monopolies	• determining and implementing a clear-cut energy-efficiency strategy constituting organic part of environmental policy • establishment of public service regulation system, which favours the energy saving on the consumer side • government policy promoting the establishment and involvement of energy management consulting firms
• the interests of the owners and tenants of buildings are divided • poor institutional background	• clarifying and rationalisation of ownership to increase stake (e.g. offering reconstruction package during the privatisation of housing associations which include energy-efficiency instruments); • strengthening institutional background which determine the standards
5. Energy-efficiency projects are not widespread	• transformation of the credit policy of international development financial institutes, e.g. local credits for local financial institutions which directly grant the credits to smaller projects; wider use of automatically renewable credits • joining projects • establishment of energy management consulting

[17] In the framework of this mechanism one participant in the conventions performs its emission-reduction obligations in another participatory country

	centres/firms
6. Energy prices • low energy prices • pricing uncertainties	• price can reflect full cost of production and distributions by scheduling price rises; social and political factors are to be taken into account in price compensation
• energy compensation	• compensation system should be clear and transparent and gradual withdrawal of compensation is to be planned (schedule) • compensation demand is to be decreased by energy-efficiency investments
• externalities are not internalised (a world-wide problem)	• international development banks and governments should take externalities into account during financial evaluation • imposing tax on polluting emissions or establishment of the market of pollution (prevention) rights

Domestic capital is dominant in energy and environmental investments therefore the mobilisation of the local industrial and domestic energy consuming expenditure is indispensable to make use of the energy-efficiency potential. Foreign companies should also be encouraged to invest energy-efficiency investments. The experimental projects supporting the joint implementation of the Framework Convention on Climate Change exemplify excellently that technical, financial and management problems hindering energy-efficiency and carbon dioxide emission reduction can be overcome.

Development institutes play key roles in the preservation of economic and environmental benefits. The international development credit institutes and other financial institutes do not really support small scale projects with their current credit policy because of the high transactions costs compared to the expectable profit. An accord between small scale projects and big credit funds is to be created: one way would be to have capital flow through energy management consulting firms.[18] The firms would sign the smaller service contracts and would pay credits for the greater number of small scale projects. The marketable construction loan provided for the local banks by international development institutes serves the same purpose.

Another deficiency is the lack of experience in the field of project development and in the preliminary evaluation of investments which would be indispensable to see whether the project can be financed. The EBRD deems the latter criterion the greatest obstacle to significant energy efficient investments. During project preparation it would be efficient to help the work of local managers, project leaders, bankers and other decision makers by the exchange of information or technical co-operation. The energy efficiency centres working in the region, employing local experts, are exemplary in the field of institution development.

[18] The profit of these firms comes from cost saving as a result of energy saving at other firms.

VI.2.4. Main governmental tasks

- making energy compensation more transparent, schedule for gradual withdrawal of compensation,
- encouraging energy efficient investments
- development of a tax system including environmental criteria
- support for experimental and commercial projects on public buildings
- creating favourable investment conditions for energy management consulting firms.

VI.2.4.1. Regulatory measures: energy-efficiency labelling and standardisation

VI.2.4.1.1. Overview of the current situation

In accordance with the EU regulation new and updated heat insulating standards have been introduced. In the case of the design and construction of new buildings updated standards are compulsory and their application - as a function of technical possibilities - is to be considered during the reconstruction of existing buildings. Although new standards were introduced for a certain group of household electric appliances, the majority of energy-efficiency requirements are outdated and require review. Taking the relevant EU regulation into account a feasibility study was carried out for the introduction of energy-efficiency qualification (labelling) of household refrigerators, freezers, washing machines and dryers and the energy certificates of buildings. The Ministry for Environment Protection and Regional Policy introduced the use of an environmentally friendly trademark in 1994; energy-efficiency is one significant criterion in the evaluation.

VI.2.4.1.2. Instruments of implementation

In this section, on the basis of standards as case studies for refrigerators/freezers and office equipment, the energy-efficiency “minimum compliance” standards are studied. The energy-efficiency standards for different equipment and appliances and the application of trademark (labelling) testifying energy-efficiency gains an increasing role in the integrated energy and environment policy. Refrigerating and freezing are important items in household electric energy consumption, and in this way provide great possibilities for energy saving. Although the consumption of electric energy is the highest in the trade sector for air conditioning and lighting, the energy consumption of office equipment, amounting to 5-20% of the trade sector, is increasing dynamically. Differing from refrigerators the technical and energy-efficiency features of office equipment are almost identical since these products are sold on a uniform market.

The conditions of introducing the Convention in the developed and transitory countries differ significantly: energy prices are different (they influence the cost-effectiveness of the standards), fuel structure is different (which influences the impact of standards on emission) and the institutional and legal backgrounds are also different (which influence the applicable political instruments). Often, the energy-efficiency standards and other national (or regional) measures, for example information for the consumer, labelling, demand side consumer influencing programs through Demand Side Management (DSM), financial incentives for the consumers, support for innovation, etc. all are applied together. Feasibility possibilities are multifold: binding (stipulated by legal means) regulation, governmental intervention policy or the system of voluntary agreements.

The foreign national standards, the common standards of a group of countries or the state or regional standards may play significant roles in the domestic political and social adoption of a standard. The unilateral measures aimed at the improvement of standards may further promote multilateral co-ordination although they lead to some kind of market interference with the limitation of trade. The “Energy Star” labelling system for US computers, for example, influenced the efficiency of sold computers on the whole world market since the US market in this field is decisive. On the other hand international agreements may urge national measures since multilateral commitment may facilitate national reforms which are difficult to carry out politically. The standards which are not too closely related to “technical descriptions” can be taken over by international qualification bodies, in this way later on they can be introduced also on a national level.

In the case of durable products the standards may influence emissions even in the short run but their impact is significant only in the long run. The standards of office equipment have impacts in the shorter run than the standards of more durable goods (for example refrigerators). The refrigerator/freezer standards in Japan where the average life of these appliances is 8.5 years have favourable emission impacts sooner than in the USA where the average life of refrigerators is 19 years.

On the basis of the EU experiences the period necessary for the research, planning and negotiation of uniform standards may be 5 years. The co-ordinated measures of product standardisation may require a series of steps which are to be taken gradually by all the developed parties in the Convention. Some transitory countries may not be in the position to introduce common, uniform standards simultaneously with the OECD member states. Gradual introduction of the requirements of the standards according to a published schedule might also be advantageous in minimising the costs of the producers.

VI.2.4.2. Participants

Municipalities, consumer protection associations, national standardisation bodies, industrial, professional associations or some industrial companies in addition to the government may take part in national standardisation. On a regional level the possible participants are: EU member states, the European Union, members of NAFTA (North American Free Trade Association), countries of APEC (Asian Pacific Economic Co-operation), international industrial companies and industrial associations. Important partners and intermediates may be the main non-governmental standardisation organisations, in this way ISO (International Standardisation Organisation) and IEC (International Electromechanical Committees).

Additional supporters of the co-operation may be IEA and OECD in the field of co-ordination and analysis and EC (European Commission).

VI.2.4.3. Benefits and disadvantages

The improvement of energy-efficiency (depending on the fuel structure and, to a different extent, on energy sources) helps to moderate the use of energy and contributes to the reduction of emissions related to electric energy production. The energy-efficiency standards contribute to the improvement of commercial standards, economic growth and to the reduction of import dependency regarding electric energy. The energy-efficiency standards may have a favourable effect on employment and foreign investments.

The introduction of energy-efficiency standards influences the development of energy-efficiency, the emission of greenhouse gases, foreign investments and trade between those countries which are introducing common measures and those which are not. Adopting one system of standards may decrease the overall costs of measurement and certifying procedures since products will no longer have to comply with and be tested for many different standards. At the same time the producers who cannot make the energy-efficiency of their products comply with higher standards may lose their markets. In the case of refrigerators, the application of common standards in the short run will probably have a insignificant impact on the emission of countries not participating since the characteristics of these products differ by countries and regions and the turnover of these products among regions is very little. Regarding the global market of office equipment, no significant impact on the countries not participating in the measure is expected even in the case of these appliances.

The international energy-efficiency standard stipulations of office equipment today already follow the American “Energy Star” labelling program.

The developed and transitory countries of the Convention can be characterised by different institutional systems, economic policies and legislation preferences, therefore different approaches are necessary in the different countries for the implementation and introduction of common standards. It is unlikely that the same sectoral instruments can be enforced in all the transitory economies simultaneously with the OECD member states. At the same time the benefit of the co-ordinated measures can be enforced if the countries use the same minimum energy-efficiency standards.

VI.2.4.4. Main possibilities for co-ordinated standardisation measures

Cost-effective energy-efficiency level

The participating countries may agree on the values of cost-effective energy-efficiency levels regarding the products. The levels of cost-effective energy-efficiency vary in the different countries. Although uniform standards would be beneficial for trade, identical levels are not necessary for each country on the basis of cost-effective energy-efficiency.

Co-ordination of product testing procedures and measurement methods

Harmonisation of testing methods may be the basis of the uniform standardisation. Harmonised testing procedures and standards would be useful for producers present on several markets or “with an eye to” new markets since today they have to meet several, different national procedures entailing significant extra costs.

Minimum energy-efficiency levels

The introduction of uniform energy-efficiency minimum levels for the products would definitely improve energy-efficiency in several countries. Most probably mass produced and widely distributed products are suitable for the introduction of uniform energy-efficiency levels. The accord on the support of product distribution may be a part of the agreements among the countries. The trade of refrigerators and freezers happens mainly on local markets, in this way the parameters of the products distributed in different regions may differ significantly. Therefore primarily co-ordinated measures within the regions may be useful and there is no need to co-ordinate the testing procedures and energy-efficiency levels widely in their complexity. In the case of office equipment broad and co-ordinated introduction of energy-efficiency levels are more realistic. As a result of the fast technological development of office equipment standards are to be updated regularly.

Product standards are static instruments which hinder dynamic and innovative development. Thus impact may be decreased if the applied standards stipulate the compliance with the required levels and not the application of given technologies.

Control and implementation costs of standards may be significant for a wide range of products incorporated into the regulation. The lack of or inadequate institutional and legal background hinders the introduction, control and implementation of the standards. In certain cases the incorporation of the product standards into the existing environmental and energy regulatory system might cause problems.

Product standards hinder the commercial turnover of the products which do not meet the standard. Industry accepts new standards more readily if there is enough time between the announcement of the standard requirements and the introduction of the standard. If the period is too short the producers who cannot sell their stock not meeting the standard in time or who cannot change their technology to meet the higher requirements during the given period may resist.

VI.2.5. “Soft” measures: training, raising awareness and the promotion of technical development

Until the mid 90s the Hungarian Electric Works Joint Stock Company (MVM Rt.) and the gas and electric supply companies launched several public awareness campaigns affecting energy saving. To inform the public about energy saving MVM and the Capital Gas Company opened a demonstration and training hall. The Green Bridge Association in Pécs which was convened by the local energy supply firms to improve energy-efficiency and environmental protection also seems too be promising. The association publishes information booklets, organises school programs, public awareness campaigns and provides consumer consulting service. The Association for Technical and Nature Sciences (MTESZ) also attributes great significance to disseminating information relating to energy saving. In this field the most significant step has been the establishment of the Regional Energy-efficiency Centres of MTESZ. The civil environmental movements also play a significant role in the field of raising environmental-energy awareness. The national ENOUGH Campaign covering several media in 1996 was highly successful. In a further section of this chapter, we will examine education as an implementation strategy in detail.

VI.2.6. Case study for the role of foreign support: SCORE Energy-efficiency Program

The SCORE (Supporting the Co-operative Organisation of Rational Energy use) program is a common energy-efficiency program of the Dutch Government and the Hungarian Government, which started in 1996.

VI.2.6.1.1. Goals

A general objective of the SCORE Program is to establish and strengthen the institutions and mechanisms related to the improvement of energy-efficiency in Hungary. Specific goals of the program are the following:

- Support for national initiatives covering several sectors and several levels of social and economic processes (e.g. analysis of macroeconomic impacts of energy-efficiency and raising energy awareness).
- Introduction of local *implementable, reproducible and exemplary* measures which may significantly improve energy-efficiency in a given region of the country (demonstration region). The goal is to introduce the possibilities resulting from the co-operation of the interested parties. The main emphasis is on the establishment of and support for local institutional frameworks and the support for local energy-efficiency initiatives and investments.

VI.2.6.1.2. Operation

The basic feature of the SCORE Program is the open and transparent operation. The SCORE Program Office invites open tenders for development and energy-efficiency initiatives to be realised in the framework of the SCORE Program and publishes them widely. Invitations for tenders are published in the periodical, Tender Observer, national media and other professional publications and information forums. The tenders are invited according to the schedule of the program plan adopted by the Steering Body of the SCORE.

VI.2.6.1.3. Funding

Basic funding of the SCORE program is provided by the Dutch Government from the funds of the following ministries:

- Ministry for Environment;
- Ministry for Economics (through PSO program);
- Ministry for Foreign Affairs.

The Hungarian Government also provides some specific funds. In addition, the Hungarian Government expressed its readiness to provide assistance for the SCORE program from some existing funds such as Energy Saving Credit Fund, Central Environmental Fund and the Economic Development Specific Earmarked Assets. The participants of the SCORE Program themselves should also aim at seeking funding possibilities elsewhere e.g. applying for tenders for additional (EBRD, EIB, PHARE) resources.

Municipalities, equipment producers, services, suppliers of energy-efficiency technologies both on the Hungarian and Dutch sides are to be taken as potential supporters of the SCORE program. A Dutch town and a Dutch county for example have already expressed their intention to provide finances and assistance in kind to Hungarian programs through a sister city relationship.

VI.2.6.1.4. National tasks

On a national level there are two big topics in the SCORE program plan.

The study, **“Analysis of the macroeconomic effects of energy-efficiency”** looks at the long term strategic effects of the improvement of energy-efficiency covering several sectors. The work-group to be established with the participation of scientific workshops and non governmental organisations develops models and makes analysis regarding long term energetic plans, analysis of price and cost relations, external costs and contributes to the understanding of the effects of energy-efficiency on the central budget and the economic, environmental processes. The study will rank the instruments which the Government may apply as incentives for energy-efficiency.

The initiative, **“Raising energy awareness”** attempts to bring about favourable changes in the energy consumption habits and to encourage specific actions. The most important part will be the television series on energy-efficiency and will be broadcast by one of the national channels. The interest aroused by the TV series will be reinforced by background activities including e.g.:

- publishing information booklets on energy saving, publications related to the topics of the films;
- establishment of local consulting centres to answer questions;
- other co-ordinated media campaigns; and
- active participation of energy suppliers, producers, etc.

VI.2.6.1.5. Local and regional tasks

A Regional Energy-efficiency Office is to be established in the demonstration region selected through tender, and that will provide wide ranging support for different specific local and regional energy-efficiency initiatives and investments. Among others the following tasks are included in the plans:

- consulting service for energy consumers;
- raising energy and environment awareness;
- establishment of energy-efficiency regional coalition;
- demonstration of energy-efficiency investments and their realisation;
- assistance for funding the investments of energy consumers.

The goal of the SCORE program can be implemented and reproduced with the support of regional and local energy-efficiency investments and other initiatives and the demonstration of energy efficient solutions and developments in wide circles is exemplary. Therefore the establishment of and support for the demonstration region wants to strengthen the professional background of energy-efficiency activities in Hungary and the utilisation of the experiences of exemplary developments will enable the implementation of several energy-efficiency initiatives on the national level.

VI.3. The Feasibility of Implementation of Energy Efficiency Measures at the Demand Side in Hungary

VI.3.1. Introduction

Demand-side energy efficiency was discussed by the previous sections as an environmental technology. It was observed that while a part of the energy saving potential can be implemented at no or low cost, significant savings can only be achieved by significant expenditures.

Fortunately, energy efficiency has multiple effects. In addition to being a greenhouse-gas mitigation technology, it is basically a cost saving instrument. Applied intensively, energy efficiency can enhance the competitiveness of an energy user or an economy.

Energy cost saving may fully or partially justify energy efficiency measures. However, if the mitigation of the climate change is to be taken seriously, further expenditures have to be borne by someone. The question, “Who should pay for energy efficiency?”, has been on the agenda since the relationship between energy and the environment became clear.

In general the society should pay for it because the fight against climate change is serving the interest of the society itself. In the case of energy, the society can be represented by

- the energy users,
- the energy suppliers,
- the state, or
- other public authorities, such as the local governments.

Ultimately, the costs are paid by the people, who are energy end-users, and at the same time taxpayers. However, much depends on the way of allocating the costs on the people. The allocation can encourage or discourage efficient energy use.

The improvement of energy efficiency needs active participation by all the forces of the society, including the energy suppliers, industries, policy makers, energy end-users, etc. When outlining a strategy for a country, such as in the present case, special attention shall be paid to the participation of the state.

