

Maciej Sadowski *, Anna Romańczak *, Iwona Kargulewicz *

The role of industrial processes in the reduction of selected greenhouse gases emission

Rola procesów przemysłowych w redukcji emisji wybranych gazów cieplarnianych

* Prof. dr hab. Maciej Sadowski, mgr Anna Romańczak, dr Iwona Kargulewicz - Institute of Environmental Protection – National Research Institute, Krucza 5/11d St., 00-548 Warszawa, e-mail: maciej.sadowski@ios.edu.pl

Keywords: GHG, emissions, industrial processes, mitigation measures, policies and measures (P&Ms)

Słowa kluczowe: gazy cieplarniane, emisje, procesy przemysłowe, działania mitygacyjne, polityki i działania

Abstract

The paper presents an analysis of the selected anthropogenic greenhouse gases (GHG) emission sources in industrial processes, as well as the mitigation policies and measures in Annex I Parties to the UN Framework Convention on Climate Change. [Text of the United Nations ... 1992]. The main gas in this category is carbon dioxide, but several countries have a dominant share of hydrofluorocarbons (HFCs) with a clear upward trend in their emissions. In Poland, the majority of the GHG emissions from industrial processes come from three categories: refrigeration and air-conditioning (HFCs), cement production (CO₂) and ammonia production (CO₂). An analysis of the policies and measures implemented or planned in this group of countries shows that voluntary programs and agreements among governments and stakeholders are the most effective. A crucial element of the voluntary programs is the support to assist enterprises in the transition to the best low carbon technologies and practices.

© IOŚ-PIB

1. INTRODUCTION

The subject matter of the policy to limit the human impact on climate is the control of atmospheric emissions of carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O) and the so-called fluorinated gases (F-gases), such as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF₆). In accordance with the adopted arrangement, the emission levels of these gases are characterized by a common denominator, which is carbon dioxide, and expressed as its equivalent, enabling comparisons among different categories of emission sources and an assessment of the total greenhouse gas emissions, at both national and global levels. These considerations do not address the most important greenhouse gas, water vapour, as it is recognised that changes in water vapour concentrations in the atmosphere are primarily determined by natural processes and the anthropogenic emissions of this gas from chemical processes in Poland are not monitored and are not subject to international reduction commitments, either at the global level, or at the European Union level.

Streszczenie

Artykuł prezentuje analizę głównych źródeł emisji wybranych antropogenicznych gazów cieplarnianych w procesach przemysłowych oraz działań zmniejszających ich emisję w krajach wymienionych w Aneksie I do Ramowej Konwencji NZ w sprawie zmian klimatu [Text of the United Nations ... 1992]. Dominującym gazem w tej kategorii jest dwutlenek węgla, ale w kilku krajach główny udział mają gazy z grupy HFCs, których emisja wykazuje tendencję wzrostową. W Polsce największa emisja gazów cieplarnianych z procesów przemysłowych pochodzi z trzech kategorii: Chłodziwo i klimatyzacja (HFC), Produkcja cementu (CO₂), Produkcja amoniaku (CO₂). Pośród zidentyfikowanych polityk i działań zapewniających skuteczne ograniczenie emisji z przemysłu, za najbardziej efektywne uznano dobrowolne programy i porozumienia zawierane pomiędzy administracją państwową a przedsiębiorcami. Istotnym elementem dobrowolnych programów są ułatwienia stwarzane przedsiębiorstwom w przejściu na najlepsze technologie i praktyki niskoemisyjne.

The main source of greenhouse gas (hereinafter referred to as GHG) emissions is the category *Energy*¹, including fuel combustion in all stationary and mobile sources (i.e. in the energy sector, industry, transport, households, etc.), as well as the extraction and processing of energy raw materials (coal, oil and gas). In the light of this, the greatest attention in the entire climate protection process is paid exactly to this sector, as well as to agriculture, which is responsible for significant emissions of methane and nitrous oxide, the gases with high global warming potentials [IPCC 2014]. Although at present they are considered to be hardly significant emission sources, the other categories increasingly gain in importance in the global climate policy, as more and more ambitious reduction targets are adopted to tackle climate change. An important element of this process is

¹ The main categories of emission sources applied in national greenhouse gas emission inventories have been unified for all the reporting countries and are consistent with the methodology recommended in the basic publications of the Intergovernmental Panel on Climate Change (IPCC).

the monitoring of the effectiveness of measures taken, as this will enable an assessment of their effects in the form of avoided greenhouse gas emissions [Gibbs, Soyka, and Conneely 1997].

