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CO_2 EMISSION TRENDS IN HUNGARY

LÁSZLÓ TIHANYI[1]–ISTVÁN SZUNYOG[2]
Petroleum and Natural Gas Institute, University of Miskolc
H-3515 Miskolc-Egyetemváros, Hungary
[1]tihanyil@kfgi.uni-miskolc.hu, [2]szunyogi@kfgi.uni-miskolc.hu

ABSTRACT

At the end of 2010, Hungarian authorities issued a national action plan on the use of renewables in the energy system, and a year later the Parliament adopted a document entitled National Energy Strategy 2030 (in Oct, 2011). Both documents primarily focus on the climate challenge, targeting substantial reduction in current CO_2 emission. Based on the statistical analysis of national and international fuel consumption data, this paper tends to summarize past trends and give projections on the future perspectives of feasible decarbonisation options.

INTRODUCTION

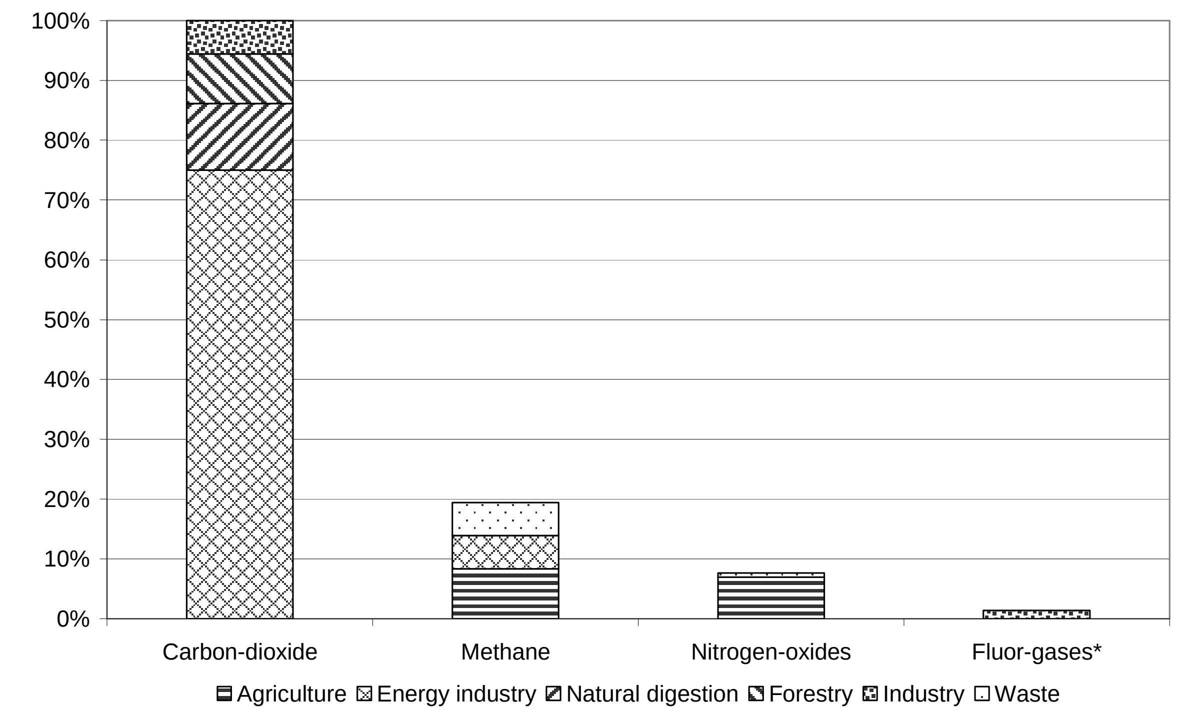
Scientific research conducted on arctic ice cores and marine deposit samples estimate the original level of atmospheric CO_2 content to have been between 180 *ppm* - 300 *ppm* along the past 650 000 years. Since the industrial revolution, the amount of CO_2 in the atmosphere has increased from 280 *ppm* to about 385 *ppm*, and is still being at a constant rise. According to the International Energy Agency (IEA) database, in 2010 cca. 30 billion tonnes of CO_2 was emitted into the atmosphere. The values are appalling.

As for methane concentration, the rise is even more drastic: the past few centuries produced a shift from a natural level of 715 *ppb* (parts per billion) to approximately 1 774 *ppb*. Considering the summed total concentration of greenhouse gases (GHG) in the atmosphere, we get as much as 445 *ppm* (expressed in carbon dioxide equivalent). This value exceeds the level of the pre-industrialized period by about 60%.