After introducing the characteristics of the present Hungarian situation, the general instruments of implementing energy efficiency strategies are reviewed in the following section. Finally, the instruments specially designed for the residential and public sectors are discussed.

VI.3.2. Characteristics of the Hungarian situation from a feasibility perspective

In terms of energy and environmental policies the Hungarian situation shows both similarities and differences as compared to the situation in the western countries.

Hungary is heading for a democratic political system and a market economy. However, eight years after the collapse of the centrally planned economy, Hungary is still in a transition, which is characterised by a painful social processes and a level of chaos.

It has to be remembered that the energy policy instruments designed for developed market economies are not always applicable in the transitional economies. For example, in Hungary there is much debate on the role of the state. In the centrally planned era the state had a decisive role in all segments of the economy. Now the Hungarians are trying to be more “capitalistic” than the classic capitalistic societies. They over-emphasise the role of the free market and minimise the responsibilities of the state. After 40 years of over-regulation now they are front-runners of deregulation. The policy-makers of today’s Hungary are very reluctant to launch central energy efficiency programs. They dislike the idea of increasing the level of redistribution (financing energy efficiency from tax money), and at the same time would not like to modify the tax system (a sensitive economic area) for environmental reasons. The present policy-makers basically leave the task of improving energy efficiency to the market. True market prices for energies will do the job, they claim.

Energy prices have significantly increased in Hungary since 1990. The trade of solid and liquid fuels has been liberalised, and the prices are determined by market forces (and taxes). The price of electricity and natural gas has reached a level which is enough to finance (re)production. These prices do not include margins for environmental investments of the production facilities (flue gas desulphurization, radwaste disposal, landscape rehabilitation, etc.). And, what is more serious, there is no provision for external costs, such as health impacts or the greenhouse effect. No special taxes are implied on energies (except for the motive fuels), and the VAT on electricity and gas is less than half of the VAT on any other products or services.

In the course of the 1989-90 changes Hungary demolished its old national institutions of energy efficiency policy. As explained by the above strong belief in market forces, no powerful institutions have been developed to replace the old ones. Today Hungary has no energy efficiency law, there are no departments in the relevant ministries specialised in energy efficiency policy, there is no national agency with proper authorisation and budget, etc.

Hungary is a small country influenced by its neighbours. It may not develop an environmental policy which is significantly different from the policy of the neighbouring countries and especially the EU. For example, it will probably never pioneer in introducing energy taxes. It will follow the European trends.

With regard to financing environmental programs (including the mitigation of climate change) it has to be understood that Hungary is rather poor. The country suffers from shortage of capital. Money is needed for several critical economic and social purposes. The environment, being a longer-term issue, with few immediate hard effects, is not very high on the priority list. The little capital that is available at the time, is used for shorter-term, survival-type programs.

Any Hungarian environmental program shall rely mainly on resources that are abundantly available within the country such as engineering knowledge, local labour, and the traditional wisdom of the people. The chances of capital-intensive efforts are low, and will remain low for the foreseeable future. The good news is that the Hungarians have not yet progressed very far in the way of developing energy wasting lifestyles associated with the consumer economy[19]. Per capita energy consumption is moderate, and if with proper policies the economic structure is rearranged, GDP growth is feasible for some time without significant growth of energy consumption.

There is a special characteristic of the Hungarian situation, which has to be considered when energy efficiency programs are designed. In Hungary, the energy supply industry has been extensively privatised. Typically foreign investors own most of the power generation companies, and all the gas and power distribution utilities. These investors are interested in profit generation and their enthusiasm for helping Hungary meet its environmental goals is limited. An example: the progress in introducing integrated resource planning and demand side management is very slow.

Finally, the position of the local governments deserves mentioning. In most of the western countries the local governments have good powers in formulating their energy and environmental policies. They typically own the local energy distribution systems, they have the right to influence the end-use

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[19] For example the thermal insulation of the Hungarian buildings is much poorer than that of the Swedish ones. However, the average size of the dwellings is much smaller, so the resulting household heating energy consumption is lower. The Hungarians are far from the materialistic consumption levels of the western countries.

energy prices, they are allowed to introduce local environmental regulations, etc.

The Hungarian local governments have much less possibilities. Out of the municipal energy supply systems they own only the district heating networks. The electricity and gas distribution systems are in the hands of regional utilities. The local governments have no influence on electricity and gas prices, which are regulated by the minister of industry and trade. They may only set the district heating prices but their freedom in this field is rather limited: the district heating organisations often buy the heat from power plants, whose prices are again centrally regulated.

The Hungarian local governments' possibilities in environmental regulation are also limited. The most important emission limits, pollution fees, etc. are set by the central government.

Finally, an important barrier at the local level is the lack of funds. The local governments claim that they are seriously under-financed. Their budgets are hardly enough to cover the costs of elementary municipal services.

With respect to the above considerations, under the present legal and administrative setting, one cannot realistically expect much financial investment from the Hungarian local governments in implementing climate change mitigation policies.

VI.3.3. Instruments effective in all end-use sectors

In this section the inventory of policy measures potentially applicable in Hungary for the implementation of climate change mitigation policies is presented together with comments regarding the chances of introduction.

Table VI-C

Instrument	**Chances of introduction**	**Comments**
Development of the legal economic and institutional background of energy efficiency (EE)		
Creation of an energy framework law	Real chances in the medium term	This law could clearly determines the responsibilities of the relevant actors.
Evaluation and modification of existing legislation from the aspects of EE	Real chances	There is, for example, contradiction between the public procurement regulation and the ESCO type activities.
More careful enforcement of existing legislation	Real chances	For example, the Hungarian building code compares to the international standards. Still, due to the poor enforcement of the code, a high % of the buildings is constructed with inadequate thermal properties.
Development of the organisational background of EE including development of ministry staff, unambiguous allocation of governmental tasks, development of national and regional EE centres.	Real chances on the longer term	The conception on the role of the state has to be re-evaluated.
Awareness development		
Integration of energy efficiency into all levels of education	Real chances in the medium term	The whole system of environmental education has to be re-evaluated, and a comprehensive program has to be developed. Certain elements of a possible EE education program era available from earlier efforts.
Awareness development campaigns	The only issue is financing	
Labelling	Real chances	Hungary will probably adopt EU practices. The development of labelling is hindered by the lack of accredited certification institutions.
Policy development		
Better preparation of energy related political decisions	Chances depend on political commitment	The conception on the role of the state has to be re-evaluated. The process of over-deregulating the state has to be stopped. It has to be understood by policy makers that the funds spent on proper preparation of political decisions are good investments.
Establishment of an EE data base	Real chances	A database, which could be established with modest expenditure could help policy development. The database could be continuously updated by data supply from implementers of EE projects.

Consideration of the aspects of EE at public procurement	Real chances	The public procurement regulation ought to be modified in such a way that EE is included in the scope of evaluation criteria.
Voluntary agreements with sectors/trades	Poor chances	The individual economic sectors and trades have not established their representation organisations yet, which could be negotiating partners of the Government.
DSM		See the evaluation of DSM later
Energy efficiency programs		
Energy audit programs	Good chances	According to the western experience state-organised audit programs are the most cost-effective instruments.
More support for R&D	Chances depend on the availability of funds	
Demonstration programs	Chances depend on the availability of funds	Demonstration programs could assist market penetration of EE technologies through decreasing the risk of users.
Energy efficiency upgrading of state-owned public buildings	Real chances on the longer run	The state itself owns a big infrastructure with hundreds of buildings. Energy modernisation of the buildings would serve two purposes, a) demonstrate the political commitment of the state, b) contribute to the implementation of national environmental goals.
Macroeconomic instruments		
Modification of the energy price and tariff system	Poor chances	The present price and tariff system was formulated through debates among the relevant parties. Modification of the system could be easily classified as disturbing a sensitive area.
Special tax credits for EE investments	Certain chances	The present financial government opposes interventions into the tax system.
Subsidies for EE investments	Certain chances	Certain subsidy schemes are already operated. The volume of investments mobilised by them is minimum a magnitude lower than the desirable volume of EE investments.
Tax reform	Chances only on longer term	The present political course opposes interventions into the tax system. Getting through a major tax shift (what would be most desirable) would be difficult. Much depends on the developments within the EU.

VI.3.4. Special instruments for the residential and public sectors

VI.3.4.1. Energy service companies

Energy service companies, or ESCOs were invented in the Western economies after the oil crises to help “layman” type energy end-users which typically lack experience in project development or are in short of capital. ESCOs offer complex services, including

- identification of energy saving opportunities (by the help of energy auditing)
- development and evaluation of energy efficiency projects
- (arrangement of) up front financing
- project implementation
- (supervision of) operation
- monitoring of energy savings
- accounting of costs, etc.

When central planning ceased to exist in the economies of Central and Eastern Europe, a strong belief appeared that ESCOs can cope with the difficult task of energy efficiency improvement, mainly in the public sector. Western advisors, including those of the multinational development banks emphatically supported this belief. They thought that the public institutions (schools, hospitals, public buildings, etc.) lacked both capabilities in project management and capital (or creditworthiness) for investments.

In the forthcoming section we attempt to review the history of ESCOs in Hungary, the barriers of development, and the tasks to be solved in order to help development.

VI.3.4.1.1. ESCOs in Hungary

The first ESCOs appeared in Hungary immediately after the political and economic changes of 1989-90. Most of the ESCOs were owned, and in many cases managed, by western companies. HESCO, SRC, or Vattenfall are examples from this early period. All the mentioned ESCOs established some kind of subsidiaries in Hungary and started marketing and project development. Hundreds of potential clients were contacted and a great number of project concepts were developed. However, within a couple of years it became clear that the real market for ESCO type services is rather limited and the risks are too high compared to expectable profits. The “big western” ESCOs withdrew from Hungary without creating real success stories.

At the same time, Hungarian vendors appeared on the scene. Many of them were trying to harness the cost saving potential of the fuel switch (from light fuel oil to natural gas) projects. Some of them were simple boilerhouse installation vendors who were ready and able to arrange some kind of financing. A couple of them were “adventurers” who made impossible promises for the clients. The activities of such “adventurers” largely contributed to the bad reputation ESCOs have today in Hungary.

The Hungarian ESCO "Credilux" can be mentioned as an exception. They specialised in public lighting retrofits and could implement several projects. Their success can be explained partly by the fact that they inherited much of the experience of ÁEEF, the former state organisation responsible for issuing public lighting development licenses.

Some years later the Hungarian combustion services company "Prométheusz" was privatised by the big French company Compagnie Generale de Chauffe (CGC). They were the first, and are still the biggest, vendor in Hungary to offer French type energy services, which means that the service company takes over the operation of energy supply systems for the contractual time of minimum 15-20 years. Prométheusz generally modernises the overtaken energy hardware. Still, their activity is not considered by everyone as an "ESCO" activity because they upgrade the systems for themselves. The lifetime of the upgrades is rarely longer than the contractual time, and some of the clients doubt that the savings appear in the contracts. EBRD supports Prométheusz by loans.

Landis & Gyr, the famous manufacturer of control equipment, established a real ESCO in Hungary a couple of years ago. They have the intention to utilise the experience they has earned in other countries with energy rationalisation. They started to develop projects in hospitals, schools, public buildings, and state owned companies. The merger of Landis with Staefa has not changed the position of their Hungarian ESCO.

Honeywell is considering the establishment of a similar ESCO. They also have international experience and would like to work in Hungary in co-operation with local business organisations.

The biggest Hungarian commercial bank, OTP is working on the establishment of ESCOs. They have teamed up with Energovill, a Hungarian engineering company specialising in public lighting. According to the publicised information many local governments have already expressed their intentions to enter business relations with the OTP-Energovill ESCO. OTP also plans to establish another ESCO for mechanical/thermal engineering projects.

In addition to the above big ESCOs that operate nationally there are several smaller ones, which typically work only locally. Most of them are installation companies willing to boost their sales by the ESCO approach.

Certain commercial banks such as Raiffeisen-Unicbank offers flexible financing services for energy efficiency projects. Although they are not true ESCOs by strict definition, they help their clients with a variety of services, including assistance in project development.

The Hungarian Government is considering providing institutional help for ESCOs. The Government will soon discuss the possibility of providing financial guarantees for ESCO projects.

There is international help available. The Global Environmental Facility (GEF) allocated $5 million USD for energy efficiency projects in Hungary. It was decided that the money would be made available as a financial guarantee for selected financial institutions that offer third party financing for energy efficiency projects.

VI.3.4.1.2. Barriers

Certain western advisors show ESCOs as a panacea that is able to overcome the difficulties of energy modernisation in Hungary. Their view is based upon the following observations:

– there is a big untapped energy conservation potential in the public sector
– the public institutions do not have the experience themselves to develop good projects
– in addition to that they do not have funds, and in most cases are not creditworthy
– investment money is available at the multinational development banks (MDB's) and a number of commercial banks.

The advisors presume that the ESCOs can bridge the gap between the non-creditworthy public organisations which have good project possibilities and banks which are not interested in small loan projects.

Unfortunately, the above reasoning is too simplified. To have a true understanding of the causes of why the ESCO business is not spreading according to the expectations, some additional points have to be considered:

1. Historically, most big Hungarian institutions used to have energy managers who did have experience in project development. Many of them still have one. Institutions with in-house capabilities may not welcome external advice (the ESCOs are providing).

2. Implementation of an energy efficiency project through ESCO costs inevitably more for the owner than implementation by its own organisation, if management capabilities are available within this organisation. The difference is the cost premium of the ESCO, which includes insurance, overhead costs, and profit.

3. An ESCO project may need complicated monitoring and accounting exercises. If interventions are implemented in complex systems (e.g. the energy system of a big hospital) the allocation of savings may be questionable. If the parties do not trust each other, tiresome disputes may spoil the attractiveness of the affair.

4. ESCOs are unable to take risks that are too high. It is simply not true that they can enter into contracts with non-creditworthy clients. They are in no better position to manage risks than the banks (In fact, they are in a worse position).

In addition to the negligence of the above points the activities of ESCOs are hindered by the following barriers:

Many potential clients do not know enough about the ESCO approach. They may be unable to select the proper ESCO and negotiate the terms. All this may discourage them to work with ESCOs. Due to the earlier activities of "adventurers", the ESCOs reputation is not high enough. Many potential clients are unable to provide proper financial guarantees for the ESCOs. State-owned institutions are, for example, not allowed to enter into contract with ESCOs, if the deal imposes any threat on the national budget. The Hungarian legal system is not fine-tuned to encourage ESCO projects. For example, the Public Procurement Law does not allow the issuing the tender invitations for any investment type projects, if the funds are not available.

VI.3.4.2. Demand side management

It is also of critical importance that DSM activities are started by the Hungarian utilities. DSM has been intensively studied by both the government and the energy industry since the changes in 1989-90. Still the progress is very slow at the present time no one can tell when real DSM activities will start in Hungary.

The major argument against DSM by the utilities is that it is a cost intensive activity and the financing is not solved. Various models are known in the world for financing DSM. Regarding the Hungarian situation the financing model should rely on the political and economic possibilities existing in Hungary today. There is a “soft” introduction path, which is able to collect experience on DSM without spending too much tax money or without posing unbearable price increases on the energy consumers. The following procedure can be suggested.

1. The relevant regulatory authority (the Hungarian Energy Office) unambiguously defines what should be meant by DSM.
2. The authority expects that the utilities review the potential of the demand side energy efficiency improvement in their service area. This kind of activity does not require heavy financing as the costs of a study are negligible for the utilities.
3. Based on the studies of the individual utilities the authority summarises the results of national bases. The resulting potential figures and cost functions can be important inputs for policy making.
4. The regulatory authority expects that the utilities actively participate in the awareness development of the consumers. The occurring costs are put into service prices. The cost of such activities are again negligible compared to the sales volume of the utilities.
5. The authority encourages the utilities to offer DSM services for their consumers on a paid basis.
6. If all the above activities have been applied in practice, enough experience will be available to decide on further steps.

It has to be noted that DSM was removed from the agenda after the collapse of the centrally planned economy because the power demand of Hungary has dramatically dropped. It was clear that the utilities did not show enthusiasm for any program having the potential to further decrease the demand. Since then, the situation has significantly changed. The electricity demand is continuously increasing and an ambitious power plant development program is ahead of the Hungarians. However, effectively and efficiently implemented, the DSM programs could replace a part of the power plant development efforts (and expenditures).

VI.3.4.3. Energy awareness campaigns

Energy awareness campaigns are known as cost-effective instruments to bring about behavioural changes in the residential sector.

