2006 IFA Technical Symposium

25-28 April 2006, Vilnius, Lithuania

Technical Research Paper no. 3

Energy Efficiency and CO_2 Emission Reduction: Opportunities for the Fertilizer Industry

presented by

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Energy Efficiency and CO_2 Emission Reduction: Opportunities for the Fertilizer Industry

Abstract

Increased use of biofuels for reasons of energy supply security and climate change could result in a substantially higher nitrogen fertilizer demand. In a scenario targeting stabilization of global emissions at below 30 Gt CO_2/year, model analysis points to use of between 76 EJ and 108 EJ of primary biomass in 2050. Biofuels would account for up to 25% of total transportation fuels (36 EJ/year) in 2050. Biofuel use on such a scale would require an additional 60 Mt nitrogen fertilizer (+41%). But such a demand scenario would only materialize if ambitious CO_2 reduction policies were put in place.

These policies would also create an incentive for higher efficiencies in ammonia production, and probably introduction of CO_2 capture and storage. The net outcome for the industry, however, would be favourable. Moreover energy efficiency in ammonia production can reduce feedstock needs and ease competitive pressure. Present efficiencies and efficiency potentials will be discussed for various world regions, and the G8 dialogue on Climate Change, Clean Energy and Sustainable Development will be introduced.

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All papers and presentations prepared for the IFA Technical Symposium in Vilnius will be compiled on a cd-rom to be released in June 2006.

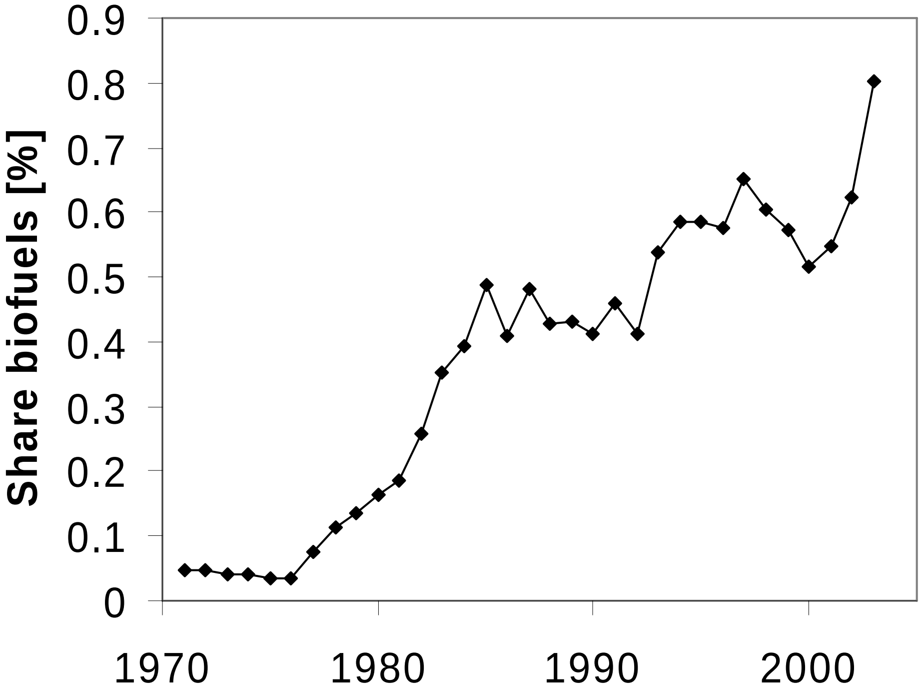
Energy Efficiency and CO_2 Emission Reduction: Opportunities for the Fertilizer Industry

1. Introduction

Energy supply security concerns, high oil prices and CO_2 reduction policies are key drivers for future biofuel use. Greater use of biofuels implies more intensive use of limited land resources, and this could substantially increase demand for fertilizers. This paper discusses trends in the bioenergy industry, potential demand over the coming decades and the impact on the market for fertilizers. It also explores the impact of energy efficiency and CO_2 policies on the fertilizer industry.

Bioenergy is today the most important renewable energy in use. Some 45 exajoules (EJ) of biomass are used per year, representing 10% of global primary energy use.[1] The past 35 years have seen steady growth in quantities consumed. The term "bioenergy" includes "traditional" biomass, however, which is non-commercial, generally combustible and often non-sustainable fuel used largely for cooking and heating in developing countries. It also includes "modern" biomass, mainly associated with industrial use of residues and energy crops. Traditional biomass accounts for roughly 90% of total biomass use (Goldemberg and Teixeira Coelho, 2004).

Figure 1. Share of biofuels in the global transportation fuel market, 1971-2003 (IEA Statistics).



