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Energy efficiency improvement in industrial sectors: international comparisons

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Abstract.

Eight major industrial processes are responsible for over 50% of industrial energy consumption in most countries. The energy efficiency of these processes was determined in a number of countries, with appropriate corrections for structural differences between countries.

It is shown that considerable differences occur between countries, but that manufacturing industry in Eastern Europe in general is less efficient than in EU countries. In all cases efficiency is worse than what is technically and economically feasible. International comparisons provide information on energy efficiency differences, insight into technological differences between countries and into costs requirements for efficiency improvements.

The comparisons can be used in international climate change negotiations and in the field of bilateral or multilateral cooperation.

1. INTRODUCTION

It is well-known that there are large differences in energy efficiency between countries. Up to now comparisons between countries are done on a national level, using aggregate measures, like the energy consumption per capita or energy consumption per unit of GDP [1]. Such comparisons can give a first impression of the differences between countries, they do not give much insight into the causes of differences or ways to reduce them.

In this paper we will make a more detailed comparison between countries to show it can be used for international climate change policy making. First, we will discuss the results of a comparisons between countries for two main sectors. Subsequently we will evaluate the use of such comparisons for policy formulation.

2. INTERNATIONAL ENERGY EFFICIENCY COMPARISONS

The level of energy consumption in an economic sector is determined by three factors: the level of human activity, the mix of activities (the structure) and the energy efficiency within the sector (the energy consumption per unit of activity) [2]. All of these can be a subject of policy to reduce energy-related CO_2 emissions. Of the three, improving energy efficiency may be considered to be the most important option on the short term.

For energy end-use activities two measures for (the inverse of) energy efficiency are used:

- energy intensity: energy consumption per unit of value added;
- specific energy consumption: energy consumption per physical unit of human activity (e.g. person-km of transportation, tonnes of steel produced).

In general the second measure gives a better insight in the technological characteristics of the use of energy. The first measure is also influenced by other factors, like feedstock and product prices. The second measure is not applicable to all sectors as not for all sectors a good physical indicator of human activity can be defined.

2.1 Energy efficiency in heavy industry

In the heavy industry the activity level can generally be measured in tonnes of product, so energy efficiency is measured as Specific Energy Consumption (SEC). In an earlier analysis [3] we have identified the mix of feedstocks (e.g. primary or secondary feedstocks) and product mix as structural factors. The potential for energy efficiency improvement is established by comparing the present SEC of a country with a 'best practice' SEC. Best practice SEC is here defined as the lowest SEC observed in a sector or plant in Europe in the reference year (1988). In calculating the best practice SEC we take into account the structural effects mentioned before. It should be noted that the energy efficiency improvement potential is time-dependent. On the basis of additional information [4..11] we extend the analysis to countries outside the European Union.

The sectors we have studied are fossil fuel-based electricity production, refineries, iron & steel production, ammonia production, the paper & board industry, the cement industry and the chemical industry. Here we present the results for ammonia and steel production.

- *Ammonia production*

Ammonia can be produced by partial oxidation of oil residues and by steam reforming of natural gas. Steam reforming of natural gas is the more energy efficient process of the two. Eighty percent of the worlds ammonia production is produced by steam reforming of natural gas. The best practice SEC of 28 GJ/tonne ammonia is derived from the ICI-AMV steam reforming process (1988) [3]. Information for non-EU countries is retrieved from [4,6,8,-11].

- *Steel production*

Steel production can be based on the Basic Oxygen Furnace (BOF) route or on the Electric Arc Furnace (EAF) route. The BOF route uses iron ore and scrap to produce primary steel, resulting in a higher quality of steel, but consuming more energy. The EAF route uses scrap only as feedstock for secondary steel production. Product type also influences the SEC. We distinguish slabs, hot rolled products and cold rolled products in the BOF route. The best practice values are based on the Hoogovens plant in the Netherlands (BOF route) and the Badische Stahlwerke plant in Germany (EAF route) [3]. Information for non-EU countries is also retrieved from [4,6,8,9,10,11].

The results are depicted in figures 1 and 2 for ammonia production and steel production respectively. From these pictures we see that there are cases of developing countries and countries in transition that are less efficient than the European countries, but that also in some cases there are no such differences.