2. MATERIAL AND METHODS

The analysis of selected GHG emission sources in industrial processes, as well as mitigation policies and measures in Annex I Parties to the UN Framework Convention on Climate Change, was carried out on the basis of national reports submitted to the UNFCCC Secretariat and is available on its website (unfccc.int): the Sixth National Communication and the First Biennial Report of 2014 [NC6 2014, BR1 2014].

3. RESULTS AND DISCUSSION

The greenhouse gas emissions from industrial processes in the countries listed in Annex I to the Convention (AI Parties) represent just over 9% of the total anthropogenic emissions of these gases in developed countries. This category includes, inter alia, the production and consumption of F-gases, the impact of which in many cases is thousands of times greater than that of carbon dioxide (e.g. 1 kg of CF₄ has a Global Warming Potential of 7,390, which means that in terms of its impact on the climate it is equivalent to the emissions of 7,390 kg of CO₂). For this reason, despite an apparently slight share in the total global emissions, it is particularly important to control the emissions of these gases in industry.

As a total, the industrial processes in Annex I Parties are responsible for the emissions of 1,396, 847 Gg CO₂eq (2011 data from BR1), where carbon dioxide represents 932,720 Gg, methane 7,676 Gg, nitrous oxide 67,336 Gg and F-gases about 389,120 Gg CO₂eq. In several cases, the emissions of methane, nitrous oxide and F-gases have not been estimated by the countries; still, their quantitative share is slight compared with carbon dioxide.

In most countries, the share of this sector in the national greenhouse gas emissions is less than 10% (Figure 1). Iceland is the country with the highest share of emissions from industrial processes (almost half the national emissions) (Figure 1). This is related to a significant share of emissions from the process of primary aluminium production – a key industrial branch in this country. A higher share of industrial processes can also be noted in several other European countries, for example Lithuania, Norway and Slovakia.

Among the greenhouse gases emitted from industrial processes, carbon dioxide dominates in the total emissions from that sector (Figure 2). It is only in Hungary that HFCs have a major share (more than 55%). In Denmark, France, Greece and the United States, gases of this group represent almost 40% of the process emissions from industry.

Methane emissions in industrial processes (which are slight as compared with those of the other greenhouse gases) come from chemical processes and metallurgy, whereas the process emissions of nitrous oxide occur practically solely in the chemical industry.

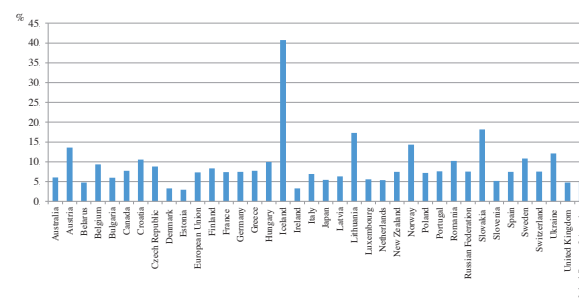


Figure 1. The share of industrial processes in the national GHG emissions in 2011 [BR1 2014].

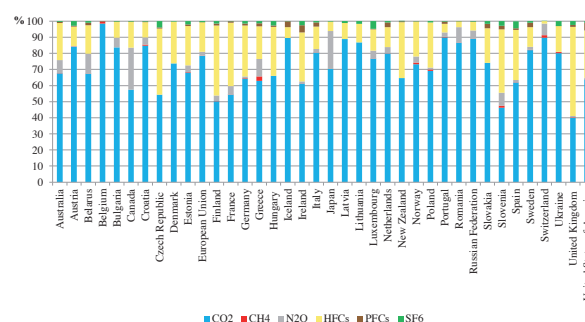


Figure 2. The share of individual gases in GHG emissions from industrial processes in 2011 [BR1 2014].

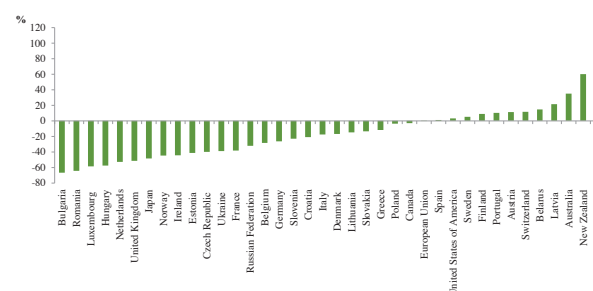


Figure 3. Changes in GHG emissions from industrial processes in 2011 compared to the base year [BR1 2014].

In recent years, in most AI Parties the levels of process emissions decreased compared with the base year (1990 or another year adopted by certain countries with an economy in transition, e.g. Poland) (Figure 3).