Rising oil prices have again stimulated interest in biofuels for the transportation sector. This development is part of an ongoing trend over the past three decades that swelled the share of biofuels in total transportation sector energy use to 0.8% (0.6 EJ) in 2003 (Figure 1). Further rapid increases are likely.

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[1] 1 EJ = 24 Mt oil, the equivalent of 100 super-tankers

Currently, two forms of biofuel dominate: ethanol and biodiesel. It is estimated that ethanol production world wide will reach 46 billion litres (bl) at end-2005, with 80% (0.78 EJ) for fuel use. 40% of current production takes place in the United States (from corn), 40% in Brazil (from sugar cane) and 7% in Europe (from wheat, sugar beet and wine) (FO Lichts, 2005). Much less biodiesel is produced. It totals roughly 3 billion litres (0.1 EJ) and is concentrated in Europe, which accounts for some 2 billion litres (EurObservER, 2005). World biofuel production is projected to grow by 100-150% over the next 10 years.

On the long term growth in use of biofuels will be determined by:

- Government policy targets;
- Biomass availability;
- Future biofuels production costs as a function of changing feedstock costs and technology improvements;
- Competing uses of bioenergy;
- Alternative options to meet transportation sector demand.

2. Biofuels prospects

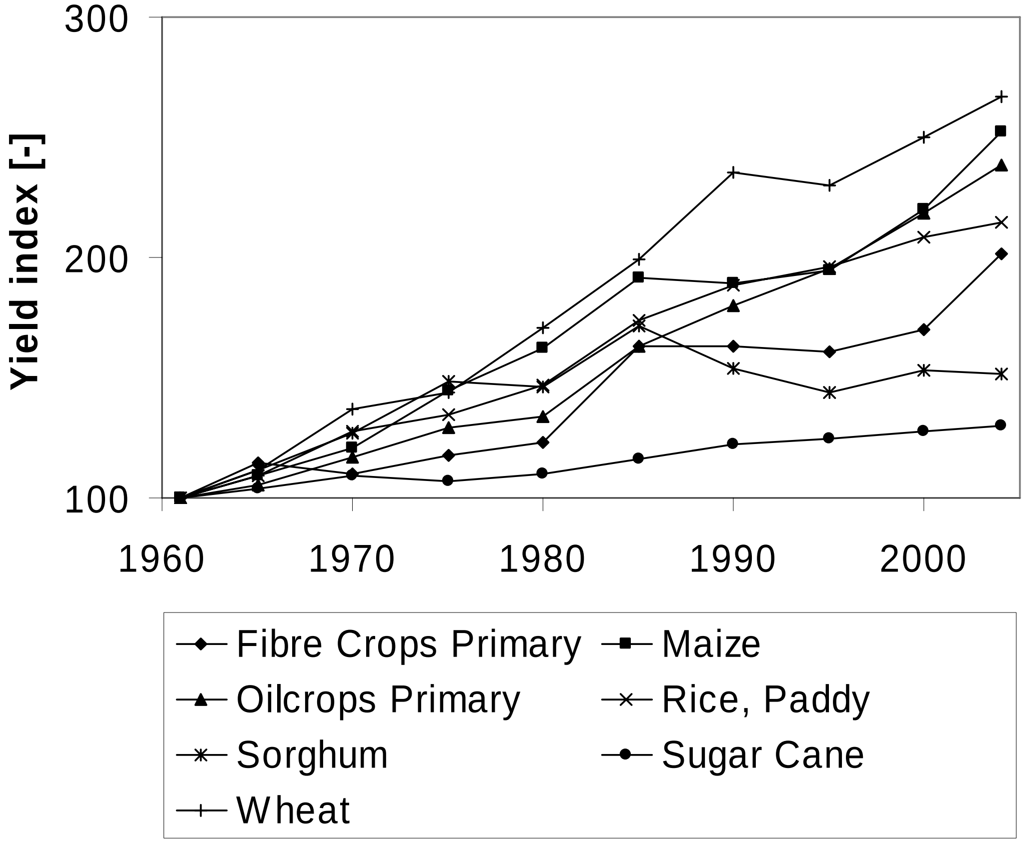
Governments in a number of countries have policies in place or under consideration to get more biofuels into the market. Many sorts of initiative exist and policy instruments range from mandatory biofuel shares in the transportation fuel pool to tax breaks on biofuels or flexible-fuel vehicles (FFVs).

A major challenge is to find ways of mixing substantial amounts of ethanol into the gasoline pool. In Europe, the ethanol content of gasoline is limited to 5% of volume; a higher ethanol share results in volatility problems. The content of ethyl tertiary butyl ether (ETBE, a component that enhances gasoline quality) is limited to 15% of volume. In energy terms, this translates into respectively 3.4% and 4.8% of the energy content (NOVEM, 2003). Various makers are unable to guarantee their cars for use of fuels with an ethanol content exceeding between 5% and 15% because higher percentages may damage the vehicle’s fuel supply system. A breakthrough has been achieved in Brazil, however, where more than 50% of vehicles sold are FFVs able to run on any mixture of gasoline and ethanol.