Diversifying the above data by emissive sources, surveys show that 41% of total CO_2 emission derives from electricity and heat generation, 23% comes from transport, 20% and 6% is produced by the industrial and residential sectors, respectively. The most substantial shares are attributable to carbon-based energy generation worldwide. Australia, China, India and Poland for instance, still provide 70–90% of their domestic electricity supply from coal-fired plants. The prior emittants are the developing countries: first of all China, almost directly followed by India and Russia. The United States occupies the second place in the list. While in 2008–2009, global CO_2 emission dropped by about 2%, China's contribution alone rose by 5% and countries of the Middle East an additional 4%. As compared, the European Union managed to achieve a 7% cut in CO_2 emission that is remarkable.

GREENHOUSE GASES

Referential values of the respective gases are published in the 2008 IEA report (in accordance with the Kyoto Protocol). As seen in *Figure 1*, methane, nitrogen-oxides and fluorous gases considerably contribute to negative climate effects, still, CO_2 is responsible for 80% of the world's emission. Energy-related CO_2 emissions (including from the industrial sector) make approximately 65% of the total amount of GHG gases and make an 80% share in the total CO_2 amount.



** Fluoruos gases include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur-hexafluoride (SF_6) which are basically related to intensive industrial activity.*

Figure 1.
Shares in the emission of distinctive greenhouse gases (expressed in CO_2 units) by sectors
Source: IEA, World Energy Outlook, 2008

The bulk of CO_2 emission relates to activities of the energy industry, basically electricity and heat generation, as well as transport. Other sources of industrial CO_2 include the utilization of fossil energy resources for non-energy purposes, the direct burning of fuels, and other polluting by-products of applied technological processes. Nitrogen-oxides are emitted into the atmosphere primarily from agricultural and industrial waste. Methane, the second most critical greenhouse gas, is being released mainly from agricultural biomass (landfill degradation) and leftovers of animal husbandry. Industry-related methane emission derives from coal mining, gas leakages and uncontrolled storage conditions. Organic waste also contributes to methane emission. Reducing methane from waste depletion (both agricultural and industrial) is a common preference for environmental protectionists and promoters of energy efficiency. Proper legal regulations are already at hand, applicable technologies being available, implementation now depends on governmental decision-makers and financing.

CO_2 EMISSION OF HUNGARY AND CENTRAL EUROPEAN COUNTRIES

Figure 2 shows CO_2 emission for the EU Member States. Each value is represented against the level of 1990 (taken as base value or 100%). In 2000, some countries happened to overrate the indicatory level however, most Member States achieved substantial reduction over the first decade. The majority of the countries continued steady falling tendencies over the second decade as well. Comparing these lines to that of Hungary, massively declining emission trends can be observed: to 81% by 2000 and to 74% by 2010.