Awareness campaigns may take various forms and may have different contents. The little experience gained in Hungary with EE awareness campaigns so far suggests the following points:

1. The campaigns should use a multiplicity of communication tools, including mass media, educational programs, brochures, etc. Communication through commercials shall be avoided.
2. The campaigns should be supported by organisations (advice centres).
3. As the environmental awareness of the population is rather low, the message of the campaigns should be primarily cost saving. At the same time generating the perception that energy efficiency is a strategy of the poor has to be avoided.
4. The content of the campaigns should be carefully designed depending on the target group. Feasible ideas and examples for implementation should be presented.

VI.4. Feasibility assessments for carbon sequestration by forestry practices in Hungary

Hungary has a long tradition in accomplishing afforestation programs. After the peace agreement of the First World War the forestation of the country was around 11%. To increase the forested area and to provide the country with forestry products a new afforestation program was announced. The aim of the afforestation program in the Great Plain was to improve the environmental conditions there. In spite of the program declaration the actual work begun only in the year of 1950. As a result by the year 1990 more than 600 thousand hectare of new forests was established. The program slowed down in the 80s, and the area of the new afforestation decreased by a half. The program resulted in 19% increase of forest-land nowadays (of conifers, soft broad-leaved and Black Locust) and a higher proportion in the harvest. The close-to-nature stands grow on about one half of the forested area, and their area has not become less. In spite of the large new afforestation areas the country is in the lower third of the rank among the European countries regarding forestation. Because of this fact the Forest Development Concept of 1974-75 suggests that 255 thousand hectares be planted by the year 1990. In many places green belt plans for cities and global afforestation plans for counties were prepared. In the mid 80s the Hungarian Academy of Sciences and the Ministry of Agriculture and Food elaborated a long term afforestation program with some 700 thousand hectares of new forests. In 1991 the new government took the proposals of the former government which suggested 150 thousand hectare of new afforestation by the year of 2000 for rational land use, reducing forest products import an increasing the recreational and protection functions of the forests. In the long run the new afforestation of 800 thousand ha is planned. Several studies were prepared for the alternatives of agricultural production, and for the alternative uses of agricultural lands. Out of the 2.7 million hectares of agricultural land with poor conditions for agricultural production, 700 thousand hectares are considered as suitable for alternative uses (forestry, grazing).

The Department of Forestry within the Ministry of Agriculture prepared an inventory of the possible areas for new afforestation, and based on this, from the year 1991 about 735 thousand hectares can be newly afforested. These areas will be first of all privately owned (because of the minimal 80% private ownership of agricultural land). Because of this fact, problems in land ownership and the lack of central funds, the programs slowed down, the afforestation rate decreased from annual 6-7 thousand hectare to 3-4 thousand hectare. From 1991 to 1996 only 31 thousand hectares of new forest were established with state support.

The demands of the society require an additional increase in forested areas, and based on this demand this increase is a common goal for the society. In accordance with the principles stated in the National Agricultural Program a National Afforestation Program has been declared in 1997, which would increase the afforestation of the land by 8.3 % up to 26.8 %. The new forests will be planted on agricultural land, and as a result the proportion of agriculture decreases by 12.6 %. The National Afforestation program can be divided into two stages. The first stage, starting in 1991 assumes the planting of 150 thousand hectare, and the second from 2005 to 2035 the planting of 623 thousand hectares. The program is supported by the Hungarian Government and by the European Union by reaching the following main objectives:

– Supporting the establishment of new forests in unfavourable areas for agricultural production
– Employment possibilities for rural entrepreneurs
– Protection and improvement of rural environment
– Improving the wood supply of the country, enhancement of wood exports possibilities

The second stage, the planting of 623 thousand hectares, shall be accomplished by an annual rate of 20 thousand hectares.

The primary function of the newly planted forests shall be 75% economic and 25% protection of forests. This emphasises the importance of the protective forests. This is in accordance with the principles of sustainable development declared in Rio by the UNCED: the material and infrastructure needs should be satisfied without any harm to the forest fond. The scenarios outlined for CO_2 sequestration are also feasible in accordance with the National Afforestation Program.

VI.4.1. Feasibility of short rotation coppice wood-for-energy plantations

Short rotation coppice is an energy crop, usually established with hybrid poplar or willow, which is used to produce either heat or electricity or both. This crop is known usually as woody biomass and is a type of renewable, carbon neutral energy resource. Short rotation plantations as renewable energy development are generally considered to be environmentally beneficial, but can have local impacts. It is the responsibility of the settlements to consider the environmental impacts, economic viability and acceptability to local communities of each scheme. Theoretical support and guideline are available for producers at proposed short rotation coppice projects.

Short rotation energy plantations are a new industry with a potential for considerable expansion, offering benefits for growers, developers, consumers, local communities, the environment, as well as biodiversity (ETSU, 1996). The developer of a new bioenergy supplied power or district heating plant should usually take overall responsibility for any larger scale wood-for-energy project. They should specify to growers the form in which the fuel is required for the power plant, and may have significant input into ways in which the crop will be managed, harvested, stored, and transported; they may even undertake the harvesting themselves. The developer will wish to have confidence in all aspects of the project since the power plant is likely to require a substantial financial commitment. The grower will have concerns about the economic viability and practical aspects of growing woody biomass as a crop, as well as being sensitive to the environmental and local concerns.

Local communities are likely to be affected by the renewable energy production projects as a result of transporting the crop to the power plant; the construction and operation of the plant itself; changes to the landscape created by the coppice plantations; the potential for increased local employment both in growing the crop and in energy production, etc. The extent to which communities are affected depends on the scale of the scheduled project. However, even small scale on-farms schemes will have an effect on neighbours and will require some early and continuos consultation.

Although the “Green” movements are likely to oppose short rotation forestry, it may be more beneficial for nature conservation than the previous agricultural crop on arable land. Narrowly spaced tree plantations have grater potential to encourage wildlife diversity than any other raw crop grown by Hungarian agriculture. They can provide habitats for large number of insects, birds, little and big mammals.

Detailed designs of the plantations are required to maximise the benefits of a short rotation coppice system in terms of productivity and environmental impacts, while avoiding detrimental effects on the landscape or conservation values. Planning should include site assessments and soil evaluation, and it should cover water availability and use, species selection and planting material, site preparation, planting methods and spacing, chemical and mechanical weed control, pest and disease control, rotation cycle, harvesting methods, storage and transportation, etc. Harvesting methods and machines to be used have a priority in planning of spacing and rotation age. Low cost technologies are likely to be used due to the Hungarian social conditions today and in the near future. Low cost technologies usually use less fertilisers as well as pesticides and other chemicals, and are thus sustainable and also are environmentally beneficial. Farmers could plan and cultivate their small-scale plantations with the consultants, but large-scale development needs more attention and support from the side of the plant developer. Practical guidelines for local consultants should be prepared by the experts of short rotation forestry systems focused on the Hungarian ecological, technical, social, juridical and economic conditions adapting available bits of information in the technical literature. Relevant German, Swedish, Finnish, English, Canadian and US papers include all the necessary pieces of information, but they may not be useful for Hungarian growers without translation and adaptation.

For large scale developments the developers should usually have overall responsibility for managing the consultation process as they will be responsible for the development of the plant, as well as influencing the growing, harvesting, storage and transportation of the crop. However, the growers will also want to manage their activities in a manner which is sensitive to the environment and local concerns, and may substantially contribute to the consultation process. Development may sometimes in a form of a community project, run by local people. However, this does not eliminate the need for wide consultation and involvement. The project leaders for the development will need to identify all the likely areas of concern and involve interested groups at the most appropriate stages. Different stakeholders will have concerns about different aspects of the project, as, for example, the visual impacts, the noise from construction, or the emissions from the plant, etc. Growers usually require help of experts for site assessments, soil evaluation, planting design, weed and pest control, harvesting and chipping methods, etc.

VI.5. Case study 1: Carbon/energy tax as an implementation tool for the reduction of CO2 emissions in Hungary

VI.5.1. Introduction

This section shows to what extent can an economic regulator, the carbon/energy tax, be an efficient tool in the reduction of greenhouse gas emissions, but mainly carbon dioxide.

There are a lot of tools for the reduction of greenhouse gas emissions which are approved by many countries: energy/carbon taxes, tradable quotas, refunding incentive mechanisms, and subsidies.

Since the energy/carbon tax has a direct influence on the emission of carbon dioxide, and since the largest emitter of carbon dioxide is the energy sector, our study focuses on the analysis of the emissions of carbon dioxide by the energy sector.

VI.5.2. The Hungarian energy sector and the use and taxation of carboniferous fuels

For a detailed description of the Hungarian energy sector and carbon emissions, please see the earlier chapters of this document. We emphasise the following important references related to the electric energy sector:

1. In Hungary in the year 1993 the monetary value of damage caused by fossil fuel use related to air pollution was estimated to be 40 - 430 billion HUF. These damages themselves necessitate some way of internalising the externalities. One of the potential instruments of internalisation is the carbon/energy tax. Fossil fuels are, however, already taxed in Hungary: revenues from non-environmental taxes on fossil fuels were estimated to be about 130 billion HUF in 1993. For this reason we propose to investigate the alternatives.

2. The analysis of the contribution of different fossil fuels to environmental damage indicates that coal and lignite cause the major part of the damage. Therefore it can be useful to investigate internalisation alternatives that pay special emphasis to the type of fossil fuels (solid, liquid, gas, nuclear).

VI.5.3. Qualitative analysis of the economic regulators suitable for the regulation of carbon dioxide emission

If we take only the carbon dioxide emissions into consideration the following charges may be used to account for extrenalities:

– emission charge (based on the quantity of the carbon dioxide emitted)
– product charge on fuels (based on the carbon content of the fuel)
– energy tax as product charge (based on the quantity or value of the energy generated by coal-based fuel)
  or any combination of these

VI.5.3.1. Taxation of generated energy as product = energy tax

Taxation of energy is a question that intensely joins the interests of the public accounts, economic development and the environment. The moving toward open market energy prices is also advantageous for *environmental policy*, which is striving for the internalisation of externalities caused by the energy sector.

It is possible to levy a tax on the processed, secondary energy sources instead of taxing the primary ones. This way electric energy and products of oil processing would be covered as well.

VI.5.3.1.1. What should we understand about the energy tax?

How do we define energy tax? The taxation of fuels and the taxes levied on them are different from country to country. There are two types of taxes in the OECD countries: either a low-level consumption tax on fuels or taxes on fuels themselves, or the transformation of a whole tax system by a wider application of environmental taxes. In the latter option certain taxes are set by taking into consideration environmental parameters and environmental effects.

VI.5.4. A combined system: the carbon/energy tax

The basis of an energy tax usually lies partly or entirely on carbon dioxide emissions, since the application of the pure carbon tax is well connected to the reduction of greenhouse gas emissions. Its introduction would affect most seriously the coal-fired power stations, while the costs of electric energy generated by nuclear power stations and power stations operating on renewable bases (water, biomass, geothermal) would remain the same. Liquid fuels are in a better situation in terms of taxation compared to solid fuels which have less polluting potential. For this reason and to stimulate the use of alternative/renewable sources, carbon tax seems advantageous. At the levy of energy tax the consideration of energy content would partially offset carbon-taxing: it would strike fuels with larger nominal (kg, cubic metre) energy content but less polluting potential (oil, natural gas) and it would tax the electric energy generated on a nuclear basis in Paks, as well energy generated on alternative basis.

VI.5.4.1. Emission reduction potential

In 1995 Tajthy made a model on several scenarios of carbon/energy tax. The scenarios were the following:

Table VI-D Table 4-2 Tax scenarios according to Tajthy (1995)

	carbon tax content	energy tax content
A	0	0
B	from 2000 5000 HUF/t C, from 2010 10000 HUF/t C	0
C	from 2000 10000 HUF/t C, from 2010 20000 HUF/t C	0
D	from 2000 35 ECU/t C	from 2000 0.7 ECU/GJ

We think that such scenario is the most realistic which says that the significant development in the Hungarian economy will take place around the millennium and the requirements of energy in 2000 will be equal to the level of 1993-1994.

So in Tijthy's model, the change of carbon dioxide emission is the following:

Table VI-E Table 4-3 Expectable trends of carbon dioxide emission in the single tax scenarios according to Tajthy (1995) [million tons]

	1995	2000	2005	2010
A	65.66	67.37	71.72	75.62
B	65.66	65.77	68.64	71.60
C	65.66	64.40	67.20	68.81
D	65.66	64.50	67.31	71.71

It can be seen that applying the charge above, the carbon dioxide emission is not decreasing but increasing. In our study we try to give an estimation for the ways in which the introduction of a carbon/energy tax would effect companies emitting carbon dioxide.

VI.5.4.2. The costs of emissions reduction

Since there is no realistic technological opportunity of decreasing the amount of carbon dioxide after its formation now and in the near future, there are three basic opportunities beyond the simple reduction of production for the producers and the consumers of energy.

The first is a change in fuels, namely the reduction and elimination of coal content in energy production. The second is an improvement in energy efficiency. The third is a consumer side decrease in energy intensity.

Since the third option is analysed by a separate study ("Épületfenntartási K+F Alapítvány: Lakóépületek energiamegtakarítási lehetőségei Magyarországon , 1993) within this project we deal with only the first two.

VI.5.4.2.1. A model for emission reduction

We model the first alternative with the following scenario: we assume that the country sets the objective to abandon the generation of coal based electric energy with the largest carbon dioxide emissions. The country "distributes" its available capacity, 2030 MW in 1993, to power stations running on nuclear and hydrocarbon (natural gas) power.

We also assumed that the overall energy consumption of the country does not increase, there are no barriers to enlarging the nuclear-based energy generation and there are no market barriers in buying additional hydrocarbon.

According to our scenario, in this case to achieve the nominal capacity of about 7 GW, two nuclear blocks would need to be installed (440 MW of each). The remaining 1150 MW capacity would be covered by modern hydrocarbon-based power stations.

Since the national coal- and lignite-based power station fleet is old and out of date, it is necessary to reconstruct these units and change these old power stations to modern ones. We can consider the costs of the reduction of carbon dioxide emission equal to the cost difference between nuclear and hydrocarbon-based energy generation and the coal-based energy generation. Our costs data comes from Fazekas (1996).

Table VI-F The costs of coal-based energy generation are:

type of power station	utilisation time[20] (hour/year)	resulting production cost (thousand HUF/MW)	capacity[21] (MW)	generated electric energy (GWh)	cost[22] (million HUF)
lignite	5 500	29 590	800	4 400	23 672
coal[23]	4 000	33 076	1 230	4 920	40 683
total			*2 030*	*9 320*	*64 355*

Table VI-G The costs of substitutive energy production:

type of power station	utilisation time (hour/year)	resulting production cost (thousand HUF/MW)	capacity (MW)	generated electric energy (GWh)	cost (million HUF)
nuclear	7 600	37 108	880	6 688	32 655
hydrocarbon[24]	3 000	28 877	877	2 632	25 325
total			*1 757*	*9 320*	*57 980*

The cost of substitution is 57 980 - 64355 = - 6375 million HUF in the case of 320 GWh, the average cost of substitution per unit is - 684 thousand HUF / GWh.

Table VI-H The reduction of carbon dioxide emission by substitution:

	change in electric energy production (GWh)	nominal emission (ton of CO_2/GWh)	change in carbon dioxide emission (thousand ton)
lignite	-4 400	1 305	-5 742
coal	-4 920	1 540	-7 577
hydrocarbon	+2 632	613	+1 613
nuclear	+6 688	0	0
balance:	0		-11 706

So it is possible to calculate the average cost per unit for the reduction of carbon dioxide emission: - 6375 million HUF / 11.7 million tons carbon dioxide = - 545 HUF / ton carbon dioxide.

[20] Rounded figures of the Hungarian power stations on the basis of the average utilisation in 1995.
[21] Built-in electric efficiency
[22] In the case of 8 percent discount rate, without taxes, insurance and rate of return on assets.
[23] Import black coal.
[24] Condensing power station unit with combined cycle, on natural gas basis.

We assumed the following at the composition of the marginal cost curve:

– firstly, we "abandon" the coal-based power stations with larger nominal carbon dioxide emission and with higher resulting production cost;
– as a second step, we substitute the lignite-based power stations;
– to maintain the balance between the base-load power stations and peak-load power stations we follow these steps: firstly we "install" the first nuclear block (440 MW), then the first half of the coal capacity (440 MW), then the second nuclear block (440 MW), and finally the second coal capacity block (437 MW).

