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Production costs of the chemical industry in the EU and other countries: Ammonia, methanol and light olefins

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ABSTRACT

Our study compares chemical production costs in the European Union (EU) and other countries in order to understand whether these costs are higher in the case of Europe than in other countries. Our analysis focuses on ammonia, methanol and light olefins (ethylene and propylene), as all of them are considered chemical compounds produced in large scale. The countries selected for comparison are USA, Russia, Ukraine and Saudi Arabia, since they have high shares of extra-EU28 trade and/or the global installed capacity of the selected products. A bottom-up approach (based on information at facility level) has been followed, including 116, 29, 122 and 224 facilities producing ammonia, methanol, ethylene and propylene respectively. Taking into consideration the complex differences in technologies and co-products between operators, costs are broken down to six components: (1) feedstock, (2) credits (due to co-products), (3) electricity, (4) thermal energy 5) other materials (chemicals, catalysts etc.) and (6) labour and other costs (salaries, overheads etc.). Our findings suggest that it is not easy to reach a common conclusion about the whole chemical industry. Overall costs compare more favourably among countries than initially thought in the case of processes producing co-products, but maybe less favourably when processes are without co-products. The European industry has lower production costs than the industries in the other countries in the case of ethylene and propylene, but higher in the case of ammonia and methanol. Feedstock costs play the most important role in the total production costs of all four products, but the presence of credits due to by-products could change the behaviour of the total costs.

Contents

1. Introduction

Discussions concerning the competitiveness of the European industry, both in the industry and in the European Commission, have raised the issue of cost differences between Europe and other countries. In the communication "For an European Industrial Renaissance" [1] it was acknowledged that production costs, especially energy costs, might be higher in Europe than in other competitors.

There are some studies that assess the industrial energy use and CO_2 emissions of chemical products [2,3], but studies on the economic assessment of energy intensive industries are limited [4,5]. They usually focus on the impact of the environmental

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Table 1
Number of facilities per product included in the analysis.

	Ammonia	Methanol	Ethylene	Propylene		
				Refinery grade	Chemical/polymer grade	
					All facilities	Facilities excluding steam crackers
EU	48	5	50	50	91	43
Russia	28	10	14	4	16	6
Ukraine	9	1	2	–	1	–
Saudi Arabia	6	8	15	1	20	7
USA	25	5	41	75	72	38
Total	116	29	122	130	200	94

legislation on the competitiveness and are not always referring directly to the chemical industry or at a European level [6–9].

As the chemical industry is very wide and diverse, it is not possible to model it as a whole, but the assessment has to be restricted to individual products. In our study we aim to establish the different parameters that affect the production costs of four main chemical products and compare these costs in Europe and other countries.

The products selected are ammonia, methanol and light olefins (ethylene and propylene). Ammonia is chosen due to its importance in the fertiliser industry, light olefins because ethylene is the largest value petrochemical commodity produced globally [10] and methanol because of its potential in the transportation sector [11,12].

Ammonia is synthesised from nitrogen and hydrogen according to the Haber–Bosch process (an artificial nitrogen fixation process) and methanol derives mainly from pressurised synthesis gas (mixture of H_2 and CO) reacting in the presence of a catalyst according to the Fischer–Tropsch process (a collection of chemical reactions). These two chemicals have the first step of the process in common, which consists of production of hydrogen or synthesis gas. Hydrogen and synthesis gas are produced mainly by two methods depending on the type of feedstock used: (1) steam reforming in the case of light hydrocarbons, such as natural gas, and (2) partial oxidation in the case of heavy oils or solid carbonaceous materials. The primary feedstock for synthesis gas or hydrogen is natural gas, followed by coal as an alternative feedstock [13].

Olefins (or alkenes) are mainly used in the production of polymers. The term "light olefins" includes mainly the first two compounds of the group: ethylene and propylene. The primary process for production of light olefins worldwide is steam cracking, known also as thermal pyrolysis. Steam cracking is a complex process, producing more than one product and accepting a variety of hydrocarbons as feedstock, ranging from natural gas liquids (ethane, propane, butane) to petroleum liquids (naphtha, distillate fuel oil). Ethylene and propylene yields vary between 24–55% and 1.5–18% respectively, depending mainly on the feedstock and operating conditions [14]. Global production from steam cracking completely meets the ethylene demand in Europe [15] and about 70% of the propylene EU production [16]. Propylene is also obtained as a co-product from fluid catalytic cracking (FCC) [17] and "on-purpose" technologies, such as olefin metathesis [18] and propane dehydrogenation [19].

2. Methodology

2.1. Boundaries and method

As already mentioned, the study focuses on four main chemical products (ammonia, methanol, ethylene and propylene), due to the complexity of the chemical industry and the variety of products and production processes. The goal of our analysis is to assess whether the production costs in Europe are higher than in other countries and for this comparison Russia, Ukraine, Saudi Arabia and the USA are selected. The choice is based on factors such as trade with the EU and/or important industries on the products of interest.

In this study a bottom-up approach is followed in order to evaluate the different costs of the manufacturing processes, based on the information at facility level provided by IHS Chemical in the form of a database [20]. The base year for our analysis is 2013, as it is the latest year with publicly available data in statistics.

The facilities covered fall in the classes 20.13 and 20.14 of the NACE REV.2 classification. Class 20.13 refers to the manufacture of inorganic chemicals using basic processes, while class 20.14 to that of organic compounds [21]. The database provided by IHS Chemical covers all facilities in the countries of interest that produce the four products selected.

Table 1 shows the number of facilities included. Propylene can be found in the market in three different quality grades: refinery (55–75%), chemical (92–96%) and polymer ($>99.5\%$). Propylene produced via FCC is of refinery grade, while steam cracking and "on-purpose" technologies produce at least chemical grade propylene. The table distinguishes among the different processes and propylene grades.

World ammonia production capacity in 2013 was about 211 Mt_{NH3} [22], with EU covering about 9% of it, Russia 7% and the USA 6% [20]. The total capacity coverage of all the countries included in the study reached 23.5% of global capacity. In the case of methanol, the nameplate capacity installed worldwide in 2012 was 95.5 Mt [23], while in 2013 it was estimated to have increased to 98.3 Mt [20]. Saudi Arabia covered more than 7% of the total capacity and all five countries together about 16%. For ethylene and propylene, the global capacities were estimated to be about 154.4 Mt and 147.7 Mt, respectively. Almost 18% of the ethylene capacity and 21% of the propylene capacity was located in the USA, while all five countries together included about 47% of the ethylene global capacity and 43% of the global propylene capacity.

2.2. Components of the cost

It should be mentioned that our analysis did not include depreciation or transportation costs and was focused entirely on the production costs. The breakdown of the costs followed in this study included six components:

a. Feedstock.
b. Credits (due to the value of the co-products).
c. Electricity.
d. Thermal energy.
e. Other materials.

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