Nowadays, about 14 million hectares (Mha) are used for the production of biofuels world wide. This is about 1% of all arable land and it yields about 1% of global transportation fuels. To get to 100%, 1.4 gigahectares (Gha) would thus be required, or the equivalent of the entire world’s arable land. Clearly, this implies competition for land use between biofuels and food production. Two factors could mitigate this competition: enhanced agricultural productivity and larger areas of productive land.

Growth in agricultural yields of key crops over the past four decades ranged from 30% for sugar cane to 150% for maize and wheat (Figure 2). This averages out at roughly a doubling. If a similar rate of expansion can be achieved over the coming 45 years, production from the same agricultural arable land would again double. At the same time, however, population would grow by 37% and average per capita food intake by 16%. That would leave 20% of all arable land for other use, without making allowance for greater land use for human habitation, or for land degradation or crop yield declines due to climate change.

Figure 2. Growth of the global average yield per hectare for some key agricultural crops, 1961-2004 (FAO statistics).



Assuming constant yields for biofuel crops (based on the high present yield of these crops), 20% of all present transportation fuels used could be replaced, or 10% of transportation fuels in 2050, taking into account a doubling of demand by then. If, at the same time, average yields of bioenergy crops increased by 30%, then the potential would be 40 EJ of primary biomass, and some 13% of all transportation fuels could be replaced. The outcome is rather sensitive, however, to future agricultural yield gains for food crops. If these average yields were to triple instead of double, almost half of all agricultural land would be usable for biomass, offering an additional 100 EJ of primary biomass potential, translating into an added 30% of biofuel potential (50 EJ/year).

Aside from dedicated crops, agricultural by-products like straw can be used to produce biofuels. According to Kim and Dale (2004), potential exists for producing 491 billion litres (10.4 EJ) of ethanol from wasted crops and crop residues. Crop residues account for 90% of this potential and Asian rice straw represents 38% of that 90%. While increased recovery of wood from existing forests is not considered in the present analysis, it may offer another 10 EJ of biomass. Animal manure may potentially represent between 9 EJ and 25 EJ, and natural organic post-consumer waste may account for up to 3 EJ.

Together, by-products and waste add up to a potential of between 40 EJ and 60 EJ of primary biomass (Hoogwijk et al., 2003). Since 45 EJ of bioenergy is used each year, mainly in developing countries such as China and India, some of this potential may, however, be mobilised already.

In conclusion, between 20 EJ and 50 EJ of biomass by-products and waste may be available for new bioenergy purposes. This brings total new biomass potential to somewhere between 60 EJ and 150 EJ, to be added to continued use of existing bioenergy sources in the range of between 40 EJ and 50 EJ.

The cost of producing biofuels depends on feedstock type and conversion technology. Both vary by region, according to differing biomass yields, land cost, labour costs and availability of capital. Moreover, in regions such as Europe, agricultural subsidies affect production costs significantly. So no single "true" cost figure can be cited for producing biofuels. But it is possible to develop cost curves. The greater the demand for biofuels, the higher the supply cost. Meanwhile, as advancing technology expands the resource base and reduces production costs, the shape of the supply curve changes over time.

Probably the best relevant example of this development is the expansion of ethanol production from lignocellulose (woody) crops. A key problem here used to be high enzyme costs for converting cellulose into sugars. These have dropped more than tenfold in the past five years to 2.5 USDcents per litre of ethanol. At a feedstock price of 3 USD/GJ, the cost of producing cellulosic bioethanol is roughly 62 USDcents/l (24 USD/GJ) (Hamelinck et al., 2005). The current oil price spike of 60 USD/barrel translates into a similar 55-60 USDcents/l gasoline. The energy content of a litre of ethanol, however, is only two-thirds that of a litre of gasoline. Furthermore, oil prices are projected to fall back to the 30-40 USD/barrel range. Therefore, further cost reductions, and possibly tax rebates, will be needed for cellulosic ethanol.

Another important constraint for biomass is the pace at which production can expand. Biofuels production processes will require large land areas, preferably close to the production plants. This could point to land reforms and development of a supply infrastructure. Moreover, the potential for expanding cultivation of crops for biofuels depends on gradual productivity gains for all crops.