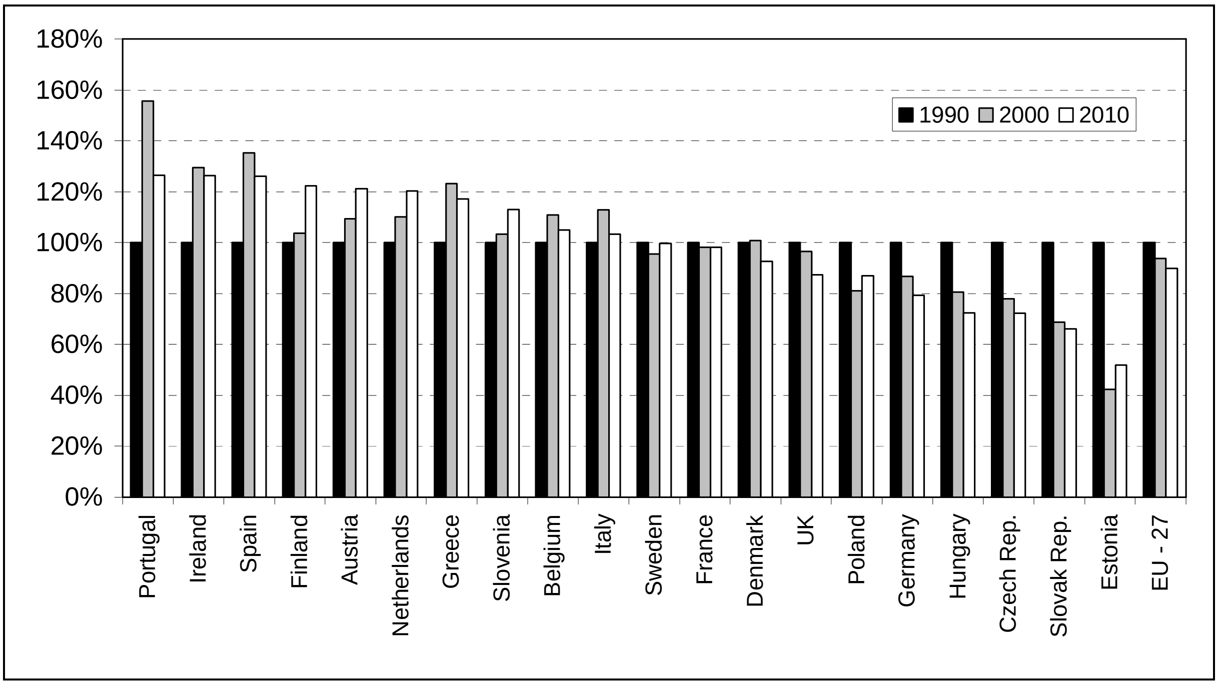


Figure 2.
CO_2 emission trends in EU Member States
Source: IEA, CO_2 Emissions from Fuel Combustion Highlights, OECD/IEA, 2012

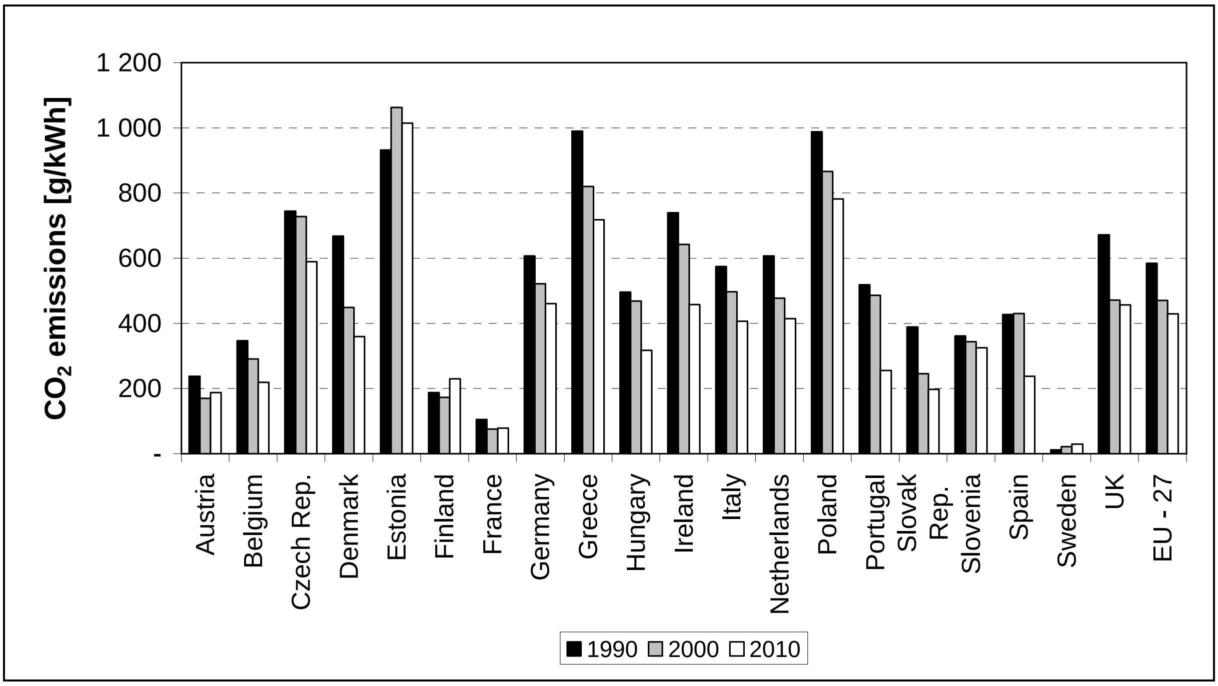


Figure 3.
CO_2 emission from electricity generation
Source: IEA, CO2 Emissions from Fuel Combustion Highlights, OECD/IEA, 2012

Figure 3 represents the CO_2 emission rates of EU states per unit volume of electricity. In this respect, Hungary falls into the OECD EU average. In countries where electricity is mostly supplied from hydroelectric plants or nuclear power stations, the indicators are kept very low. Whereas, in other countries that are heavily dependent on coal-based electricity generation, the indicators are extremely high. The figure also shows that specific CO_2 emission from electricity generation has been reduced in most countries over the past 20 years.