Table VI-I The course of substitution is the following:

leave	**MW**	**GWh**	**million HUF**	**enter**	**MW**	**GWh**	**million HUF**	**balance (million HUF)**	**marginal cost (million HUF/GWh)**
coal	836	3344	27 651	**nuclear**	440	3344	16 328	- 11 323	- 3,39
coal	330	1320	10 915	**hydro-carbon**	440	1320	12 706	- 1 791	- 4,07
coal	64	256	2 117	**nuclear**	34	256	1 262	- 855	- 3,34
lignite	561	3088	16 600	**nuclear**	406	3088	15 066	- 1 534	- 0,49
lignite	239	1312	7 072	**hydro-carbon**	437	1312	12 619	+ 5 547	+ 4,23

The reduction of carbon dioxide emission taken out by the substitutive steps

Table VI-J Figure 4-1 Marginal costs of emission reduction

step	**million HUF/GWh**	**- CO_2 (thousand tons)**	**+ CO_2 (thousand tons)**	**CO_2 change (thousand tons)**	**cumulated change**
1	-3,39	5 150	0	5 150	5 150
2	-4,07	2 033	809	1 224	6 374
3	-3,34	394	0	394	6 768
4	-0,49	4 030	0	4 030	10 798
5	+4,23	1 712	804	908	11 706

According to the second, theoretically analysable option the efficiency of energy production is growing, so more electric energy can be generated by a unit of coal. This means that carbon dioxide emissions are decreasing at the generation of a unit of electric current.

VI.5.4.2.2. Conclusions

On the basis of the aforementioned marginal cost curve we would assign a serious role for carbon taxes since they would stimulate a wide scale of emission reduction. We have two reasons not to do so:

1. The dubiousness of reliability of data used in the calculation
2. The non-market characteristics of the Hungarian electric energy sector

The most dubious is the reliability of the costs of nuclear power stations. According to several Hungarian researchers the hidden subsidies from the state are not taken into account.

But now we examine the other factor in a more detailed way, on the basis of the thorough study of Paizs (1997). The production, transport and distribution of electric energy takes place under monopolistic conditions defined by the act on electric energy of 1994.

On the production side the power stations operate on the basis of a permit valid for a given time period. Except for the power stations producing for not their own use (public purpose power stations), they are obliged to offer their entire capacity for the supplier, they are not allowed to sell electric current to someone else (single buyer model). The entry of a new power station is strictly limited. The supplier invites tenders for power station construction every two years in which the size, type and fuel of the necessary new capacity are given. This means that it is not possible to install a power station unless it fits into the establishment plan of the state-owned supplier. Typical attributes of the single buyer model are the centralised strategic decisions and the *restricted role of price signals* in the allocation decisions.

Electric energy is a product with an officially maximised price. The prices are set by the minister of industry and on the basis of a method defined in a legal rule. In Hungary the price regulation is a regulation of return on capital employed type which guarantees an 8% rate of return on assets for the producer. The producer can also assert the additional costs resulting from the tightening of environmental regulations in the price.

In such a system the stimulating effect for emission reduction of a carbon/energy tax is not working, the producer asserts the additional cost caused by the tax in the price. Otherwise, the change in fuel must be approved by the supplier.

The supplier's decision on the fuel is likely determined by more important national factors than global climate change since it is a state-owned company.

The consumption of electric energy is characterised by price inelasticity.

Taking the aforementioned issues into consideration, we can draw that:

- a carbon/energy tax levied upon the producer does not stimulate the reduction of carbon dioxide emission;
- such a high carbon/energy tax which can force the consumers to be saving or to decrease the energy intensity is politically not viable;
- therefore the carbon/energy tax has only the role of creating monetary basis;
- so its efficiency is defined by the spending of the such generated revenue.

This is why the institutional issues of taxation are important.

VI.5.4.3. The role of carbon/energy tax in the implementation of emission reduction options

Further on, we examine the political efficiency of carbon/energy tax in the implementation of emission reduction options described in this research project.

Since there was no possibility to make a complex cost-benefit analysis, we chose to take the tax degree recommended by the EU for the basis and we examined to what extent can such a tax promote the implementation of reduction options proposed.

According to other studies of this research project the three optimal reduction options are reduction of heating energy, reduction of electric current, and the reduction of energy use of hot-water of use.

All the options touch households and the institutional sector. The levy of carbon/energy tax would take place in a way that the tax would be actually paid in by the energy producers which would be built in the price of products (electric current, distance heating) (see 4.2.2). The question is the efficiency of carbon/energy tax, if it is an indirect effect in the energy price to the consumers.

Two options out of the three are true that their marginal costs[25] are negative in the entire or the most of the domain. In these two cases (electric energy and the use of hot-water) there is no need for serious financial incentives but for harmonised state subsidies, measure for information and public awareness, and political intentions. The stimulation can play a role in the reduction of heat energy where marginal costs are positive in a wider domain.

An optimal tax degree cannot be determined without the knowledge of marginal utility of reduction options, but we can compare it to the tax degrees recommended by the EU[26]. Or we can try to answer the question whether which tax degree can stimulate to reach a set level of savings.

If we examine the latter option, the question is: if we want to realise a 30.000 TJ decrease in the long term with 3% discount rate, then the introduction of which carbon/energy tax will result in 20.000 HUF/TJ rise in the price of fuels? Nevertheless, distance heating is the relatively most expensive heating method in Hungary (but not in western Europe). The reasons are that there are vast losses in the distance heating system because of, firstly the transport to large distances, secondly the ill-isolated network, and thirdly most of the households have no possibility to alter their temperature. The "extra price" covering these losses can be regarded as a kind of "extra tax". The tariffs of distance heating are too high compared to the average income of the consumers: an average flat (50-60 square metres) costs 10.000 HUF for distance heating. This is one-fourth to one-fifth of the Hungarian average

[25] The marginal costs of reduction options are calculated in the medium terms (till 2010) and in the long term (till 2030) with 3 and 5 percent discount rates.

[26] See Table 4-2.

salary! In our opinion, in this situation consumers would have an incentive to make investments that would help save energy if 1) individual measurements of heating is compulsory, so the flat rate would cease to exist, and 2) if there is a preferential credit granting system which helps households to implement savings strategies.

Based on these facts we do not consider the carbon/energy tax as an optimal tool for direct incentives of the three chosen options. Carbon/energy tax would have, however, a role in creating this if the revenue received from it is used to in turn to support the actions above.

VI.6. Case study 2: The educational and training objectives of the mitigation scenario

A number of both international and domestic experiences prove that particular persons participating in the organised and school-system like environmental education may play a very important transmission role in improving other groups and age-classes of society. The importance of environmental education of school age-classes is confirmed by the following factors:

1. The school age-classes form the biggest and most sensitive group of society.
2. The environmental education and approach formation are the least expensive environmental investments.
3. The school age-classes have a considerable multiple effects on the other groups of society.
4. The present school age-classes are potential decision making experts and consumers for the next few decades.

The scenario for the control of greenhouse gas emission in Hungary is particularly based on the economical and legal incentives and as well as the prospects of technical and technological development. The environmental protection and environmental economics information built into the system of education and training is one of the best ways of forming environmental sensitivity.

The Hungarian **National Environmental Protection Programme** (NEP) (National AGENDA-21.) also gives a distinguished and strategic importance to the improvement of public involvement and consciousness (see NEP, Chapter 3.1.6) in handling those important environmental problems to which the control scenario applies to. The increase of public awareness, education and professional training (see NEP, Chapter 3.2.5) as well as information, mass media and professional environmental communication (see NEP, Chapter 3.3.6), is considered by the programme key areas of the implementation of environmental objectives.

The energy sector (see NEP, Chapter 3.2.1.1) is also considered a key area by the NEP. Two of the nine planned and recommended energy efficiency programs mentioned in this chapter directly affect public involvement as well as education and communication objectives. One is the

National Energy Saving Action Programme that aims to spread the "proper housekeeping" method, i.e. the scope of the implementation of the program is the household. The other is the National Environmental Health Action Programme that considers the rationalisation of energy consumption in the workplaces and households, as well as the related educational and propaganda activity, as an important part of evolving a healthy way of life and living conditions.

The above mentioned items of the Hungarian national program for sustainable development actually document the importance of education, training and communication in relation to implementing the scenario for Hungarian emissions control of greenhouse gases. In the remaining part of this section, we will examine the organisational frameworks, results and tasks that affects the objectives of environmental education and training as well as the public approach formation and particularly the energy efficiency problems of greenhouse gas emission control.

We are aware that this positive environmental approach itself will not thoroughly solve any of the environmental problems, but it may amplify the effectiveness of the "offered" economical incentives. The apperception and implementation of concrete environmental objectives must be supported by a complex set of tools such as those outlined below, particularly in case of countries in a transition stage, such as Hungary. This theorem is also emphasised by some UN documents (e.g. BRUNDTLAND Committee report, Rio documents – operating AGENDA-21, GEF):

1. Organised education and training at school (public education: elementary education, secondary education, vocational training, higher education).
2. Professional institutes, organisations (policy offices, local governmental organisations, special institutes).
3. Civil organisations (environmental associations, local autodynamic movements, special clubs).
4. Other areas (media-press, lyceum).

VI.6.1.1. Organised education and training at school

The importance of environmental education of those involved in organised education at school has been already mentioned in this study.

The fundamental document of public education in Hungary is the National Core Curriculum (NCC) in which the common requirements of education and training prescribed for every Hungarian school is determined for the first ten grades of the twelve years long general compulsory education. The practice of compulsory central control is no longer used. Instead, it provides a base for the development of local syllabuses, programs, textbooks and teaching tools as well as examination requirements. The possibilities of environmental education and training at school are improved by that in some aspects: **(a)** The requirements are defined for single cultural domains as unified requirements, not for subjects, thus more favourable conditions have been established for integrated education, which is also a basic condition of environmental education. **(b)** The prescribed unified requirements can be achieved in 50–70 % of the available lesson time, the remaining part may be used for other aims. **(c)** Two of the single cultural domains (Humans and nature, Our Earth and the environment) directly aim the formation of an environmental approach and obtaining information, and one (Lifestyle and practical skills) supports it indirectly.

Environmental education is considered a fundamental requirement of modern education by NEP. It should influence all the elements of the education at school. The requirements of the NCC provide a **legal and organisational** frame for important environmental education and training problems such as the issue of global climatic change, the role of energy utilisation in the emission of greenhouse gases, the importance of reducing and rationalising energy consumption, the objectives of energy efficiency on a national and household level. As 30–40 % of the total lesson time is defined "free" by the NCC, the discussion of these problems at school is also possible. Within this limit, instructors can budget time on their own.

The ministries (Ministry for Culture and Public Education and Ministry for Environment and Regional Policy), pedagogue groups (Hungarian Environmental Education Association and Natural and Environmental Protection Teachers' Association) and civil environmentalist organisations (e.g. Air Workgroup, Energy Club, KÖRLÁNC) interested in environmental education and training developed a number of **recommendations, guides, and programs** respectively as well as co-operatively in order to assist the development of curriculum and to contend the role of environmental issues in these. Programs in which the efficient energy use is also an important factor of the environmental approach formation are described on the next few pages. The accomplishment of the objectives of the scenario including the reduction of Hungarian emission of greenhouse gases as outlined in the national plan can be remarkably promoted by the **activation of these programs, initiatives and publications**, through education at school and the formation of public awareness.

In the first place, the **National Environmental Education Strategy** should be mentioned. By now, only an unfinished version has been emerged and presently it is under professional debate. It is worth to mention that the material has been assorted together by some civil organisations with the co-ordination of the Hungarian Environmental Education Association with the considerable financial support of both ministries. (The civil organisations, however, played a determining role in the Hungarian environmental education already in the 1970—80's and put encouraging pressure on the ministries responsible for education.)

Energy is considered a distinguished sector of economics by the NCC and its measurement plans. Amongst the main programs developed for the environmental protection of that sector, the most important is a subprogram of the Energy Saving Action Programme, the Energy Saving Awareness Improvement Programme (EN.2.C). This subprogram emerged separately first in the draft of the 1999 Measurement Plan.

Standing apart from most of the programs and subprograms, there is no financial source for the subprogram indicated in the draft. In lack of this, even the tasks of the program cannot be defined. Therefore the financial source should be supplied as soon as possible.

The development and improvement of school age-class attitude encouraging energy saving is presently supported by the following particular education programs in Hungary (these programs are not compulsory and participation of schools is voluntary):

1. **International Environmental Education Co-operation Programme**

The program addressing secondary-school age-classes is actually an international natural scientific education project that, independently of nationality and culture, can be applied in every secondary-school. This is also indicated by the title: Science Across the World. The targets of the program are:

- To establish the global dimensions of education; to make students aware of the different lifestyles of different countries.
- To draw attention to influences of natural scientific education and technology on society, economics and environment.
- To promote international co-operation of instructors and students.

The method of work also relates to the mentioned targets of the program:

The secondary-schools participating in the program are provided by the regional centre with tasks that fit both the curriculum of countries and the common European environmental education values. The tasks are accomplished in projects of 2–4 lessons.

The tasks are based on data collection and observations in the dwelling and school environment. As a result of the analysis and mutual exchange of the documentation, a series of books will be produced. The series draws the attention of students of the joined secondary-schools to those environmental problems that also relate to the local curriculum of schools. These books are:

- Acid rain in Europe
- **Household energy consumption**
- **Renewable energy**
- Drinking water
- Meals
- **Global warming**
- Household waste
- Public road safety
- Health care
- Chemistry in everyday life

The program is strongly based on the so called “Cross curriculum” relationships, i.e. beside the requirements of natural scientific education, the regional geography, economic lifestyle and environmental education requirements are also emphasised.

The participation of Hungarian secondary-schools is co-ordinated by the National Public Education Institute, and it has professional support from the KÖRLÁNC Environmental Education Programme. 12 Hungarian secondary-schools take part in the program launched in 1997. They represent the whole Hungarian education structure (local governmental and church schools, grammar and vocational schools, capital and country schools).

We recommend that those asserting the books on energy should be informed about the content of the national study.

It should be ensured (providing the necessary infrastructure costs) that as many schools can join in the program as possible. The stage of international contacts is the INTERNET. Theoretically, there is no future objections to that, as the implementation of the INTERNET Network is handled by the Hungarian Ministry of Public Education.

The participation of vocational schools should be strongly supported because the economic areas to which the objectives of the control scenario relate to are directly influenced by their curricula (energy, construction, traffic, trade).

2. SPARE! School energy program

Soon, Hungarian schools will join in the SPARE! (School Project for Application of Resources and Energy) energy program the aim of which is school educational. This action was initiated in Norway, and it draws attention to the economic use of natural resources and energy. In the framework of this program, the students of some 50 thousands schools of 9 countries, including Hungary, will gain common knowledge about energy, while they can gain experiences on the ways and environmental consequences of energy application in their own environment.

The education program preparing for both theoretical knowledge and experience is divided into the topics of energy – energy sources – energy application. For example, the “energy application” block addresses the following sub-problems (every sub-problem focuses on individual consumer end use):

- Milestones in the history of energy application (from the application of local renewable energy to the irresponsible waste of non-renewable energy $\rightarrow$ energy dependence)
- Global energy use (energy use in different societies, uneven global distribution).
- Consequences of energy use (environmental consequences, greenhouse effect).
- Energy crisis, prospects.

The mobile tasks that requires the autonomous activity of children (e.g. collecting energy saving activities from school and home, mutual exchange of these between schools participating in the program, international drawing competitions on energy saving) form an integral part of the SPARE school energy program.

We recommend that the broader publicity of the SPARE international program (and the one mentioned under 1.) should be provided towards Hungarian schools than they have today. It is useful to organise a preparing training for the program supervisors of the participating schools, and the necessary tools should be provided for schools, in the framework of an application.

Experts should be involved in the development of the knowledge carrier education materials of the program. Professionalism should be aimed at.

3. Energy? training pack

The training pack was compiled and provided to the natural and environmental protection training centres in the summer of 1997 by a civil organisation (ENERGIA KLUB). Objectives of the pact were: (a) assistance to the teaching of modern and actual problems of energy to upper school (10-14 years old) pupils and teachers, (b) making them aware of the negative tendencies of the current energy production and consumption as well as demonstrating the sustainable energy economics.

The program pack consists of two parts:

- work-sheets (for pupils) for use at school or home, also applicable in normal lessons or special activities.
- methodological books (for teachers), methodological – professional assistance to thematic process, recommendation for processing the topic of energy efficiency voluntarily but being controlled and evaluated.

The most important advantage of the training pack is that the requirements of the National Core Curriculum are also considered. The tasks fit the frames of the traditional teaching of subjects, however they can be worked on in contexts as well (through special activities, forest school).

The natural and environmental protection training centres are recommended by the NEP as the base of environmental education. There are some 100 training centres in Hungary today. Six of these should be developed as centres of environmental continuative education of instructors, the financial background of which is provided by central sources (Ft 200 million yearly).

The national study should be handed over to the continuative education centres, and support for the professional processing of that should be also offered.

4. The ENERGIA (ARGE Umwelterziehung) training material

Considerable international support has been provided for years to the Hungarian environmental education and teachers participating. The first connection formed with an environmental education work-group (ARGE Umweltziehung). The traditional forms of co-operation were thematic exchange of experiences, common continuative education courses and providing professional materials. The issue called ENERGIA was amongst the first professional materials (1994) translated to Hungarian by the Austrian workgroup. The training material has also been presented in a seminar form.