Figures 3 shows bioethanol supply curves for the years 2010, 2030 and 2050. These take account of both supply expansion limitations and technological change. They do not allow for competing uses of bioenergy, which could raise feedstock costs and therefore raise supply cost in a CO_2-constrained world. According to this analysis, the potential for bioethanol increases from 2 EJ in 2010 to 45 EJ in 2050. Supply cost will decline significantly. Sugarcane and lignocellulosic crops are the main potential feedstocks for producing bioethanol. Bioethanol from grain and biodiesel from oil crops play a secondary role because yields per hectare are considerably lower than yields from lignocellulose crops. Biodiesel would pose another 18 EJ of fuel potential by 2050 at a production cost of less than 40 cents per litre. This biodiesel production would be largely based on Fischer-Tropsch (FT) synthesis.

Figure 3. Bioethanol supply curves.

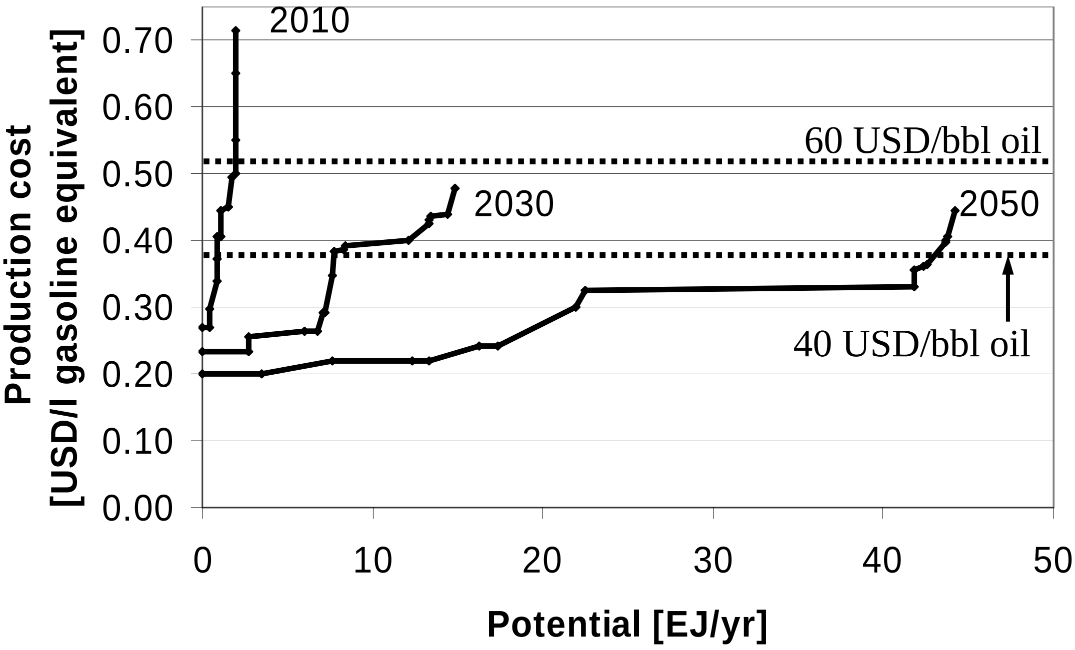
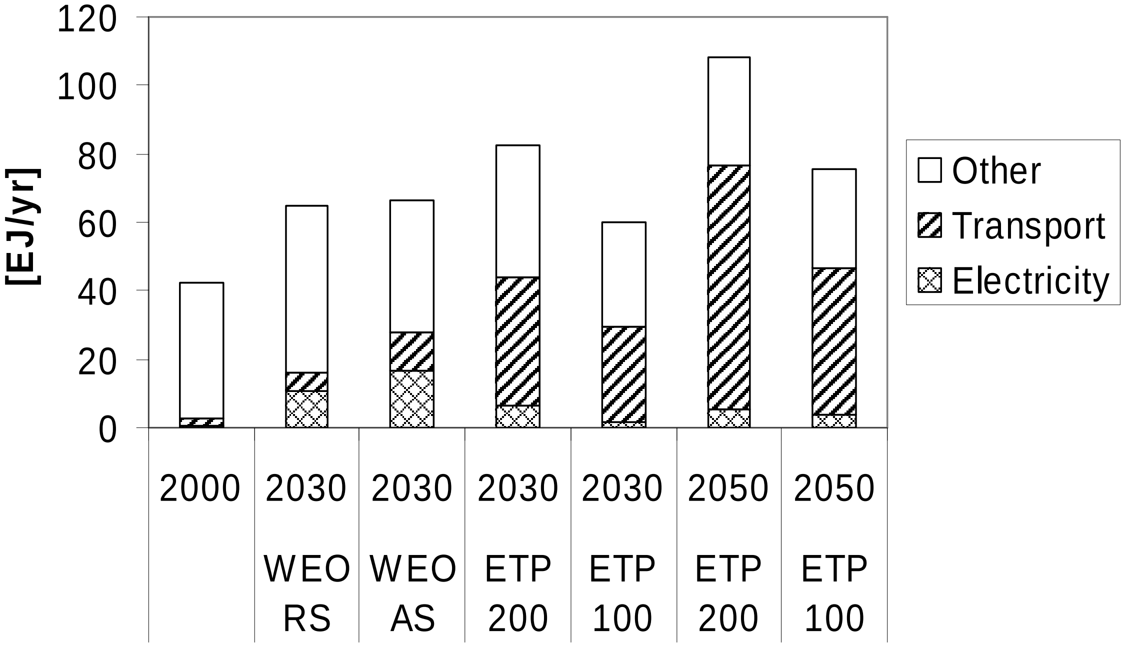