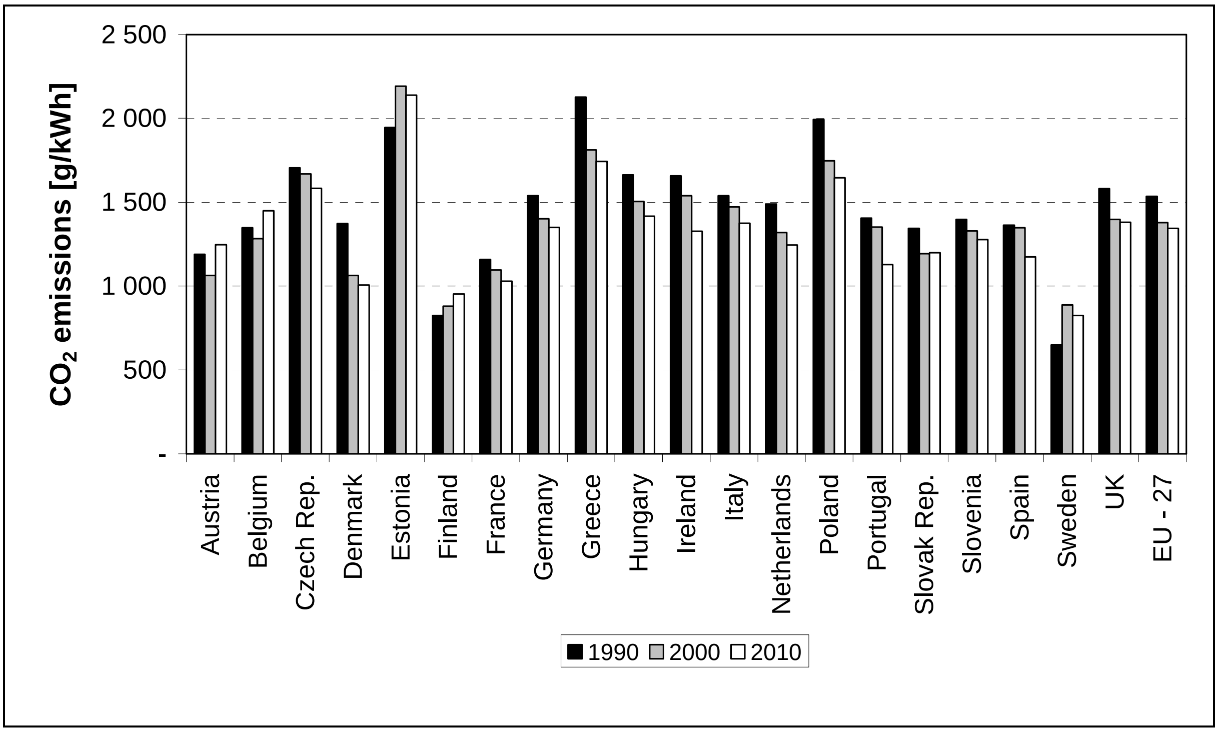


Figure 4.
CO_2 emissions from electricity generation using coal/peat
Source: IEA, CO_2 Emissions from Fuel Combustion Highlights, OECD/IEA, 2012

Considering coal-based fuel plants – as seen in *Figure 4* – no substantial emission reduction is observable over the past 20 years. Indicators mostly exceed 1000 *g/kWh*, in some countries even 2000 *g/kWh*.