The advantage of this material, besides general thematic knowledge about energy, is that it gives a great publicity to everyday methods of energy saving (What is that everybody can do? Ideas for energy saving!). It calls attention to individual and environmental damages resulted by energy loss and to energy sparing household methods with playful experiments and remarkably picturesque examples.

As providing for the financial background for the international exchange of experiences became difficult in recent years, we recommend that an **individual support foundation** be established for organising the common seminars (which does not merely apply to the Austrian relations). Needs cannot be satisfied with the presently available application-foundation possibilities.

5. Environmental education and training of teachers (PHARE project)

The PHARE project lasting 2 years is a continuative training program for teachers. Within the frame of the training, the participants could get acquainted with the tasks of organising and co-ordinating environmental programs. One hundred and fifty instructors took part in the preconditioning. By the end of the two-year long continuative education, a series of books for teachers has been developed in workshops. The “Energy” book is also included in this series. The content of the books:

- cross curriculum program recommendations
- case studies of dwelling environmental problems
- games and other recommended activities
- pedagogic-methodological recommendations

The program ran in 1994-1996. The series of books has been finished but it has not yet been published. It would be a useful additional material in environmental education (at ground- and secondary-schools, as well as training and continuative education courses for teachers).

The education of school age-classes is a distinguished strategic principle of environmental policy, even in the viewpoint of energy efficiency. Amongst the general tasks of environmental education, attention is worth paying to **vocational education** as well as the training and continuative education of instructors. The importance of this was tried to be emphasised through the presentation of the programs and recommendations above.

The vocational education (medium level training of skilled labourers) areas accredited by the state are involved in the National Training Register (NTR). The improvement of the training requirements system of environmental professions was a distinguished aspect in the recent development of this list. Curriculum proper for new training programs are still under development. This work is co-ordinated by the Environmental Economics Institute and the National Vocational Training Institute and financed from a Central Environmental Foundation budget for public tasks and from the budget of a World Bank program.

Recommendation: The problem of energy efficiency should be emphasised not only in the training development and improvement of NTR professions related to environmental protection (some 20 in NTR) but also in the development of training materials for other, especially technical, agrarian and economical professions.

It is very deterministic how In technical economic higher education the aforementioned training is carried out. Therefore this area is also considered an essential development area by the NEP. The training of teachers is described under footnote (3). According to one goal of the NEP, by the end of the program (2002), every university or high-school student must be taught environmental education. For this reason, the fundamental curriculum of higher environmental education has to be produced.

On the initiative of the Minister of Environmental Protection, formed at the beginning of 1997, was a work-group co-ordinating the penetration of modern environmental management systems in Hungary. One of its objective is to produce the above mentioned **fundamental curriculum** (planned deadline: 1998).

ENERGY MANAGEMENT has to be considered an important factor in the development of the fundamental curriculum.

Since institutional autonomy is an essential element of higher education, a proper (financial and professional) initiative system has to be worked out so that as many higher education areas as possible will be interested in the integration of the fundamental curriculum.

It seems useful to implement **referential centres** of the education and curriculum development of environmental management, on the foundation of the presently successfully operating institutes.

VI.6.1.2. Other civil and professional initiations

Hereafter, a brief introduction is given of **other civil and professional initiations** that give priority to energy efficiency objectives in the propagation of general ecological culture. The **primer target groups** of these actions are **inhabitants and their representations.**

1. The **energy efficiency program ELÉG** started in 1996 on a civil initiative however with professional support. It was launched by Hungarian environmentalist and social organisations after a Dutch example. Its objective is that as many people as possible use energy **consciously**, i.e. they recognise the energetic consequences of their everyday decisions in the household, workplace, traffic, trade etc. One conclusive reason of the program is that reducing energy use does not merely mean helping the environment but also our own purse.
2. The program provides also financial support for local campaigns, professional continuative education, and national school contests. This work is helped by its own informative: books and the press (e.g. the content of the informative book called “Energy saving in blocks of flats[27]” adjoins the objectives of the control scenario of the national study by many points).

[27] Large groups of blocks of flats were build in the communist times. The basic characteristic of this type of housing is that they were all of the same design and of poor quality.

3. Eight-hundred issues of the book called “**Towards sustainable energy economics**” were published in 1996 in the nursing of one of most significant civil environmental organisations, the Hungarian Association of Naturalists. This publication is a part of a series called “New facts in Central-Eastern Europe” that is promoted by the European Council and the Dutch Ministry for Environmental Protection. The aim of the book is to call the attention of professional and civil organisations in the region to the unique chance to alter their energy consumption to a sustainable direction.
4. Practical methods of energy saving and efficiency in households, the business sector and industrial transportation are introduced in this publication.
5. Within the frame of the program (SCORE – Energy and Environmental Awareness Programme) for the popularisation of energy efficiency knowledge on a national level, a **consulting network** formed in 10 towns. It provides free consultation for people. The **television series of 20 episodes called “Energy ABC”** has been produced by means of the program support. It has been played on the Hungarian television from 31 January 1998. Topics of the episodes played so far are: Renewal of houses – Bath – Household equipment – Wastes – Heater, boiler, gas-geyseer – Garden – Traffic etc. A **campaign** called “Energy is more than money! Protect the Earth!” has been launched in the **daily press** on the initiative of the related ministry and supported by the program PHARE.
6. The **professional conferences and exhibitions** give information and possibility to exchange experiences for the representatives of professional public opinion. **ENERGIA-ÖKOEXPO** is a conventional occasion of an international energy saving and environmental technology conference and special exhibition. These occasions inform us about the potential (technical-financial) methods and tools of industrial-economical and residential-local governmental energy management.

Recommendation: In the special conferences in the near future, the national study should be communicated within the frame of presentations.

A conference for the energy efficiency representatives of civil organisations should be organised. The editors and experts of the national study could present the scenario for reducing greenhouse gas emission in Hungary at this conference.

VI.6.1.3. Costs

The achievement of the objectives indicated in the scenario for greenhouse gas emission reduction outlined in the national study could be to a great extent supported by the education and public opinion formation. These objectives can be fitted into the general system of environmental education-training and awareness formation. The NEP programme includes the main junctions of this system for the next few years. Hereafter, the **planned financial background of the educational and awareness formation tasks** written in the NEP and its yearly Measurement Plans is presented **as a summary**:

(1) The planned sum for education-training tasks in the **1998** Measurement Plan:

sum Ft 65 million

source: central sources

(2) The total sum needed for education-training tasks in the 1999 – 2000 period (according to the 1999 Measurement Plan):

sum: Ft 3.25 million

source: central sources + others

VI.7. Implementation assistance for the selected mitigation measures

This subchapter discusses the Kósi Kálmán assistance system for the improvement of end-user energy efficiency. Upcoming projects are highlighted which are relevant to the selected measures discussed earlier in this document. The support of the selected measures can be realised by the different elements of the assistance system for the improvement of the user's energy-efficiency.

VI.7.1. Subsequent insulation of roofs, walls and floors

VI.7.1.1. M DEM credit for panel buildings

The government has decided in the first half-year of 1996 that preferential credits will be available for the habitants of block-buildings. The principles of this financial solution will be summarised below.

The amount of the credit will not exceed 800 000 HUF per flat and the applicant must contribute at least 25% of the investment costs.

The financial institutions may account a maximum of 2.5% interest gap in addition to the base interest of the issuing bank, assuming that the basis of the assistance is the total interest.

The costs for the judgement of the credit and for the technical supervision of the execution are to be paid by the beneficiary of the credit. The maximum time duration of the credit is 10 years. Participation is allowed for natural persons and companies with or without legal entity.

Subject of the application can be any house, incorporating at least 10 flats and built by industrial technology, one or more block of flats, whose energy consumption is uneconomical and whose modernisation results in energy saving, or any other flats or several blocks of flats where the renovation results in energy saving.

The applicant must describe, in a manner defined in detail in the application, the basic technical data of the building, and, in natural values and/or in cost, those energy consumption data before the renovation, which will be reduced by the renovation. The data has to be related to the last whole year before the application date.

How and why will the planned renovation will result in energy savings must be given. Other effects (conservation of substance, improvement of comfort) expected, apart from the energy savings, must be known. The necessary expenditures including the origin of the financial sources (own financing, credit, assisting partner) have to be defined.

The application must be filled out with the help of an energy expert. The technical supervision contains the checking of the documents required for the credit: the expected heat engineering data, a designer's or expert's opinion about their acceptability, and, for the partial and final accounting of expenditures, the completion of the work in accordance with the plans and on an appropriate technology level.

VI.7.1.2. National program for heat insulation of buildings

The program offers assistance for the creation of a cost-efficient, healthy, and environment-friendly flats. The leaders of the project, the professional union of the manufacturers and dealers of heat insulation materials, have given it the name of TEK from the abbreviation of the Hungarian words cost-efficient, healthy, and environment-friendly. The aim the initiative from the Hungarian Union of Building Insulators and Roofers (ÉMSZ) was to help flat owners in their efforts in reducing heating costs and in the selection of the most appropriate heat insulation technology. The project has set a long-term goal of heat insulation for 40,000 flats per year.

From the completion of the first stage of the project, the following advantages are expected at the national economy level: an energy savings of near 75,000 GJ per year, which, projected to a 10 year period, is equivalent to 110 kt of crude oil, (calculating with the present world-market price of the crude oil this means 3,7 billion HUF cost savings). Also 58 tons of sulphur-dioxide, 36 tons of carbon-monoxide, 7 tons of nitrogen-oxide and 19 tons of solid air polluting materials per year will not be emitted to our environment. Furthermore, the decrease of health injuries as a consequence of improvement of air quality allows us to save at least 400 million HUF in public health expenses.

It is an essential task to be in possession of a proper strategy against the increasing energy charges. Costs of electric energy, district heating, water and gas are changing every three months and are representing a an increasingly greater burden in household budgets.

In households most energy is directed to heating. As a consequence of this, most energy savings can be attained in the most effective way by decreasing the depredation of heat, by rationalising energy consumption, by choosing optimal heating appliances and operating them in an optimal way. From the point of view of energy dependence and energy import, the attainable degree of energy savings and the protection of our environment and living space are also of great importance.

The quantity of energy used for heating of flats is greatly influenced by the building material as well as the material and insulation roofs. Out of used energy, 14% escapes through the cellar-floor, 18% through the loft-floor, 32% through the side-walls and 19% through the windows. The remaining 17% leaves the flat during airing. Overheating must be avoided, if possible, because increasing the mean temperature of the flat by 1 degree Celsius requires 6-8% more energy. On the outside panels of the buildings the insulating procedures can also be carried out subsequently. By covering the walls and the floors with polystyrene foam (6-10 mm thick), heat loss can be reduced by 75%.

VI.7.1.3. ***Energy Saving Credit Project***

The investment incentive scheme relating to the public institutes of the local governments was advertised in 1997. It stimulates energy saving investments by offering credits with preferential conditions.

The degree of the interest preference is 50% of the current interest of the issuing bank. The source of support is the Special Budget for Economy Development sponsored by the Ministry of Trade, Transport and Tourism. The credit fund in the year 1997 was 800 million HUF.

VI.7.1.4. Energy Saving Credit Fund

In the year 1991 the government of the German Federal Republic has granted an sum of 50 million DEM to the Hungarian economy for the purchase of coal. After the coal was sold to the domestic market, 60% of the income of the Hungarian National Bank was (according to the Government Decision No. 3283/1991,VII. 10), divided into a fund for the disposal of the Ministry of Trade and Industry. This fund was the source of the preferential credits paid for energy-improving investments and the moderation of energy consumption.

Thereafter, the financial and operating system of the energy saving credit project was organised. The application system was announced on 1 August 1991. Therefore, the total development cost of the „living projects" (297 units) approved by the Professional Jury became 7019,0 Mat (million HUF), from which the preferential credit is 4785,4 Mat.

Table VI-K Investment distribution by subject is demonstrated in the following chart:

Category	**Number of subjects**	**Total investment cost 1000Ft**	**Preferential credit 1000 Ft**	**Energy source saving TJ/year**
Energy converter equipment, modernisation and optimisation of distributing networks and heating systems	144	3 138 041	2 240 685	1452,17
Application of energy saving technologies and production systems	24	798 195	562 081	469,79
Regulation, automation, computer control of technological processes and equipment	4	126 430	104 160	66,56
Application of waste heat recycling equipment and systems	9	244 494	187 983	419,02
Build-up of a complex energy saving and energy supplying system	2	45 198	35 900	25,36
Update of lighting	71	1 090 91l	786 898	493,49
Increase of electric power production, creation of connected heat and electric power production	7	546 487	232 500	291,04
Energetic utilisation of refreshing energy sources, industrial, agricultural and silvicultural waste and secondary products.	22	835 693	496 997	1137,32
Modernisation and increase of manufacturing capacity of energy-saving equipment, machines and tools	4	24 364	17 750	170,64
Actions allowing energy saving at district-heating systems	7	76 003	62 198	40,92
Creation of measuring, data-processing, process-control for optimising of energy and power management	2	90 172	55 700	57,74
Moderation of depredation of heat by insulation	1	3000	2550	1,82
Total	297	7 018 988	4 785 402	4625,87

VI.7.2. The changing of windows in existing buildings

VI.7.2.1. M DEM credit for block buildings

The state funding contributes to the payment of the bank credit interests taken for modernisation works, if the following criteria is satisfied:

- if the house does not meet the requirements of the heating technology standards, and the renovation, modernisation, and the subsequent heat insulation work extends to the outside walls, the loft and the cellar floor to the replacement or air sealing improvement of the outside doors and windows, or
- if one part of the bordering structure of the house does not meet the requirements of the heating technology standards and the works extend to everything, and if so the heat insulation value of the building complies with the required values of the effective heating technology standards.

The state grants assistance for a maximum of ten years for other modernisation works resulting in energy savings, if the border structures of the house satisfy the required values of the effective heating technology standards, or if the result of the works meet these required values.

VI.7.2.2. National Project for Heat Insulation of Buildings

By subsequent insulation of the doors and windows the temperature of the flats increases by 3 - 5 degrees Celsius. In this way, an energy saving of 10 - 15% can be reached by self-gluing or profiled type of insulators, which are made of silicone rubber and are placed on the doors and windows. The basic material holds its elasticity in the range of -40 to +70 degrees Celsius, is non-ageing and resists chemical influences well.

The investment cost of insulation is expected to be refunded in 1 - 1.5 heating seasons in case of individual heating and in 3 years in case of district heating. By subsequent insulation of the doors and windows 10 - 25% of the heating costs can be saved. Additionally, these reduce draughts, incoming dust and noise which will increase comfort levels.

VI.7.2.3. Energy Saving Credit Project

This long-term project, according to the annually determined aims and means, supports the nationally targeted goals of energy savings and energy-efficiency, hereby promoting the reduction of environmental pollution, the Hungarian import-dependency, the societal burden and public expense.

VI.7.2.4. The Dutch Enterprise-Development Project for Energy-Efficiency

The Dutch government provides support for Hungary in the improvement of energy efficiency since the change of the regime. In the framework of the bilateral energetic project the competent ministries of both countries agree each year on the particular content of the co-operation projects. From the Hungarian side those entrepreneurs are allowed to participate in the project, which, in the framework of the Dutch-Hungarian co-operation, are planning to manufacture and to put into circulation products, services, materials, etc. improving energy efficiency, for the Hungarian and possibly for the foreign market.

From 1996, it is possible to apply for projects to improve the energy efficiency of public buildings. The projects can be directed also at the improvement of the efficiency of building bordering structures (building envelopes), heat, lighting, electricity, water supply systems, etc.

VI.7.3. The introduction of co-generation in existing heating plants and heating power plants

VI.7.3.1. SYNERGY project

The Synergy project promotes the proper formation of energy policy. In the framework of the Synergy project the member states of the European Union want to also co-operate with the states not belonging to the Union, in order to guarantee the safety of gas supply and to make steps toward a sustainable development.

Natural gas is the energy source having the purest chemical composition, and as a consequence of mixing with the air it burns easily. During the burning of coal, gas and oil, carbon dioxide and steam forms.

Seventy-five to ninety percent of the carbon dioxide emission caused by man contributing to atmospheric warming originates from this activity. This proportion, taking into consideration all sources, i.e. including natural sources, is responsible for two-thirds of the greenhouse effect causing atmospheric warming.

Natural gas is also advantageous in regional and local respects. To produce the same amount of energy from coal results in 5 units of sulphur dioxide, from oil or diesel results in 3.5 units of sulphur dioxide, but from natural gas 1/1000 unit of sulphur dioxide is produced. This proportion makes natural gas more favourable also in case of nitrogen oxides.