Figure 4 shows primary biomass use. The column to the left shows the situation in 2000. The next two columns show the projections of the IEA *World Energy Outlook* (WEO) 2004 under its 2030 Reference Scenario (RS) and its 2030 Alternative Scenario (AS). These reflect, respectively, implemented energy policies and policies that are under consideration (IEA, 2004a). Four columns reflecting the IEA Energy Technology Perspectives (ETP) model follow, two for 2030 and two for 2050 (Gielen and Unander, 2005). Two scenarios are brought into play. In the first (ETP200), biomass availability increases to 200 EJ/year by 2050. In the second (ETP100), biomass availability is limited to 100 EJ/year. Both ETP scenarios assume that all countries introduce CO_2 abatement policies, reflected in an incentive of 50 USD/tonne of CO_2. This incentive is introduced progressively: from 2015 in industrialised countries, and from 2030 in developing countries.

All projections in Figure 4 show a significant increase in biomass use against 2000 levels. Projections for 2030 range from 60 EJ to 82 EJ. Projections for 2050 range from 76 EJ to 108 EJ. The fact that the full biomass potential is not exploited indicates that competing options become more attractive at a certain point along the bioenergy supply curve. ETP projections suggest much greater biomass use for transportation fuels than do the WEO projections, but less biomass use for electricity production. Total biomass use increases due to the CO_2 incentives. Biomass use for other applications (heating and cooking) declines somewhat. Within this category, traditional methods for using biomass are largely replaced by modern methods. This is an optimistic assumption. In reality, the pace of economic progress in developing countries and market distortions could mean sustained widespread and rather energy inefficient traditional usage of biomass over the coming decades. But even if the level of traditional biomass use remained constant, a substantial biofuels potential would still be unexploited.

Figure 4. Primary biomass use as a function of resource availability.



In a reference scenario without CO_2 policies, transportation fuel demand doubles from now until 2050 and reaches about 180 EJ per year. Demand is reduced to about 150 EJ if ambitious CO_2-policies are introduced. Biofuels account for one quarter (36 EJ) and other synfuels such as hydrogen for another quarter of all transportation fuels in such a scenario. Ethanol represents about 40% of biofuel use, the remainder being diesel and kerosene. Biofuels use falls short of the full potential indicated in the supply curves. This is attributable to competing biomass use for other applications, the introduction of other synthetic transportation fuels and energy efficiency measures.

3. The impact on fertilizer markets

The production of biofuels creates fertilizer market opportunities for two reasons:

- New biofuel crops will need fertilizers;
- The yield of other crop areas must be raised in order to sustain the production of food and other agricultural products.

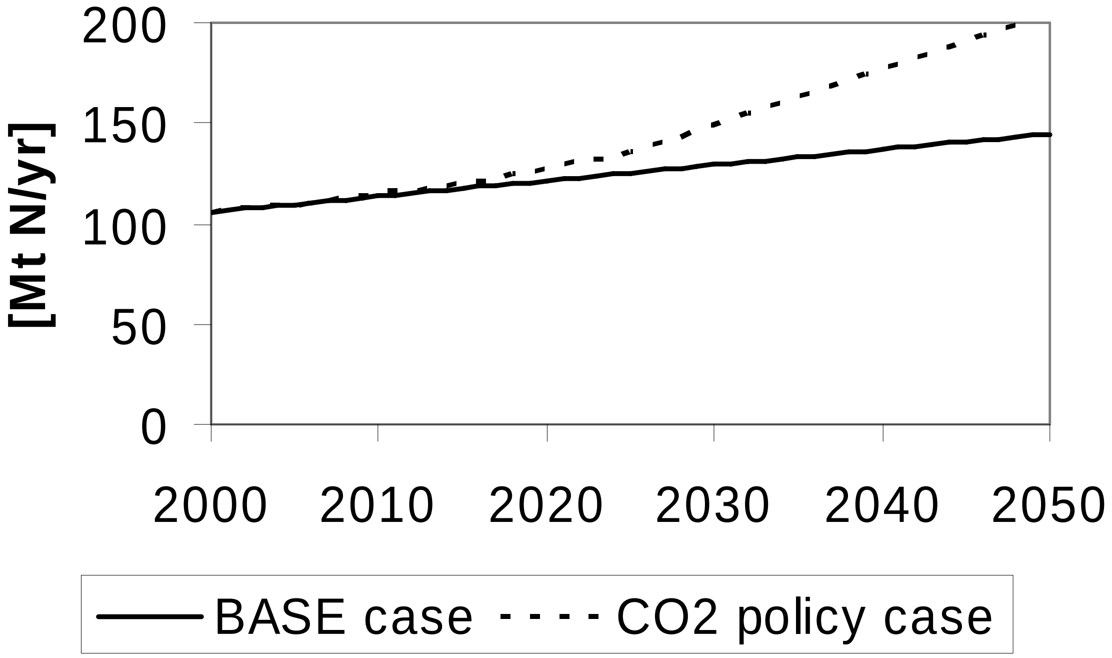
The amount of fertilizer that will be needed for biofuel crops depends very much on the crop type. At the moment, sugar cane, maize and rapeseed are the three main crops for biofuel production. In the future, wood-type crops may join these. Also, increasing attention is being focused on palm oil and other fatty acid methyl ester (FAME) feedstock opportunities.