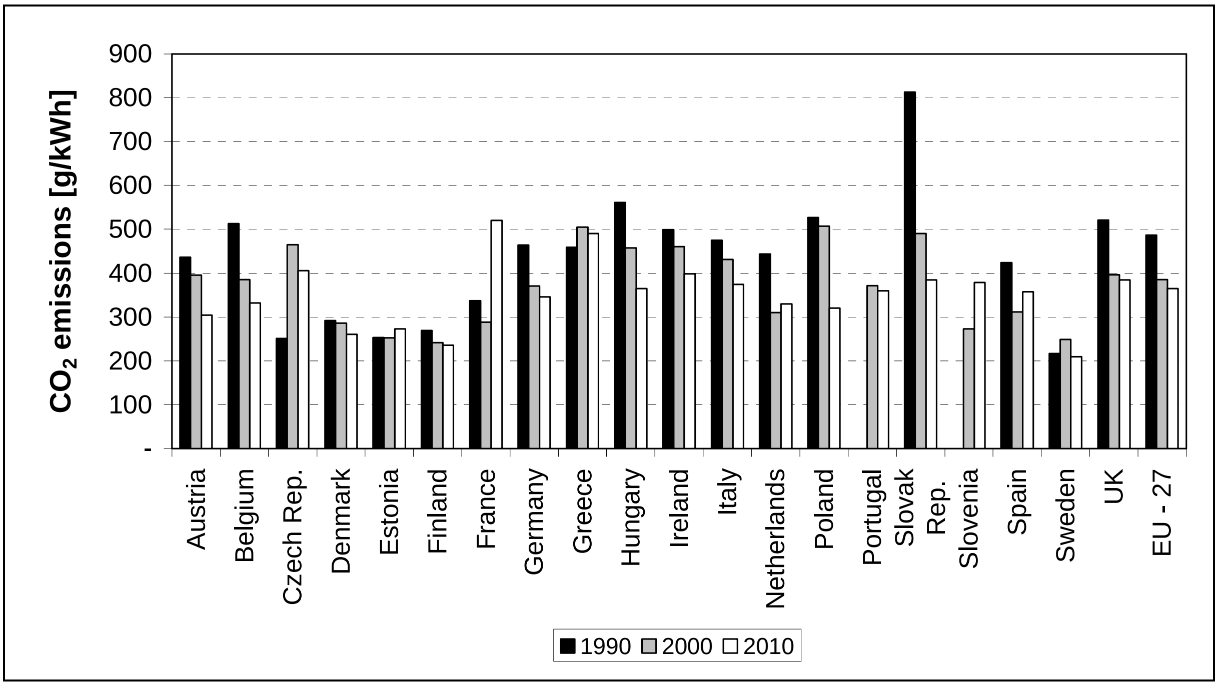


Figure 5.
CO_2 emissions from electricity generation using natural gas
Source: IEA, CO_2 Emissions from Fuel Combustion Highlights, OECD/IEA, 2012

As compared to the above data, specific CO_2 emission rates are a lot more favorable for gas plants. As shown in *Figure 5*, the indicators for most countries stay below 500 *g/kWh*, and a falling tendency is observable.