VI.7.3.2. The Dutch development project for energy-efficiency enterprises

In this project the following topics appeared on the agenda: exploring the energetic losses of some industrial plants in the earlier years, clearing the conditions of low-power connected energy production, helping the energy management of the local governments, energy production with gas-engine, helping the energy efficiency entrepreneurs and demonstrating DSM.

In the previous years, 7 investments were made (see chart 1) in the field of connected thermal and electric energy production with 232,5 million HUF of preferential credit being awarded to them.

VI.7.4. Water saving taps

VI.7.4.1. Energy Saving Credit Fund

Projects eligible for credit are those that, for example:

- decrease the specific energy needs of energy production, transport, transformation and end-use, reduce losses
- use and spread modern, energy-saving technology systems
- utilise waste heat and use some secondary products and waste for energy purposes
- utilise biomass, wind, solar and geothermal energy sources
- regulate and measure the use of heat and hot water in flats with district heating systems and thereby decrease the energy consumption
- moderate the use of electric energy and heat connected to energy production
- moderate the energy consumption by insulation in case of industrial, civil and communal consumers
- modernise outer, inner and public lighting systems
- apply energy-efficient appliances and equipment

In the previous years 4 investments for increasing the efficiency of water supply systems were supported with 17,7 million HUF of preferential credit.

VI.7.4.2. The Dutch development project for energy-efficiency enterprises

Since 1996 one can apply for projects that will increase the energy efficiency of public buildings. The projects can be targeted to the improvement of the efficiency of bordering structures of buildings, heating, electric energy, water-supply systems, lighting etc.

Of course the public buildings of those local governments are preferred, that took part in the advisory project called “For the energy-efficiency of settlements”. The enterprises apply for financial assistance with their projects considered to be the best. The budget available for the aid is approximately 60 million HUF. Each project is eligible for a maximum of 50% assistance.

VI.7.5. Condensation boilers, including the necessary replacement of radiators

VI.7.5.1. Energy Saving Credit Fund

On the basis of the applications presented to the Fund 144 such investments have been assisted, whose subject was the modernisation of energy transformation equipment, distribution networks and heating systems. The amount of the preferential credit paid out was 2,24 billion HUF (see chart 1).

VI.7.6. The replacement of armatures in public institutions

VI.7.6.1. Dutch development project for energy-efficiency enterprises

The aim of the project is to improve the supply of products and services improving energy efficiency in the Hungarian market. The organisers wish to achieve long-lasting results. They expect that the enterprises which have came into being or have strengthened with the help of the project will also work for the improvement of the energy efficiency after finishing the project.

VI.7.7. High efficiency appliances (washing machines)

In the interests of energy saving the Ministry of Industry, Trade and Tourism (IKIM) has worked out a National Energy Saving Project, which has been adopted by the Government in 1994. In order to realise the aims of the project, the Ministry has laid down the particular tasks in the Action Program for Energy Saving. The Action Program has been adopted by the Government on 13 December 1995, and the execution of its tasks has begun.

The Program formulates aims at measuring and qualifying the energy-utilising equipment and appliances as well as providing information for customers.

Under the Program the energy efficiency of appliances has to be marked as is in EU countries. Therefore a decree is necessary with the content of those EU-directives (92/75 /EEC Directive of the Council and 94/2/EC Directive of the Committee) which have been (or are being) incorporated into the own legal system of the member states.

In the qualification system the energy efficiency of the appliances has to be tested. The distribution of the products having proved to be energy wasting or environment polluting must be prohibited in accordance with the minimum efficiency requirements of the EU and in a way conforming to the GATT.

On December 1997 the decree of the minister of industry, trade and tourism has entered into force. This decree prescribes the marking (labelling) of the energy-efficient products.

VI.7.8. Individual systems of ventilation instead of communal ones

VI.7.8.1. Dutch development project for energy-efficiency enterprises

The Dutch project has to be mentioned again, pointing out the aims of improving the energetic efficiency of the public buildings. The particular projects can target the improvement of efficiency of bordering structures of buildings, heating, electricity and water supply systems, etc.

VI.7.8.2. Energy prices

The National Energy Saving Program and its Action Program deals also with the problem of energy prices.

The Program aims for the application of a price, and a tariff system, which is proportional to the costs and incentives for energy saving.

To achieve this both in the case of the modification of the price and tariff system of the energy sources, and in the further development of the tariff system, it has to be taken into consideration that the prices and fees have an incentive effect on energy saving and on the reduction of the peak loads in the electric supply.

In **August 1995** the Government has adopted such a decision (Government decision on the price regulation and on the price adjustment valid until 1st January 1997, No. 1074/1995. Korm.), which prescribes that the development of the market prices has to be executed in **three steps**.

In a market economy the liberalisation of the prices is also necessary on the energy market therefore the price of the energy sources is to be set at market value. In accord with this, competitive conditions have to be created, restricting the formation of monopolies. An exception from this rule is, as already mentioned, the category of the natural monopolies. Electric energy and natural gas (where the prices are settled by authorities) can be considered to be a monopoly.

The right for settling the official energy prices belongs to the minister for industry, trade and tourism. The proposal for the actual price is made by the main director of the Hungarian Energy Office (MEH). The base of the price is the actual economic cost, which supplies funds for the production (or purchase) and amortisation. It must necessarily also contain profit. Domestic and import costs have to be taken into consideration jointly.

The Parliament passed in 1994 the Law No. XLVIII on the production and transport of energy (in a unified structure with the Government Order No.

34/1995. (IV.5.) Korm on the execution of the individual orders). The Law was modified in 1995 by the Law No. LXXXI. The legal basis for the raising of the prices in the period since then has been created by this law. The Government has given an Order in August 1995 to raise prices, which must be executed in three steps. At the same time a price correction mechanism has been worked out, and the rises of the prices from January 1997 were introduced on the basis of previously elaborated and published formulae. Each rise in price is preceded by a cost supervision previously carried out by the MEH.

For a summary of the official energy prices from March 1996 to January 1998, see Appendix 1.

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VIII. APPENDICES

Appendix 1. - Tables

Table VIII-A Highest fixed energy prices[28]

category	**Prices (without VAT) from Sept 1995**	**Prices (without VAT) from March 1997**	**Prices (without VAT) from Jan 1997**	**Rate of price rise (%) March 1996**	**Rate of price rise (%) January 1997**	**Price in January 1997 with 12% VAT**
Electric energy (Ft/kWh)	6.69	7.90	9.87	18	24.9	
Communal	7.05	8.45	10.56	20	24.9	11.83
During the day (average)	8.53	10.29	12.86	19	24.9	11.83
Block 1 <50kWh/month	7.00	9.00	11.20	29	24.4	12.54
Block 2 50-300kWh/ month	9.20	10.70	13.40	16	25.2	15.01
Block 3 >300kWh/month	11.30	12.40	15.50	10	25.0	17.36
During the night (average)	3.97	4.97	5.97	21	24.6	6.69
Block 1 <200kWh/month	3.80	4.70	5.90	24	25.5	6.61
Block 2 200-1000 kWh/month	4.30	5.00	6.20	16	24.0	6.94
Block 3 >1000kWh/month	4.80	5.30	6.60	10	24.5	7.39

Source: Békés György: Új energiaárak 1997. januártól (*New Energy Prices from January 1997)* (Energiafogyasztók Lapja, Vol. II, No. I, April 1997)

[28] Tariffs valid at the writing of the section (1997). Since tariffs are regularly being revised, these maybe obsolete by the time of the completion of the whole report.

Table VIII-B The effective prices for other consumers (Ft/kWh) are as follows:

Category	**Prices (without VAT) from Sept 1995**	**Prices (without VAT) from March 1996**	**Prices (without VAT) from Jan 1997**	**Rate of price rise (%) March 1996**	**Rate of price rise (%) January 1997**
Non-communal (average)	6.51	7.60	9.50	17	25.0
Rail transport	4.55	5.70	7.10	25	24.6
Road transport	5.95	7.00	8.80	18	25.7
Public lights	9.99	11.07	13.83	11	24.9
General tariff (average)	9.79	11.08	13.84	13	24.9
Output fee (average)	5.77	6.88	8.59	19	24.9
High voltage (average)	4.47	5.69	7.09	27	24.6
Medium voltage Variation of the official (maximum) line energy source prices in % (without VAT)(average)	5.97	7.05	8.82	18	25.1
Low voltage (average)	7.58	8.53	10.63	13	24.6

Source: Békés György: Új energiaárak 1997. Januártól (*New Energy Prices from January 1997)* (Energiafogyasztók Lapja, Vol. II, No I, April 1997)

Summary of the official energy prices from March 1996 until January 1998:

Table VIII-C Variation of the official (maximum) line energy source prices in % (without VAT)

Category	from March 1996.	from January 1997.	from April 1997.	from July 1997.	from October 1997.	from January 1998.
Electric energy (Ft/kWh)	**18,1**	**24,9**	**3,7**	**4,5**	**6,6**	**4,9**
Residential (average)	**19,9**	**24,9**	**3,6**	**4,5**	**6,8**	**5,0**
Tariff A) (day)	**20,6**	**25,0**	**3,6**	**4,4**	**6,9**	**5,0**
Block I. < 50 kWh/month	28,6	24,4	3,6	4,3	6,6	4,7
Block II. 50-300 kWh/month		25,2	3,7	4,3	6,9	5,2
Block III. >300 kWh/month	9,7	25,0	3,2	5,0	7,7	5,0
Tariff B) (night))	**20,7**	**25,5**	**3,3**	**4,7**	**6,5**	**4,8**
Block I. < 200 kWh/month	23,7	25,5	3,4	4,9	6,3	4,4
Block II. 200-1000 kWh/month		24,0	3,2	4,7	7,5	5,6
Block III. >1000 kWh/month		24,5	3,0	4,4	7,0	5,3
Not residenti al (average)	**16,7**	**25,0**	**3,7**	**4,5**	**6,5**	**4,9**
railway transport	25,3	24,6	4,2	4,7	7,1	4,8
road transport	17,6	25,7	4,0	4,4	7,3	4,9
public lighting	10,8	24,9	3,7	4,7	7,1	4,9
general price (average)		24,9	3,6	4,4	7,1	5,0
power tariff (average)	19,2	24,9	3,7	4,6	6,2	4,9
high voltage (average)	27,3	24,6	3,8	4,5	4,4	4,9
middle voltage(average)e		25,1	3,6	4,7	7,1	5,0
low voltage(average)	12,5	24,6	3,8	4,4	7,2	5,0
Heat energy, average (Ft/GJ)		**26,6**	**3,7**	**7,0**	**4,5**	**4,7**
Hot water (average)		21,9	3,7	7,0	4,4	4,9
Steam (average)		31,7	3,9	6,5	4,5	4,6

Natural gas (Ft/GJ)						
Wholesaler	25,1	16,9	3,6	13,5	3,2	6,1
End-user (average)	24,2	18,0	3,8	11,2	3,2	5,5
Residential	**29,4**	**18,8**	**3,7**	**9,9**	**3,5**	**5,0**
Non residential (average)	19,2	12,1	3,7	12,7	3,0	6,0
General purpose	19,4	16,7	3,5	12,3	2,5	6,0
Power tariff (average)		22,5	3,6	12,8	2,9	6,0
gas tariff	25,0	17,9	3,7	13,2	3,0	6,0
power tariff (Ft/MJ/h/year)		16,6	3,6	9,7	3,1	6,1
Puffer (gas tariff only)	25,0	17,9	3,7	13,2	3,0	6,0
Natural gas (Ft/m^3)						
Wholesaler	25,1	16,9	3,6	13,5	3,2	6,0
End-user (average)	24,2	18,1	3,7	11,2	3,2	5,4
Residential	**29,4**	**18,8**	**3,7**	**9,9**	**3,5**	**5,0**
Non residential (average)	19,2	12,1	3,8	12,7	3,1	6,0
General purpose	19,4	16,7	3,5	12,3	2,6	6,0
Power tariff (average)		22,4	3,7	12,8	3,0	5,9
gas tariff	25,0	17,9	3,7	13,2	3,0	6,0
power tariff(Ft/MJ/h/year)		16,6	3,6	9,7	3,1	6,1
Puffer (gas tariff only)	25,0	17,9	3,7	13,2	3,0	6,0

VIII-D. CO_2 emissions by source and removal by sink categories

Source and sink categories		1985-87	1990	1991	1992	1993	1994
1A. Fuel Combustion		**80089**	**68105**	**65255.35**	**58635.51**	**58754.36**	**57045.71**
	1A1. Energy & Transformation	36928	29746	28520.28	27475.65	27574.76	26290.43
	1A2. Industry	10893	7893	6379.87	5131.01	5548.08	6306.13
	1A3. Transport	7741	8208	7382.56	7189.48	7140.78	7211.81
	1A4. Commercial and Trade	3403	3290	3958.90	3516.82	3821.60	3969.88
	1A5. Residential	16639	15125	15669.79	12195.51	12270.89	11453.04
	1A6. Agriculture and Forestry	3132	2462	2119.82	1593.21	1498.55	1536.60
	1A7. Other	1353	1381	1224.13	1533.83	899.70	277.82
1B. Fugitive Emissions							
	1B1. Coal Mining			-	-	-	-
	1B2. Oil and Natural Gas	NEF	NEF	NEF	NEF	NEF	NEF
2. Industrial Processes		**3587**	**3568**	**1381.89**	**1167.91**	**1318.28**	**1396.73**
	2A. Iron and Steel			-			
	2B. Non-ferrous Metals	NEF	NEF	117.14	49.69	51.57	Not Est.
	2C. Inorganic Chemicals			-	-	-	-
	2D. Organic Chemicals			-	-	-	-
	2E. Non-metallic Products	3587	3568	1264.75	1118.22	1266.71	1396.73
	2F. Other			-	-	-	-
3. Agriculture							
	4A. Enteric Fermentation	-	-	-	-	-	-
	4B. Manure Management	-	-	-	-	-	-
	4C. Rice Cultivation	-	-	-	-	-	-
	4D. Agricultural Soils	-	-	-	-	-	-
	4E. Savannah Burning	-	-	-	-	-	-
	4F. Field Burning of Agricult. Resid.	-	-	-	-	-	-
4. Forestry		**-3097**	**-4467**	**-3238.52**	**-3822.54**	**-4697.47**	**-4819.70**
	5A. Changes in Stocks			-4747.36	-5336.46	-6194.02	-6271.32
	5B. Forest/Grassland Conv.			1508.84	1513.93	1496.55	1451.62
	5C. Abandonment of Managed Lands			-	-	-	-
	5D. Other			-	-	-	-
5. Waste		**NEF**	**NEF**	**753.72**	**753.72**	**753.72**	**753.72**
	6A. Solid Waste Disposal on Land			153.72	153.72	153.72	153.72
	6B. Wastewater Treatment			-	-	-	-
	6C. Waste Incineration			600.00	600.00	600.00	600.00
TOTAL		**83676**	**71673**	**67390.96**	**60557.13**	**60826.36**	**59196.16**
International Bunkers		NEF	NEF	375.87	385.85	361.15	532.23

VIII-E. CH_4 emissions by source categories

Source and sink categories	1985-87	1990	1991	1992	1993	1994
1A. Fuel Combustion	**7.7**	**5.6**	**36.775**	**24.234**	**24.323**	**20.786**
1A1. Energy & Transformation	Not Est.	Not Est.	Not Est.	Not Est.	Not Est.	Not Est.
1A2. Industry	Not Est.	Not Est.	Not Est.	Not Est.	Not Est.	Not Est.
1A3. Transport	Not Est.	Not Est.	Not Est.	Not Est.	Not Est.	Not Est.
1A4. Commercial and Trade	Not Est.	Not Est.	Not Est.	Not Est.	Not Est.	Not Est.
1A5. Residential	Not Est.	Not Est.	Not Est.	Not Est.	Not Est.	Not Est.
1A6. Agriculture and Forestry	Not Est.	Not Est.	Not Est.	Not Est.	Not Est.	Not Est.
1A7. Other	Not Est.	Not Est.	Not Est.	Not Est.	Not Est.	Not Est.
1A8. Biofuel Comb.	Not Est.	Not Est.	Not Est.	Not Est.	Not Est.	Not Est.
1B. Fugitive Emissions	**448.3**	**366**	**452.780**	**383.420**	**385.170**	**379.150**
1B1. Coal Mining	222.8	167	160.640	124.400	109.470	104.810
1B2. Oil and Natural Gas	225.4	199	292.140	259.020	275.700	274.340
2. Industrial Processes	Not Est.	Not Est.	**0.005**	**0.001**	**0.000**	**0.000**
2A. Iron and Steel	Not Est.	Not Est.	0.005	0.001	0.000	0.000
2B. Non-ferrous Metals			-	-	-	-
2C. Inorganic Chemicals			-	-	-	-
2D. Organic Chemicals			-	-	-	-
2E. Non-metallic Products			-	-	-	-
2F. Other			-	-	-	-
3. Agriculture	**208.4**	**173**	**167.695**	**144.302**	**126.567**	**120.848**
4A. Enteric Fermentation	156.6	125.6	122.236	105.098	90.448	85.243
4B. Manure Management	48.1	44.3	41.697	37.113	34.029	33.513
4C. Rice Cultivation	3.7	3.1	3.758	2.088	2.088	2.088
4D. Agricultural Soils			-	-	-	-
4E. Savannah Burning			-	-	-	-
4F. Field Burning of Agricult. Resid.			0.005	0.003	0.002	0.004
4. Forestry			**0.280**	**0.255**	**0.221**	**0.228**
5A. Changes in Stocks			-	-	-	-
5B. Forest/Grassland Conv.			-	-	-	-
5C. Abandonment of Managed Lands			0.280	0.255	0.221	0.228
5D. Other			-	-	-	-
5. Waste	Not Est.	Not Est.	**256.586**	**256.258**	**255.767**	**255.166**
6A. Solid Waste Disposal on Land			68.125	68.125	68.125	68.125
6B. Wastewater Treatment			188.461	188.133	187.642	187.041
6C. Waste Incineration			-	-	-	-
TOTAL	**664.4**	**544.6**	**914.121**	**808.470**	**792.048**	**776.177**
International Bunkers			0.011	0.011	0.010	0.015