Sugar cane typically requires 80-100 kg of synthetic nitrogen fertilizer per hectare. For maize, rates of fertilizer use vary widely, from 80 kg nitrogen in Europe to 150 kg in the United States. For oilseed rape, 150-180 kg/ha is used in Europe (FAO, 2002). Fertilizer use for wood crops is considerably lower. Wood crops typically contain 5.2 kg of nitrogen per dry tonne. Assuming a 50% efficiency of nitrogen fertilizer uptake and 16 GJ/tonnes oven dry matter (odm), this translates into 0.65 kg nitrogen per GJ primary biomass energy. Given a yield of 10 tonnes odm/ha for temperate regions and 30 tonnes/ha for tropical regions, this translates into 100 and 300 kg/ha, respectively.

Current biofuel crops cover about 14 million hectares, i.e. about 1% of all arable land worldwide. If biofuel production grows 1.5-fold in the next 10 years (to around 2.5 EJ), this will imply an increase in use of nitrogen fertilizer of 2.1 Mt for biofuel crops. The impact on fertilizer use for other crops, however, is less clear. A decrease can be expected, as 21 million hectares less is devoted to growth of other crops. Given an average global nitrogen fertilizer use of around 65 kg/ha, this translates into a reduction of 1.4 Mt fertilizer. However the remaining land must be used more intensely. Given diminishing returns as nitrogen fertilizer use increases, this effect is estimated at 1.7 Mt fertilizer. Therefore the total effect is an increase in fertilizer use of 2.4 Mt.

Longer term, the impact could be more marked. Assuming that use of biofuels amounts to around 35 EJ by 2050 (20%-25% of total transportation fuels), coming largely from wood crops, 46 Mt of nitrogen would be needed for biomass crops, allowing for a 50% yield in the production of these fuels. In combination with increased fertilizer needs for other areas to make up for the food production loss, about 60 Mt of nitrogen would be needed (Figure 5). This would represent an increase of 41% against the base case without biofuels. This suggests that the net effect of widespread use of biofuels could be substantial, but a transition to a substantial biofuel use may take time. These rough calculations do not, of course, mean that nitrogen availability will be the determining factor for higher production levels of either biofuels or other crops. Biotechnology may also help to increase yields, but its future role is as yet unclear. More biotechnology input could reduce the need for nitrogen fertilizer.

Figure 5. Potential impacts of new energy and climate policies on the nitrogen fertilizer market.



It should be noted, nevertheless, that this market opportunity also poses a challenge for the fertilizer industry. Due to its high energy intensity and nitrous oxide emissions from fertilizer production and fertilizer use, it may be affected in other ways by ambitious CO_2 policies. These emissions are dwarfed, though, by the potential CO_2 reduction due to transportation fuel substitution. The emission reduction effect of 35 EJ biofuels equals approximately 3 Gt CO_2, while the additional fuel and feedstock ose for ammonia production accounts for 100 Mt additional emissions. Moreover these emissions can be reduced by CO_2 capture in ammonia production.

4. Energy use in the fertilizer industry

Anhydrous ammonia is the source of nearly all the nitrogen fertilizers produced in the world. Ammonia is produced by combining nitrogen with hydrogen. The nitrogen is obtained from the atmosphere, while the hydrogen is obtained from natural gas.

Global ammonia production represents about 1.2% of global primary energy use, and 5% of global natural gas consumption (Table 1). The cost of natural gas accounts for between 70% and 90% of the production cost of ammonia. So, when natural gas prices increase, production costs for ammonia also increase. This may or may not translate into higher ammonia prices, depending on the global supply situation. Because gas prices play such an important role, the energy efficiency of gas based ammonia plants is similar in most world regions.