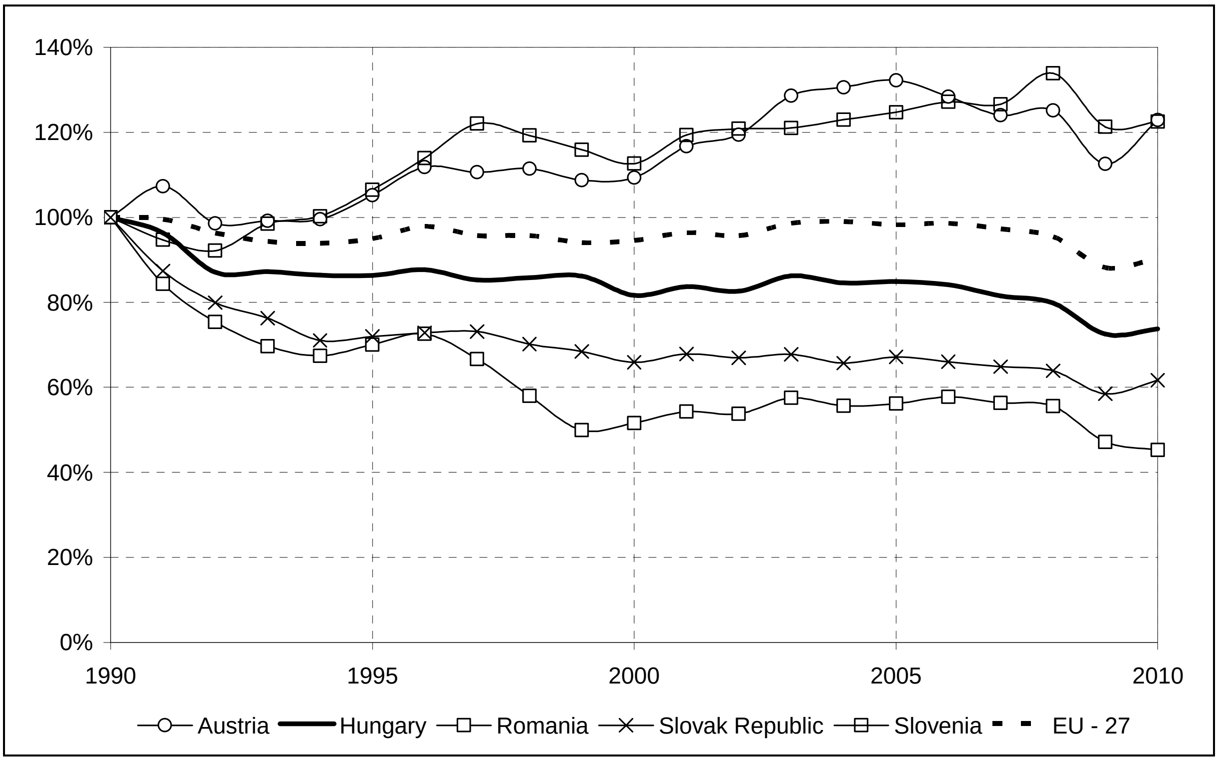


Figure 6.
Trends in CO_2 emission, with reference to the 1990 base level
Source: IEA, CO_2 Emissions from Fuel Combustion Highlights, OECD/IEA, 2012

Figure 6 represents CO_2 emission trends in Hungary and the neighbouring countries between 1990 and 2010. As seen, the EU-27 and Slovenia are showing similar patterns as Hungary, yet, the emission of these two countries notably overrated the level of 1990 between 1995 and 2010. The trends of Hungary and Slovakia are alike in achieving considerable reduction by 2010, in due accordance with the EU-27. Romania is characterized by a peculiar curve, reaching final decline from 2000 on.

To conclude, Hungary seems to have performed remarkably well in achieving substantial CO_2 emission reductions between 1990 and 2010; results forecast, with great certainty, that the country will be able to successfully accomplish the Kyoto target. In the light of historical data, reflecting a leveled precession over the past decades, the Kyoto mandate seems realistic.

On the basis of IEA database (IEA, 2012), *Figure 7* represents Hungary's annual CO_2 emission levels between 1971 and 2010. As clearly seen from the graph, a period of intensive increase up to the early 1980s was followed by a sharp decrease. Around 2000, CO_2 emission levels stayed constant then started falling again.