Practically, all the countries felt the impact of the economic recession in 2008, which brought an effect in the form of reduced emissions from industrial processes, particularly from cement production. The largest emission reductions could be seen in European Union countries (with 8 EU countries in the first ten, including Bulgaria, Romania, the Netherlands and the United Kingdom), Japan and Norway. However, in several countries, the greenhouse gas emissions increased in the industry, including those in EU countries, such as Latvia, Austria, Portugal, Finland and Spain. Increased emissions are most often related to higher industrial output levels. In the analysed period of almost 20 years, the greatest increase – of more than 100% – in emissions from

industrial processes could be found in Iceland. In that period, Poland saw a slight decrease – of less than 4% – in the process emissions of greenhouse gases.

In the emission reductions achieved in industrial processes, mineral products and metal production have the largest share in the scope of carbon dioxide, and so does the chemical industry in the scope of nitrous oxide. In turn, methane emissions grow in all the branches of industry which are the sources of this gas. Changes in the emissions of F-gases have a much differentiated character. HFC emissions can be seen to intensely grow, as a result of the use of these gases as substitutes for gases which deplete the ozone layer. A different situation can be found for PFCs, the emissions of which show a falling trend in most countries, as a result of a reduced aluminium output or technical modernisation of primary aluminium production processes. SF₆ emissions maintain a similar trend.

Both the Convention and the Protocol require the countries listed in Annex I to the Convention to present in their periodic reports (National Communication, Biennial Report) not only the results of emission inventories and projections, but also to inform what measures they are taking to reduce the greenhouse gas emissions. Such information is called 'Policies and Measures' (P&Ms), and it covers all the sectors subject to the reporting obligation. The aim of a wide presentation of these measures is, inter alia, to support countries with less experience in access to information on the existing methods for reducing emissions, and thereby to make it easier for them to draw on the experiences of others in the implementation of such practices or measures in their territory, so as to enhance their capacity to reduce emissions. The analysis of the Sixth National Communication of AI Parties and their Biennial Report in the scope of industrial processes indicates that most countries only present general assumptions for climate protection in their government or regional policies and strategies (e.g. Australia and others). But it is to a slight extent that they provide information on the measures which have resulted in the reduction of greenhouse gas emissions into the atmosphere. This may result from the fact that specific measures and technologies which are already implemented or are only planned for successive years have been laid down in the above mentioned policy documents or other accompanying documents. Given a wide, interdisciplinary scope of a policy or a strategy, most often it is difficult to determine the effects of single measures or groups of measures adopted in them on greenhouse gas emissions. As a result, the share of policies with estimated current and future emission changes is limited among the huge number of government policies which are indicated as those that lead to greenhouse emission reductions or their enhanced removals. Figure 4 shows an analysis of the climate policy system, consisting of all the sectors of the economy, including industrial processes.

On the basis of an analysis of the National Communication of AI Parties, several groups of causes of emission reductions in industrial processes are listed below [NC6 2014]:

- the reduction or cessation of production,
- technological modernisation,
- controlled emission reductions through legal and financial mechanisms and voluntary agreements.

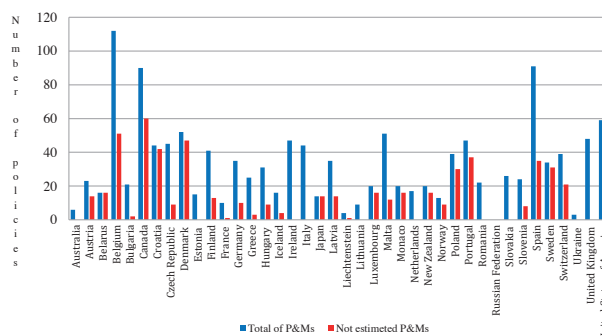


Figure 4. The assessment of the mitigation impact of P&M in the Annex I countries [BR1 2014].

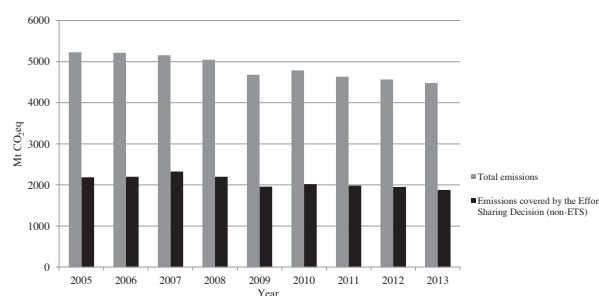


Figure 5. Trends in GHG emissions in the European Union [EEA 2014].