Table 1. Energy consumption in ammonia production, year 2004 (EFMA, 2003; IEA data).

Region	Production [Mt NH_3]	Share gas [%]	Share Oil [%]	Share coal [%]	Gas based [GJ/t NH_3]	Oil based [GJ/t NH_3]	Coal based [GJ/t NH_3]	Energy intensity [GJ/t NH_3]	Fuel use use [PJ/yr]
Western Europe	13.2	100			36			36.0	476.6
North America	16.4	100			37.9			37.9	622.4
Former Soviet Union	18.9	100			39.9			39.9	754.7
Central European Community	5.9	100			43.6			43.6	257.5
China	42.3	20	17	63	34	42	54	48.0	2 026.7
India	13.0	50	50		36.5	50		43.3	562.9
Other Asia	12.2	100			37			37.0	451.6
Latin America	8.4	100			36			36.0	301.8
Africa	3.3	100			36			36.0	119.1
Middle East	7.3	100			36			36.0	263.9
Oceania	1.1	100			36			36.0	39.3
World	142.1							41.4	5 876.4

The average natural-gas steam reforming plant in the U.S. or Europe uses 35-38 GJ/t ammonia; the best available technology uses 28 GJ/t (auto-thermal reforming process). The autothermal reforming process combines partial oxidation and steam reforming technology. According to the European Fertilizer Manufacturing Association (EFMA), two plants of this kind are in operation and others are at the pilot stage (EFMA, 2000).

The theoretical minimum energy use for the production process is 21.2 GJ/t ammonia, given that three atoms of hydrogen are needed per molecule of ammonia and hydrogen has a lower heating value of 120 GJ/t. But the LHV of ammonia is only 18.7 GJ/t. As a consequence, 2.5 GJ of residual heat is generated in the production process and may be used for other purposes. Given the theoretical minimum, current gas-based ammonia production achieves about 60% efficiency. Global average energy use for ammonia production is 41.4 GJ/t. Compared to the Best Available Technology of 28 GJ/t, the energy saving potential is almost 2 EJ per year. However this would imply a complete switch to gas feedstocks.

China and India pose interesting case studies for ammonia production efficiency in developing countries. Together these two countries account for almost half of world ammonia production. Chinese ammonia production amounted to 43.3 Mt in 2004, almost 30% of global production. This makes China the largest ammonia producer in the world. The Chinese production is unique because of its feedstock mix. 63% of all ammonia is derived from coal, 17% from oil products and only 20% from natural gas. The coal based production can be split into medium and small scale plants, with a share of 10 and 90% of production. The energy efficiency depends on the feedstock type and the scale of production: 34, 42, 55 and 53 GJ/t ammonia for gas based, oil based, medium sized coal based and small scale coal based production. The average energy use amounted to 46 GJ/t ammonia in 2004. 2.4 Mt of the coal based production uses Western technology with a plant size of about 0.4 Mt/yr. Many more of such plants are planned. Higher gas prices may result in a wider uptake of this coal based technology. New coal-based plants are being built routinely in China. Eighth of the Chinese plants in operation were using Western gasification technology (GE and Shell technology) in 2004, accounting for 2.4 Mt ammonia capacity. Another 17 plants of the same type, equaling 8.3 Mt ammonia capacity, were planned.

India is currently the second largest producer in the world. The Indian ammonia production reached 13.0 Mt in 2004. Half of the Indian production capacity is based on natural gas, the remainder uses naphtha and fuel oil. Gas based plants used on average 36.5 GJ/t ammonia in 2000-2001, naphtha based plants 39.9 GJ/t and fuel oil based plants 58.4 GJ/t.

The fact that these two countries represent half of world production points to the fact that developing countries must be included in a framework that aims for efficiency in global ammonia production. Also these two cases show that the feedstock situation must be taken into account when energy efficiencies are compared. Finally the energy efficiency of similar installations is similar in industrialized and developing countries, and a limited number of equipment suppliers are responsible for most new installations. Therefore a global technology development approach is needed.

Ammonia and ammonia fertilizer can be shipped around the world at a cost below 50 USD/tonne. In gas feedstock terms, this equals a price difference of less than 2 USD/GJ. Given the much wider existing price gap across world regions of up to 8 USD/GJ it is no surprise to see the relocation effects in the ammonia industry. This is not a new phenomenon but an ongoing trend that has been accelerated by recent developments.

Significantly, 16 ammonia plants in the United States have closed permanently over the past five years, primarily as a result of rising natural gas prices in that country. An additional five plants are currently idle. As a result, ammonia production in the United States fell by more than 6 million tonnes, or 34%, in only five years. As a consequence, the United States fertilizer industry, which typically supplied 85% of its internal needs from domestic-based production during the 1990s, now relies on imports for nearly 45% of nitrogen supplies (The Fertilizer Institute, 2005).