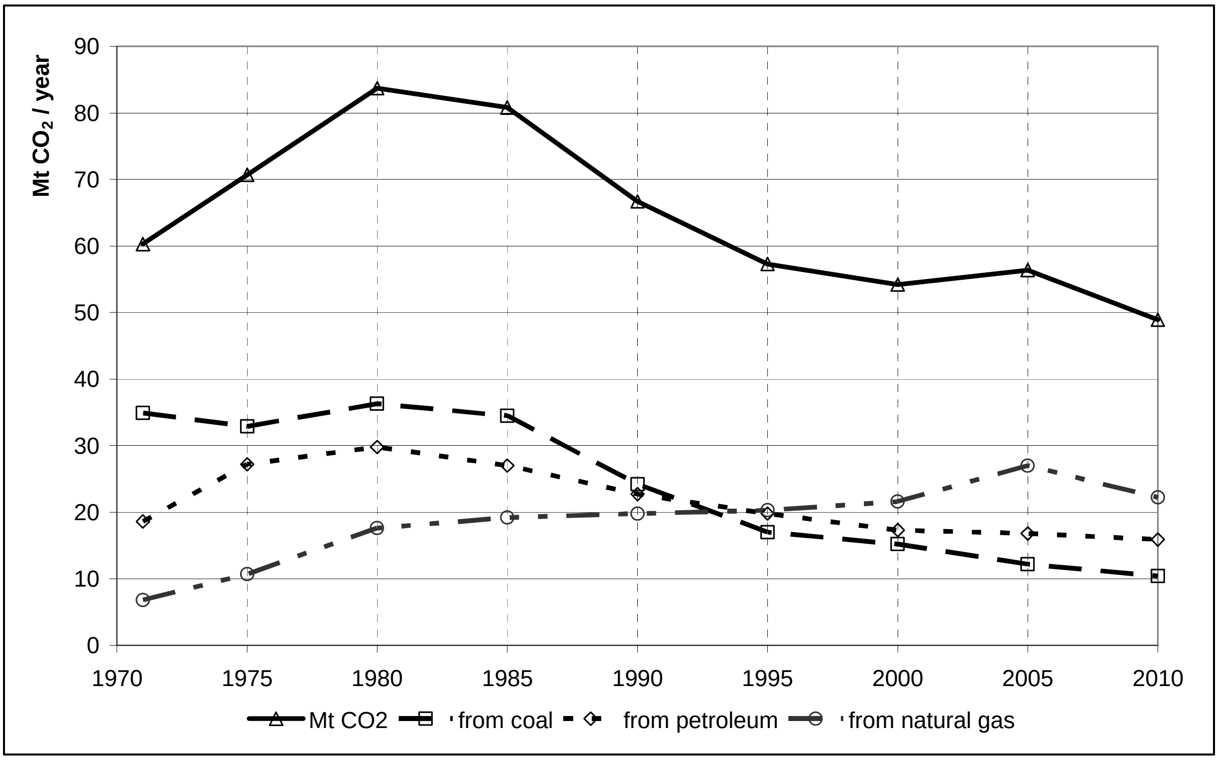


Figure 7.
Hungary's CO_2 emission between 1971 and 2010
Source: IEA, CO_2 Emissions from Fuel Combustion Highlights, OECD/IEA, 2012

As shown, Hungary's CO_2 emission fell drastically in the 1980s. Rather than resulting from conscious energy policy measurements, this trend is basically attributable to heavy setbacks in agricultural and industrial production and to the decline of the formerly operating energy system. Besides radical political changes of the time, Hungary's entire energy infrastructure underwent basic transformations. Solid and fluid fossil fuels were being gradually replaced by natural gas. The dominant role of heavy industry became underplayed by light industry and effective low-carbon technologies were implemented. Developments in the 2000s brought new types of energy demand, leading to increased levels of CO_2 emission once more.

In the context of joint commitment by the Member States to the Kyoto Protocol, Hungary has agreed to achieve a 6% reduction of GHG emissions over the period of 2008–2012, as compared to the base levels of 1985–87. In the past two decades, Hungarian economy and industry underwent fundamental structural transformations leading into a more efficient and competitive low-carbon energy system. As a result, the country's CO_2 emission stayed 43% below the Kyoto base level in 2009, even allowing for extended facilities of emission allowance trading.

AIMS AND EFFORTS IN HUNGARY

The First Paragraph of Parliamentary Order No. 77/2011 (X. 14) declares the requirement of restructuring the entire energy system unavoidable, entangling an increased share of renewable resources in electricity generation, the implementation of new, innovative technologies, heating capacity extension using alternative fuels or green power, the deployment of biofuel vehicles and other low-carbon means of transport. However, as clearly reflected in the document, the current high share of natural gas in the energy market is not expected to be replaced by competitive alternatives, nor other fossil fuels are likely to become eliminable from the energy mix. Thus, there is little chance of experiencing rapid and unprecedented drop in CO_2 emission. Hungary has great potentials to capture and store CO_2 originating from combined heat and power plants, which can largely contribute to realizing the Kyoto targets and making low-carbon energy structure a feasible option.

Further initiatives are set to lower primary energy consumption from 1085 *peta joule [PJ]* (2010 level) by 2030, but not in the worst case exceed 1150 *PJ*. 6–9% of primary energy might be saved from refurbishing obsolete, inefficient fuel-fired power plants, with the additional result of reducing CO_2 emission from today's level of 370 gCO_2/kWh to around 200 gCO_2/kWh. Modernization processes in the energy sector should be delivered in a way to facilitate a higher penetration of renewable energy. The national energy mix is still likely to include nuclear power, with respect to the contribution of Paks reactor, where new atomic blocks are going to be installed. This capacity extension will lead to successful decarbonisation in the middle-term (up to 2030). However, the planned closure of the currently operating four blocks of the nuclear plant following 2032–2037, is likely to result in substantial supply shortages, which will have to be provided from alternative low-carbon sources. A possible scenario to compensate for capacity losses is the establishment of new, fossil-based energy utilities, like gas combustion plants or coal-fired thermal power blocks. Due to subsequent environmental effects, this option is only acceptable if supplemented with mature CCS technologies. In an opposite case, that solution would lead to drastic increase in CO_2 emission, making extra CO_2 emission quotes necessary for Hungary.