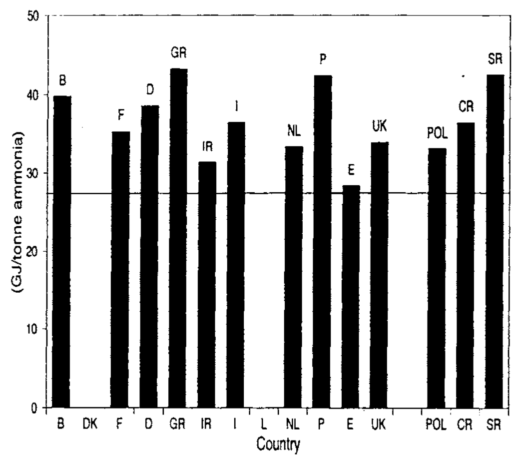

Figure 1. Comparison of the specific energy consumption in ammonia production for various countries. The bars represent the present SEC, whereas the solid line represents the best practice (steam reforming of natural gas).

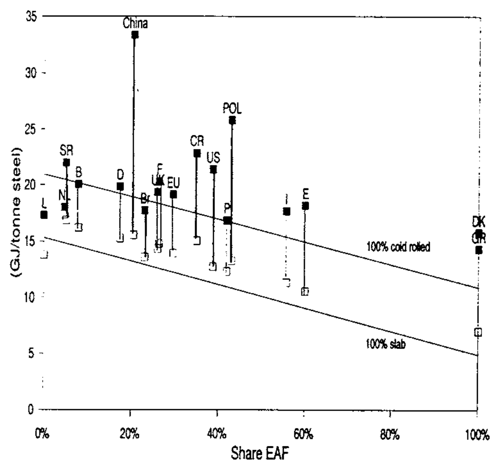

Figure 2. Comparison of specific energy consumption in steel making. ■ represents present SEC and □ represents best practice (with current feedstock and product mix). The solid lines indicates improvement potentials.

2.2 Discussion

The methodology used heavily depends on data retrieved from international statistics. Production and energy statistics are main sources of information for studies like ours. Errors and deviations in these statistics will affect the reliability of the results. For non-OECD countries the accuracy of the statistics is in general less reliable than that of OECD countries. Improvement of available statistics, in an internationally harmonized way, is needed to improve the results of this type of analyses. There is also a strong need for the design of common methodologies to calculate energy efficiencies. The developed methodology needs to be tested for applicability in other sectors, than the ones described in this paper.

4. APPLICATION OF INTERNATIONAL ENERGY EFFICIENCY COMPARISONS

In this section the applicability of international energy efficiency comparisons for the development of international climate policy will be discussed.

•*Improvement of the knowledge on potentials and costs of energy efficiency improvement.*

For many studies on potentials and costs of energy efficiency improvement carried out before, results are difficult to compare. International comparisons of energy efficiency, followed by a sector-by-sector comparison of costs can form the basis for a better understanding of the real differences in potentials and costs for energy efficiency improvement.

•*International agreements on energy efficiency levels.*

In international negotiations on CO_2 emission reduction several approaches (e.g. equal relative emission reduction) lead to objections from part of the countries involved. An alternative approach is to close agreements on energy efficiency levels by sector (taking into account structural differences) that should be obtained by participating countries. International comparisons of energy efficiency are the first step of evaluating possibilities and effects of such agreements.

•*International technological cooperation.*

In international cooperation regarding CO_2 emission reduction (for instance in the field of 'joint implementation') international comparisons of energy efficiency can give an important contribution by steering the cooperation activities by indicating which sectors in which countries should have the highest priorities; furthermore, they can give an indication which type of transfer is most needed: investment capital, knowledge and education, licences, etc.

5. CONCLUSIONS

International comparisons of energy efficiency can be done for many sectors, covering a considerable part of world energy demand. Development of common methodologies of measuring energy efficiency and improving the availability and quality of data is necessary. Taking into account the possible applications of international energy efficiency comparisons in international climate policy, such a task seems worthwhile undertaking.

6. REFERENCES

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Abbreviations

B Belgium
Br Brazil
EU European Union
L Luxembourg
CR Czech Republic
D Germany
DK Denmark
F France
E Spain
GR Greece
I Italy
IR Ireland
NL Netherlands
POL Poland
SR Slovak Republic
UK United Kingdom