This raises the issue if CO_2 policies can result in major industry relocation and an increase of CO_2 emissions elsewhere, so-called carbon leakage. The US gas price hike would equal the impact of a unilateral CO_2 tax if 70 USD/t CO_2. This case suggests that leakage is a real problem and a major barrier for CO_2 policy making. Clearly leakage is an issue that must be addressed, for example through global sectoral agreements for emissions reduction.

Looking at the longer term, the future role of producers in countries with ample amounts of “stranded” gas merits special attention. This gas may be available for industries at a price of 0.5-1 USD/GJ, irrespective of the world price of oil. At these gas prices, production and transportation costs are well below those for European and United States producers, who are paying well above 3 USD/GJ. It is no surprise, therefore, that production of ammonia and fertilizers is gradually shifting to the countries endowed with large reserves of stranded gas.

5. The G8 dialogue

The leaders of the G8 countries launched the Dialogue on Climate Change, Clean Energy and Sustainable Development at their summit in Gleneagles in July 2005 (G8, 2005). In the framework of this dialogue they have given asked the IEA to help with 14 tasks. One of these tasks focuses on promising areas for enhanced industrial energy efficiency as a means to reduce CO_2 emissions and energy dependency, and increase competitiveness.

The task is aiming for an analysis of current efficiencies across all world regions and across all industrial sectors by January 2007. This will be followed by an analysis of efficiency improvement options and strategies to put these potentials into practice.

Ammonia production deserves special attention in this framework as it accounts for 5% of industrial energy use. The goal is to assess current average efficiencies on a plant, country or region level by feedstock type. In order to assess improvement options, this information must be combined with age profiles for the existing capital stock.

The information will be combined with data for best available technology. As feedstock price trends will differ by region and determine the economics of ammonia plants, the economics of new processes will require scenario analysis.

Important questions remain, such as:

- How to deal with carbon leakage?
- Should attention focus on gas feedstocks only, or will coal emerge as feedstock?
- What level of energy efficiency is cost-effective?
- Are new installations needed or is retrofit of energy efficiency possible?
- What would be the best moment in time to increase energy efficiency?
- Is energy efficiency, CO_2 capture and storage or efficient fertilizer use the preferred option for CO_2 emission reduction?
- How should such measures be financed?

Fortunately the data situation for ammonia production is better than for many other industrial activities. However, the IEA seeks industry cooperation for the assessment of efficiency and emission reduction potentials. The main work would entail help with additional data collection and review of draft reports. Similar cooperation has been established with other industry organizations. It is proposed to channel the cooperation on Ammonia through the International Fertilizer Industry Association and its Technical Committees.

Also the goal is to expand the analysis from industrial efficiency to CO_2 emission reduction options. For example CO_2 capture and storage (CCS) from ammonia plants and more efficient use of fertilizers may pose interesting opportunities. It raises the question if maximum energy efficiency should be aimed for, or a combination of efficiency and CCS. At the same time it is important to explain that increase biomass use implies increased ammonia production. Emission reduction policies should account for such interactions, for example if emission credits are allocated.

6. Discussion and conclusions

Biomass can play an important role in future energy supply. Model analysis points to use of between 76 EJ and 108 EJ of primary biomass in 2050, against 45 EJ at present. Biomass will be used much more efficiently than today. Model analysis also suggests that using the bulk of available biomass for transportation purposes would be more cost effective than using it for electricity production.

In a scenario that targets global emissions stabilisation at below 30 Gt CO_2/year, biofuels would account for 25% of total transportation fuels (36 EJ/year) in 2050. This would represent a 50-fold increase over current levels. Production of biofuels would be based largely on processes unlike those in use today. Further development of these technologies and their market introduction will be imperative if the full potential quantified in this analysis is to be realised.

Turning this scenario into reality could expand nitrogen requirements for fertilizers by 60 Mt of nitrogen (+41%, compared to the base case). However such an increase implies ambitious worldwide energy diversification and CO_2 policies. CO_2 policies would have other effects, notably heightening the need for higher energy efficiency in ammonia production, introduction of CO_2 capture and storage in ammonia plants and possibly calling for measures to reduce nitrous oxide emissions from fertilizer use, not discussed in this paper. The interaction of energy policies and rising oil and gas prices could accelerate re-location of ammonia production to countries with cheap stranded gas resources, and potential carbon leakage effects must be taken into account when energy and CO_2 policies are designed.

But the potential benefits of such ambitious policies for the fertilizer industry as a whole would probably outweigh the constraints.

The leaders of the G8 countries have asked the IEA to look into industrial energy efficiency across developed and developing countries, including the fertilizer industry (G8, 2005). Industry cooperation will be imperative during the coming months in order come up with credible and useful recommendations.

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