The decarbonisation of the energy industry is the most crucial driving factor in the European Committee's Energy Roadmap 2050. Due to present knowledge, this objective only seems feasible with a substantially increased share of renewable energy sources and retain of nuclear energy in the overall energy mix, amended with the wide-scale commercialization of CCS technologies. Considering the decarbonisation principle, CCS will play an essential role in coal-based electricity generation and related industrial fields within the Community. The European Parliament and of the Council extended the scope of emission trade regulations to CCS technologies from 2013. Economic viability of applying CCS technologies basically depends on the market pricing of CO_2. Meanwhile, the European Commission, in its Directive 2009/31/EC on the geological storage of carbon dioxide laid down all the principles for regulating carbon capture and storage processes, from site selection to monitoring and environmental control.

In the national scale, the legislative framework has been established by the Hungarian Parliament via 2010 modification of Article No. XLVIII of 1993 (see Article No. XL of 2010). Subsequently, any kind of exploration, fitting-for-purpose operation, maintenance and closing up of underground geological formations applicable for industrial or energy-related CO_2 storage fall under the effect of Mining Law. Paragraph 22/C of the respective Article lays down the rules for exploiting geological structures applicable for storing large volumes of CO_2 from the energy industry, and provides explicate regulations for storing and handling large volumes of CO_2 in such underground formations. Reporting on the capacity assessment of industrial or geological formations in Hungary potentially applicable for underground CO_2 storage were required to be accomplished by responsible governmental authorities by 31 Dec 2011.

CCS-related storage capacity demands are estimated to amount to about 150 million tonnes by 2018 (Kubus, 2009). In theory, available storage capacities in Hungary are assessed to be orders of magnitude larger, about 26 billion tonnes (see data included in the pertinent Parliamentary Order). The bulk of this volume (cca. 25 billion tonnes) would be covered by deep saline aquifers (located min. 1000 *m* below sea level), supposing that proper geological and safety management information will have been obtained by the time actual operations would start. Underground carbon layers/seams are likely to store about 717 million tonnes CO_2, whereas, depleted hydrocarbon fields might retain as much as 469 million tonnes, in theory.

In 2007, Hungarian power plants emitted cca. 18 million tonnes of CO_2. According to MAVIR data, this amount is expected to abate to 14 million tonnes by 2025. Taking the mean average (16 million tonnes) and dividing it with the potential storage capacity demands assessed up till 2018, it becomes clear, that currently explored underground storage formations seem unable to keep up with CCS needs in the long run (more than 9 years).

CONCLUSIONS

The analysis of CO_2 emission trends in Hungary over the past four decades allow a comparison of historical results with proactive governmental measurements and strategy incentives (included in the National Energy Strategy 2030) to achieve emission reduction by 2020–2030. Conclusions can be summarized as follows:

- The performance of Hungary to achieve substantial reduction in CO_2 emission between 1990 and 2010 is remarkable, and it forecasts, with great certainty, a successful accomplishment of the Kyoto target. In the light of the data, reflecting leveled precession over the decades, the Kyoto mandate seems realistic. Hungary's results are promising and mark the road to pursue in the deployment of energy strategy plans up to 2020.
- Reducing CO_2 emission within the power sector is cost-demanding. Investments are not only required to modernize existing power production, but also to optimally integrate renewable energies and resources into electricity generation. No EU-conform emission reduction targets seems realizable without installing new nuclear power blocks. Since fossil fuels are likely to retain their leading role in the diversified energy supply portfolio, the application of new CCS technologies will be an imperative.
- The high renewable energy resources scenario seems insufficient to deliver substantial emission cuts. Assuming that global climate policies prescribe emission reduction up to 90–95% in the power sector, fossil-fired plants will have to be supplemented with mature and reliable CCS technologies. Most of these projects are still in the innovation phase and need further development to become cost-efficient.

- Hungary has promising facilities to implement CCS technologies: with proper eligibility measures taken, assessed storage capacities in depleted hydrocarbon fields will be enough to retain the current rate of annual CO_2 emission from the power sector over a 9 year term. Yet, safety requirements, providing secure and sustainable storage conditions for centuries are still a critical issue.

The two paramount issues for making CCS technologies economically attractive for investors and market participants in Hungary are: competitive carbon-dioxide prices and scientifically proven evidence that deep underground saline aquifers will be applicable to securely store CO_2 for centuries.

ACKNOWLEDGEMENT

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ABBREVIATIONS

CCS: Carbon Capture and Storage
GHG: greenhouse gases
MAVIR: Hungarian Independent Transmission Operator Company Ltd., MAVIR ZRt.
OECD: Organisation for Economic Co-operation and Development

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