VIII-F. Summary tables of greenhouse gas emissions

Greenhouse gas emissions in 1985-87 (Gg)						
Source/Gas	**CO_2**	**CH_4**	**N_2O**	**CO**	**NOx**	**NMVOC**
Energy	80089	456	8.4	743	231.4	126.5
Agriculture		208.4	4.6			-
Industry	3587	.				78.5
Waste Management						-
Forestry	-3097					-
Total Emission	**83676**	**664.4**	**13**	**743**	**231.4**	**205**
International Bunkers						
Greenhouse gas emissions in 1990 (Gg)						
Source/Gas	**CO_2**	**CH_4**	**N_2O**	**CO**	**NOx**	**NMVOC**
Energy	68105	371.6	7.25	733.6	199.6	98.5
Agriculture		173	4.1			
Industry	3568					44.5
Waste Management						
Forestry	-4467					
Total Emission	**71673**	**544.6**	**11.35**	**733.6**	**199.6**	**143**
International Bunkers						
Greenhouse gas emissions in 1991 (Gg)						
Source/Gas	**CO_2**	**CH_4**	**N_2O**	**CO**	**NOx**	**NMVOC**
Energy	65255	489.6	2.6	1393.3	228.3	84.70
Agriculture	-	167.7	1080.0	95.3	1.0	-
Industry	1382	0.0	3.7	0.2	1.8	3.81
Waste Management	754	256.6	-	0.1	0.5	-
Forestry	-3239	0.3	0.0	2.5	0.1	-
Total Emission	**67391**	**914.1**	**1086.4**	**1491.3**	**231.8**	**88.52**
International Bunkers	376	0.0	0.0	0.6	1.5	0.10
Greenhouse gas emissions in 1992 (Gg)						
Source/Gas	**CO_2**	**CH_4**	**N_2O**	**CO**	**NOx**	**NMVOC**
Energy	58636	407.7	3.3	1212.7	206.0	80.05
Agriculture	-	144.3	1047.6	65.0	0.7	-
Industry	1168	0.0	2.8	0.2	1.2	4.03
Waste Management	754	256.3	-	0.1	0.5	-
Forestry	-3823	0.3	0.0	2.2	0.1	-
Total Emission	**60557**	**808.5**	**1053.7**	**1280.2**	**208.4**	**84.08**
International Bunkers	386	0.0	0.0	0.7	1.6	0.10
Greenhouse gas emissions in 1993 (Gg)						
Source/Gas	**CO_2**	**CH_4**	**N_2O**	**CO**	**NOx**	**NMVOC**
Energy	58754	409.5	3.4	1250.6	200.9	81.43
Agriculture	-	126.6	939.6	52.3	0.6	-
Industry	1318	0.0	2.5	0.2	1.1	3.77
Waste Management	754	255.8	-	0.1	0.5	-
Forestry	-4697	0.2	0.0	1.9	0.1	-
Total Net Emission	**60826**	**792.0**	**945.6**	**1305.1**	**203.2**	**85.20**
International Bunkers	361	0.0	0.0	0.6	1.5	0.09

Greenhouse gas emissions in 1994 (Gg)						
Source/Gas	**CO_2**	**CH_4**	**N_2O**	**CO**	**NOx**	**NMVOC**
Energy	57046	399.9	3.6	1208.6	208.0	80.33
Agriculture	-	120.8	1159.2	78.7	0.8	-
Industry	1397	0.0	3.4	0.0	780.0	3.92
Waste Management	754	255.2	-	0.1	0.5	-
Forestry	-4820	0.2	0.0	2.0	0.1	-
Total Net Emission	**59196**	**776.2**	**1166.2**	**1289.5**	**989.4**	**84.24**

Appendix 2. - Figures

CO_2 abatement "supply curves" of the mitigation options

For a description of the curves and the individual mitigation measures, please refer to Chapter IV. These curves are a diagrammatic representations of the mitigation option tables, with the per ton CO_2 savings costs shown on the "y" axis, and the magnitude of the abatement potential possible with the particular measure on the "x" axis.