Further analysis is focused only on the last two items, which directly result from the planned national or international policies for the industrial sector.

The measures to reduce greenhouse gas emissions, which are implemented or planned in the category of industrial processes, focus on the application to entities in the industrial sector of a set of policy instruments, including legal requirements (e.g. to reduce F-gases), and economic instruments (taxes and tax reliefs). But first of all, the focus is on the voluntary programmes and agreements concluded between the state administration and entrepreneurs, complemented with information and research instruments. Important elements of voluntary programmes are the measures carried out to facilitate the shift of enterprises to the best technologies and low-emission practices.

Another group consists of economic or social strategies of a declarative character. They indicate the major directions/objectives of tackling of climate change, but do not suggest how they will be translated into specific measures which will affect greenhouse gas emissions. In the Member States of the European Union, the policy which is most often mentioned is the European Emissions Trading Scheme and many Directives which regulate the problem of emissions. However, as indicated by the analysis of the trends of change in the greenhouse gas emissions in the EU since 2005 (Figure 5), the ETS scheme has not had any major impact on emission reductions, although it will still continue to be the most important EU climate policy instrument until 2030 [EEA 2014].

The most effective technologies implemented or planned in Annex I Parties which have been listed in the National Communications of these countries, as well as in other documents (e.g. those of the IEA), have been made available in different databases.

The most complete ones include the database which has been established at the Secretariat of the Convention – the Technology Portal CLEAR (http://unfccc.int/ttclear/pages/tech_portal.html) and the database of the International Energy Agency – Dealing With Climate Change: Policies and Measures (<http://climate.iea.org>).

4. CONCLUSIONS

1. Despite an apparently slight quantitative share of this category in the global emissions (only about 9% in developed countries), industrial processes are important because industry produces and consumes gases with much greater impacts on the climate than that of CO₂. For this reason, it is particularly important to control the emissions of these gases in industry.
2. Carbon dioxide is the dominant gas in the emissions from industrial processes, but several countries have a major share of HFCs with a strong upward trend. Methane emissions can also be seen to grow in the branches of industry which are the sources of this gas. In Poland, the highest greenhouse gas emissions from industrial processes come from three categories: refrigeration and air-conditioning equipment (HFC emissions), cement production (CO₂ emissions) and ammonia production (CO₂ emissions).

3. The three main reasons for decrease of the greenhouse gas emission in industrial processes are: the reduction or cessation of production, technological modernisation or controlled emission reductions through legal and financial mechanisms and voluntary agreements.
4. The most effective measures to reduce emissions from industry are voluntary programmes and agreements concluded between the state administration and entrepreneurs. An important element of voluntary programmes is the set of measures carried out to facilitate the shift of enterprises to the best technologies and low-emission practices.
5. To date, in the emission reductions achieved in industrial processes, mineral products and metal production have had the largest share in the scope of carbon dioxide, and so has the chemical industry in the scope of nitrous oxide.
6. The results of the analysis of the climate policy of Annex I Parties show difficulties in determining the impacts of the adopted single measures or groups of measures on greenhouse gas emissions. Thus, they indicate the need to strengthen the assessments of the effectiveness of the implemented government policies, indicated as those that lead to greenhouse gas emission reductions or their enhanced removals.

REFERENCES

- BR1 (First Biennial Reports of Annex I Parties). 2014. http://unfccc.int/national_reports/biennial_reports_and_jar/submitted_biennial_reports/items/7550.php [2015, October]
- EEA (European Environment Agency). 2014. *Total greenhouse gas (GHG) emission trends and projections* (CSI 010/CLIM 050).
- GIBBS M.J., SOYKA P., CONNEELY D. P. 1997. CO₂ Emissions from Cement Production. In: IPCC Background Document: *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*. Intergovernmental Panel on Climate Change.
- IPCC (Intergovernmental Panel on Climate Change). 2014. *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.). IPCC, Geneva, Switzerland.
- NC6 (Sixth National Communications of Annex I Parties). 2014. http://unfccc.int/national_reports/annex_i_natcom/submitted_natcom/items/7742.php [2015, October]
- NC GLs (Guidelines for the Preparation of National Communications by Parties included in Annex I to the Convention). 2006. Part I: UNFCCC Reporting Guidelines on Annual Inventories 2006. Document FCCC/SBSTA/2006/9. <http://unfccc.int/resource/docs/cop5/07.pdf>
- Text of the United Nations Framework Convention on Climate Change. 1992. http://unfccc.int/files/essential_background/background_publications_htmlpdf/application/pdf/conveng.pdf