Figure VIII-A. Heat Strategy One - Residential Sector

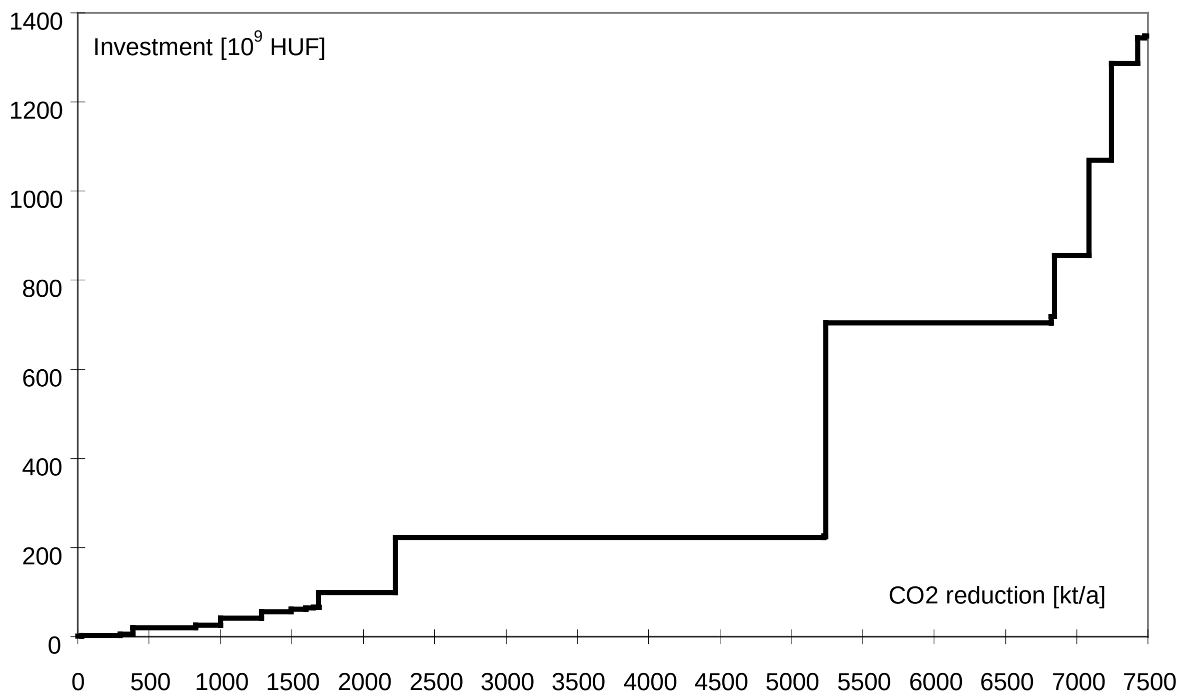

Figure VIII-B. Heat Strategy One – Communal Sector

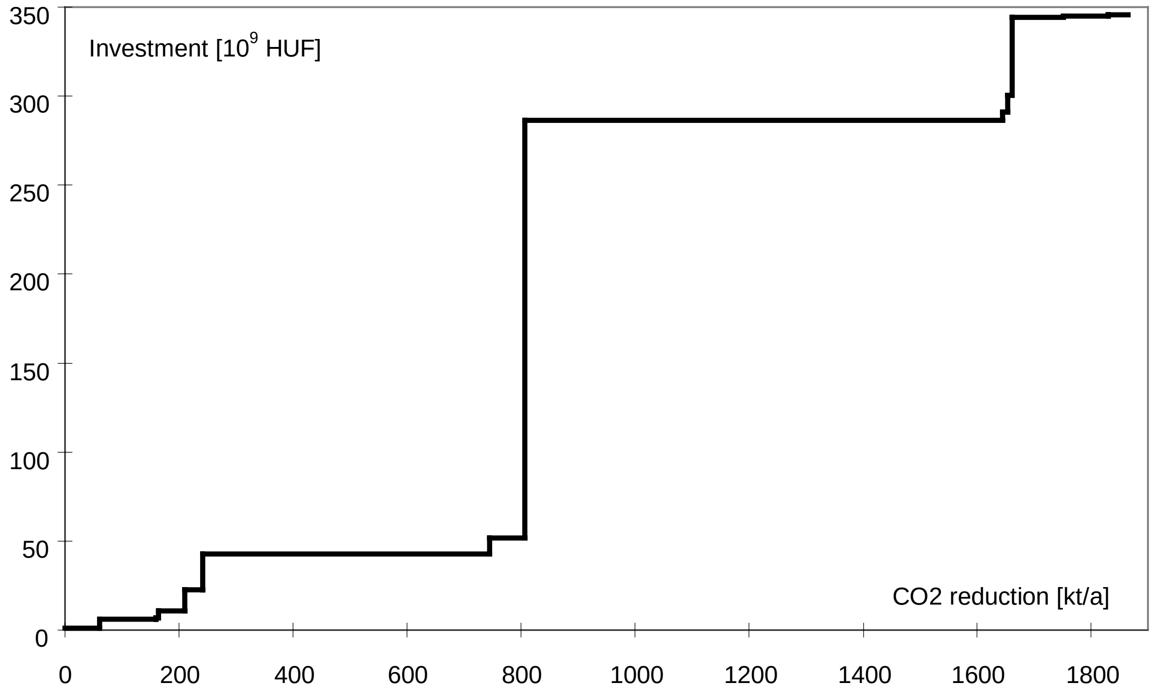

Figure VIII-C. Electricity Strategy One - Residential Sector

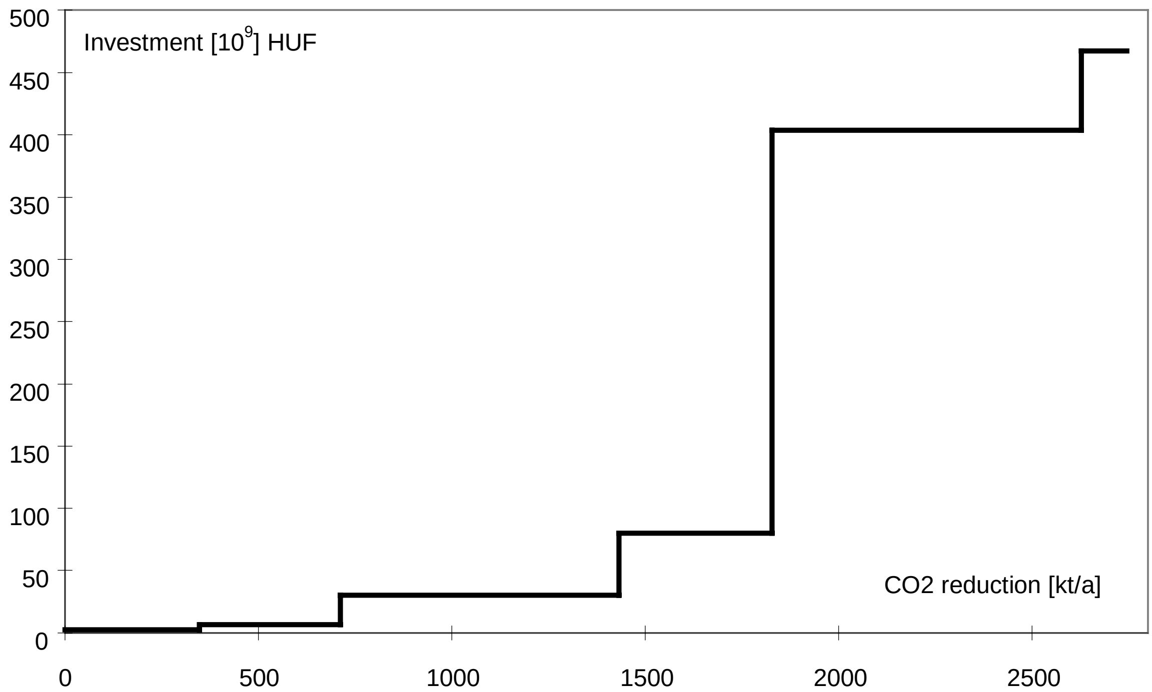

Figure VIII-D. Electricity Strategy One – Communal Sector

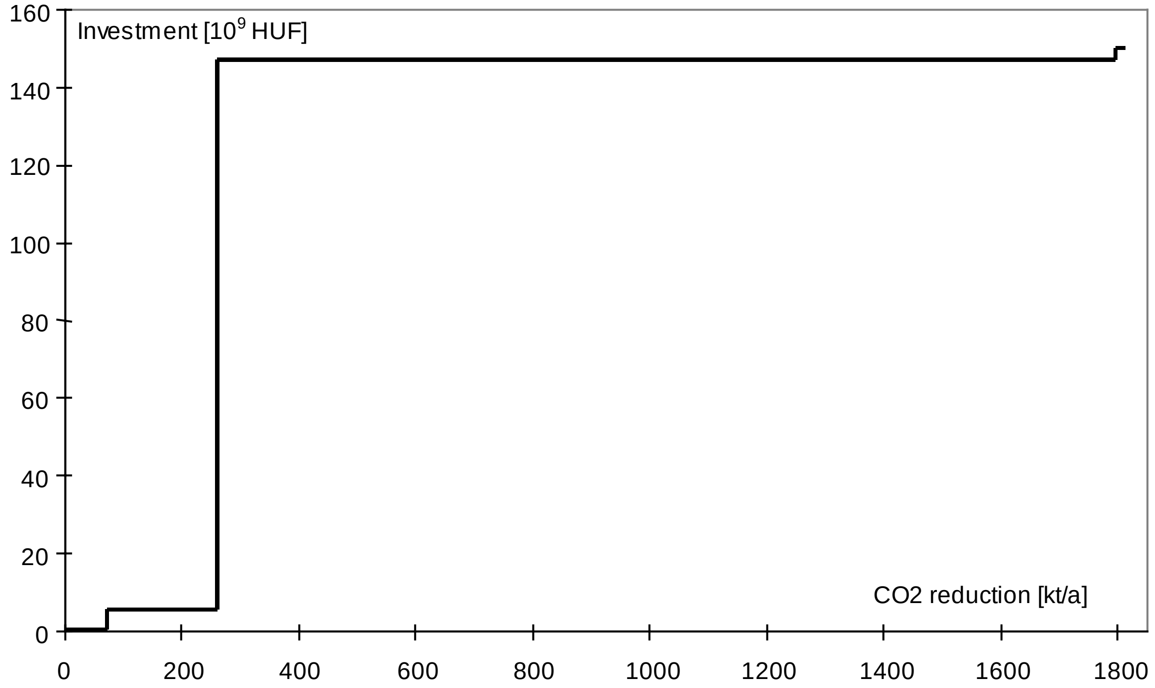

Figure VIII-E. Heat Strategy Two - Residential Sector

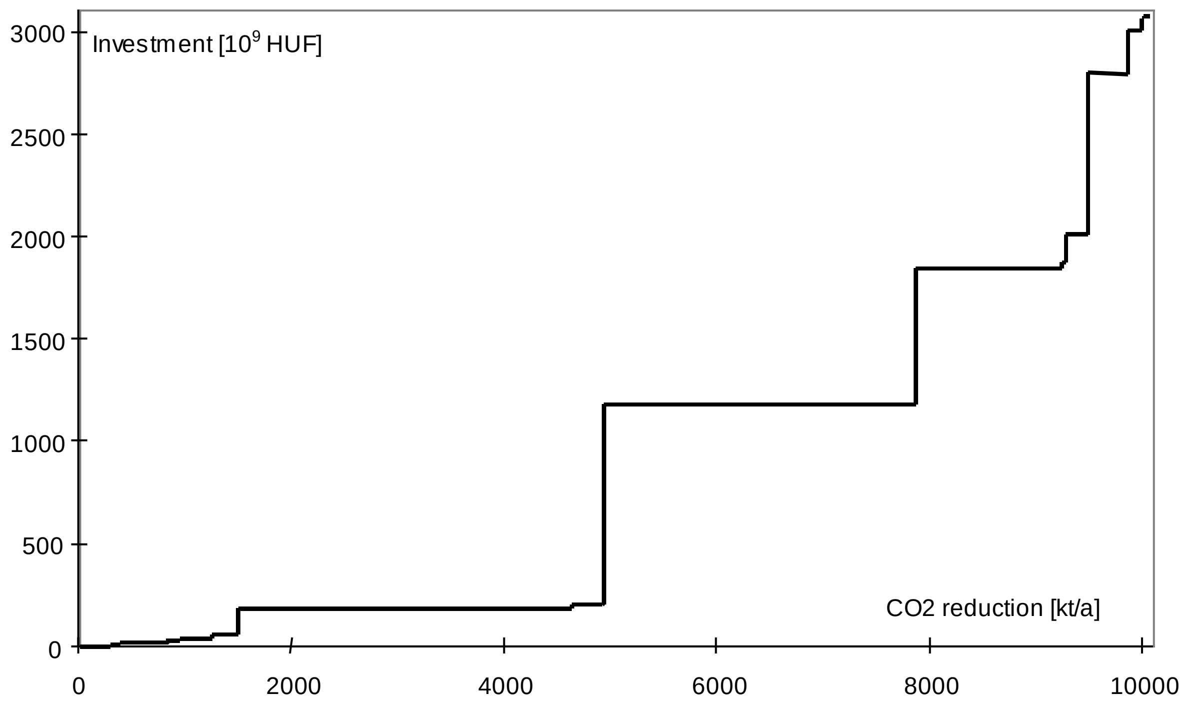

Figure VIII-F. Heat Strategy Two - Communal Sector

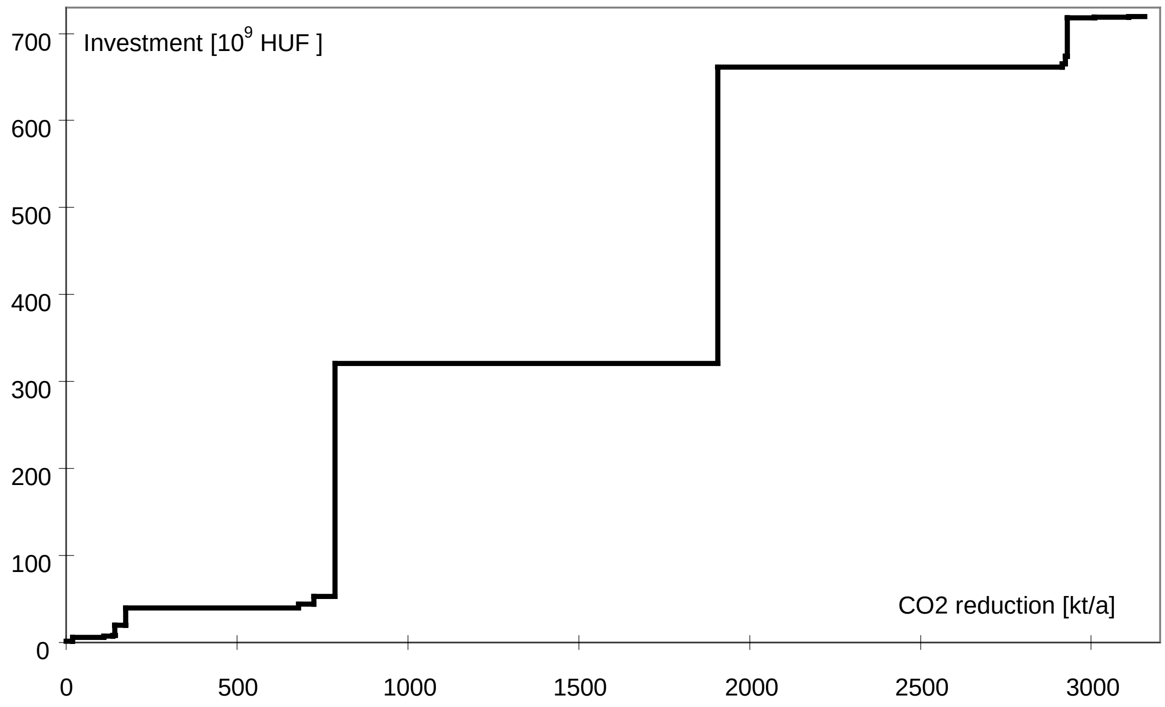

Table VIII-G. 1 Fuel price assumptions

Country: HUN

Table 1.1 basic assumptions	Base year		
	1985-87	2005/10	2020/30
International (CIF) price of crude oil, US$/bbl	20	22	24
International (CIF) price of coal, US$/ton			
Local price of fueloil, local currency/GJ	360	580	632
Local price of gasoil/diesel, local currency/GJ	1 200	1 900	2 300
Local price of natural gas, local currency/GJ	400	845	866
Local price of gasoline, local currency/GJ	1 100	2 000	2 500
Local price of coal, local currency/GJ	320	632	646
Local price of fuel1, local currency/GJ			
Local price of fuel2, local currency/GJ			

Table 1.2 sensitivity case	Base year		
	1985-87	2005/10	2020/30
International (CIF) price of crude oil, US$/bbl	20	22	24
International (CIF) price of coal, US$/ton	79		
Local price of fueloil, local currency/GJ	360	580	632
Local price of gasoil/diesel, local currency/GJ	1 200	1 900	2 300
Local price of natural gas, local currency/GJ	400	845	866
Local price of gasoline, local currency/GJ	1 100	2 000	2 500
Local price of coal, local currency/GJ	320	632	646
Local price of fuel1, local currency/GJ			
Local price of fuel2, local currency/GJ			

Table VIII-H. 2 Key national indicators

Country: HUN

Table 2.1 GDP* mill HUF		Base year		
		1985-87	2005/10	2020/30
Total (fixed local prices of the year 1991)		2 832 658	4 528 200	8 450 900
Primary	Agriculture, Forestry	210 528	317 000	507 000
Secondary	Industry, Mining	891 175	1 177 000	2 112 725
	Construction	172 951	360 000	676 000
	Transport	227 110	317 000	590 000
Tertiary	Services	1 046 787	2 130 000	4 395 000

Table 2.2 National indicators	Base year		
	1985-87	2005/10	2020/30
Population (millions)	10 630 900	9 755 159	9 131 976
Urban population (%)	58.4	63.1	65.0
Land cover (1000 km2)	93 030	93 030	93 030
Forest land (%) in baseline	19	19	19
Agricultural land (%) in baseline	70	67	67

* without balance of product taxes

Table VIII-I. 3 Macroeconomic statistics

Country: HUN

Table 3.1 GDP (Mill HUF)		Base year
		1985-87
Consumption	Households	1 910 000
	Government	257 000
Investment		628 000
Foreign trade	Exports	951 000
	Imports	915 000
Monetary	Inflation (%)	7

Table 3.2 Labour force (thousands)		Base year
		1985-87
Primary	Agriculture, Forestry	986.2
Secondary	Industry, Mining	1 536.1
	Construction	347.5
	Transport	400.5
Tertiary	Services	1 621.8
Unemployment		no data

Table 3.3 Exchange rate	
Exchange rate of to (name of local currency)	1US=HUF
1986	45.83
1987	46.99
1988	50.42
1989	59.10
1990	63.20
1991	74.81
1992	79.00
1993	92.03
1994	105.13
1995	125.69
1996	152.57

Table 3.4 Inflation rate	%
1996	23.6

Table VIII-J. 4 Energy sector (a)

Country: HUN

Table 4.1 (a) Total energy requirement (PJ)	Base year		
	1985-87	2005/10	2020/30
Reference scenario total	1332.9	1320	1560
Oil products	366.7	435	480
Natural gas	401.7	451	500
Coal products	359.3	260	400
Hydropower	1.6	1.6	1.6
Nuclear	83.	140	140
Fuelwood	14.1	29	35
Other renewables 1	-	-	-
El. en. import	106.5	3.4	3.5

Table 4.2 (a) Total final energy by sector (PJ)	Base year		
	1985-87	2005/10	2020/30
Reference scenario total	1019.7	1001.3	1198.2
Industry	486.2	370	420
Agriculture	65.8	75	95
Service	76.6	120	167.5
Residential	273.5	316.3	375.7
Transport	117.6	120	140

Table 4.3 (a) Electricity supply (GWh)	Base year		
	1985-87	2005/10	2020/30
Reference scenario total	38848	47300	63300
Oil	4021	6800	9900
Natural gas	5832	9700	14400
Coal	9895	16300	24400
Hydro	159	160	160
Nucleas	8296	14000	14000
Renewables (incl. geothermal)	-	-	-
Net import	10645	340	350

Table VIII-K. 4 Energy sector (b)

Country: HUN

Table 4.1 (a) Total energy requirement (PJ)	Base year		
	1985-87	2005/10	2020/30
Mitigation scenario total	1332.9	1244.8	1485.2
Oil products	366.7	423.9	468
Natural gas	401.7	405.9	460.3
Coal products	359.3	241	376.8
Hydropower	1.6	1.6	1.6
Nuclear	83	140	140
Fuelwood	14.1	29	35
Other renewables 1	-	-	-
Electricity import	106.5	3.4	3.5

Table 4.2 (a) Total final energy by sector (PJ)	Base year		
	1985-87	2005/10	2020/30
Mitigation scenario total	1019.7	952.7	1142
Industry	486.2	370	420
Agriculture	95.8	75	95
Service	76.6	110.7	150.6
Residential	273.5	277	336.4
Transport	117.6	120	140

Table 4.3 (a) Electricity supply (GWh)	Base year		
	1985-87	2005/10	2020/30
Mitigation scenario total	38848	44380	60105
Oil	4021	6080	9280
Natural gas	5832	8830	13465
Coal	9895	14970	22850
Hydro	159	160	160
Nuclear	8296	14000	14000
Renewables (incl. geothermal)	-	-	-
Net import	10645	340	340

Table VIII-L. 5 GHG emissions (million tonnes)

Country: HUN

Table 5.1 (a) Reference scenario emissions	Base year		
	1985-87	2005/10	2020/30
Reference scenario total CO_2 [kt]			
CO_2 from fossil fuels	87760	81230	97340
CO_2 from decrease of biomass stock			
CO_2 from cement & lime	5130		
Reference scenario total CH_4 [kt]			
CH_4 from combustion	27.8	21.2	27.9
CH_4 from oil and gas sector	194.8		
CH_4 from coal mining	74.8		
CH_4 from enteric fermentation	215.5		
CH_4 from landfills/sewage treatment	228.9		
CH_4 from rice production	6.5		
CH_4 from forest and savannah burning	-	-	-
Reference scenario total N_2O [kt]			
N_2O from combustion	10.6	11.4	13.4
N_2O from agricultural soils			

Table 5.1 (b) Mitigation scenario emissions	Base year		
	1985-87	2005/10	2020/30
Mitigation scenario total CO_2[kt]			
CO_2 from fossil fuels	87760	77223	90005
CO_2 from decrease of biomass stock			
CO_2 from cement & lime	5130		
Mitigation scenario total CH_4[kt]			
CH_4 from combustion	27.8	19.6	24.6
CH_4 from oil and gas sector	194.8		
CH_4 from coal mining	74.8		
CH_4 from enteric fermentation	215.5		
CH_4 from landfills/sewage treatment	228.9		
CH_4 from rice production	6.5		
CH_4 from forest and savannah burning	-	-	-
Mitigation scenario total N_2O			
N_2O from combustion	10.6	10.7	12.2
N_2O from agricultural soils			

Table VIII-M. 6 Cost curve data

Country: HUN

Table 6.1 Short term cost curve, 2005/10	reduction (1000 tonnes GHG)			local currency/ton-	US$/ton-
CO_2 mitigation option	CO_2	CH_4	N_2O	CO_2 equivalent	CO_2 equivalent
1 2.1.1 k More CFLs in public buildings	9,9			-38402	**!Syntax Error,)**
2 2.1.1 l More CFLs in households	43,3			-30092	**!Syntax Error,)**
3 1.3.1 Individual metering of hot water consumption	50,6			-15114	**!Syntax Error,)**
4 1.3.2.l Efficient faucets and shower-heads in the residential sector	167,7			-8879	**!Syntax Error,)**
5 2.1.2 Technology change in lighting (replacement of luminaries and controls)	82,6			-8594	**!Syntax Error,)**
6 2.4.1 l Replacement of common ventilation (in multi-storey buildings) by individual ventilation	161,4			-6312	**!Syntax Error,)**
7 1.3.2 k Efficient faucets and shower-heads in the public sector	36,4			-4917	**!Syntax Error,)**
8 1.2.20 Programmable thermostats	78			-3664	**!Syntax Error,)**
9 energy forest	406			-1571	19,28
10 1.1.1.l Post-insulation of roofs, walls, and basement of existing buildings, residential sector	1066			413	**!Syntax Error,)**
11 1.1.1.k Post-insulation of roofs, walls, and basement of existing buildings, public sector	278			6016	**!Syntax Error,)**
12 1.1.5.l Replacement of windows of existing buildings by efficient ones (low emissivity glazing, tight frames), residential sector	589,9			6847	**!Syntax Error,)**
13 1.1.5.k Replacement of windows of existing buildings by efficient ones (low emissivity glazing, tight frames), public sector	304,5			9261	**!Syntax Error,)**
14 1.2.22 Upgrading existing combustion equipment by adjustment and better maintenance	34,7			2822	**!Syntax Error,)**
15 1.3.3.l Active solar DHW system, residential sector	42,4			41910	**!Syntax Error,)**
... 1.3.3.k Active solar DHW system, public sector	6,5			131869	**!Syntax Error,)**
Total reduction					
Total reference scenario emissions					

Table 6.2 Long term cost curve, 2020/30	reduction (1000 tonnes GHG)			local currency/ton-	US$/ton-
CO_2 mitigation option	CO_2	CH_4	N_2O	CO_2 equivalent	CO_2 equivalent
1 2.1.1 k More CFLs in public buildings	19,6			-57527	**!Syntax Error,)**
2 2.1.1 l More CFLs in households	80,3			-50356	**!Syntax Error,)**
3 1.3.1 Individual metering of hot water consumption	93,8			-13097	**!Syntax Error,)**
4 1.3.2.l Efficient faucets and shower-heads in the residential sector	311			-11795	**!Syntax Error,)**
5 2.1.2 Technology change in lighting (replacement of luminaries and controls)	163			-7848	**!Syntax Error,)**
6 2.4.1 l Replacement of common ventilation (in multi-storey buildings) by individual ventilation	299,3			-5775	**!Syntax Error,)**
7 1.3.2 k Efficient faucets and shower-heads in the public sector	71,8			-4168	**!Syntax Error,)**
8 1.2.20 Programmable thermostats	144,6			-3579	**!Syntax Error,)**
9 1.1.1.l Post-insulation of roofs, walls, and basement of existing buildings, residential sector	1976,6			-1586	**!Syntax Error,)**
10 1.1.1.k Post-insulation of roofs, walls, and basement of existing buildings, public sector	516,3			1151	**!Syntax Error,)**
11 1.1.5.l Replacement of windows of existing buildings by efficient ones (low emissivity glazing, tight frames), residential sector	1093,4			1229	**!Syntax Error,)**
12 energy forest	1976			1462	7,694736842105
13 1.1.5.k Replacement of windows of existing buildings by efficient ones (low emissivity glazing, tight frames), public sector	564,7			2524	**!Syntax Error,)**
14 long rotation forest	3396			3059	16,1
15 1.2.22 Upgrading existing combustion equipment by adjustment and better maintenance	64,3			6329	**!Syntax Error,)**
16 1.3.3.l Active solar DHW system, residential sector	78,6			25993	**!Syntax Error,)**
.17 1.3.3.k Active solar DHW system, public sector	12			88053	**!Syntax Error,)**
Total reduction					
Total reference scenario emissions					

Please list the options after increasing marginal cost!

Table VIII-N. 7 Individual option data

It is not possible to interpret for the Hungarian individual options

Country: HUN

Option number and name

Costs in Local currency	Mitigation option	Reference Option
Electricity consumption Capacity of unit Efficiency Fuel type Fuel consumption		
Annual fuelcost Investment Lifetime (years) Discount rate Levelized investment Annual O&M Total annual cost		
CO_2 emission N_2O emission CH_4 emission Total CO_2 equivalent		
Number of installed units		

Local currency/ton CO_2 eq.	

Please give a short description of the option including other important assumptions