AGRO-ECONOMICS AND BIOFUEL

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1. Introduction

Global biomass potentials

There is a worldwide orientation on the possibilities to produce fuels on the base of biomass. It helps to reduce the CO2-emission, as a renewable source it reduces the depletion of sources and the dependence of political instable systems is less. The expectations for bio-energy are high. Targets for bio energy in many national policies are ambitious, reaching 20-30% of total energy demand in various countries.

Current global energy supplies are dominated by fossil fuels (388 EJ per year), with a much smaller contribution from biomass (45 ± 10 EJ). However, biomass is by far the most important renewable energy source used. The contribution of biomass is the highest in the developing countries (20-30%), most of it non-commercial uses. In the industrialised countries biomass contributes less than 10% to the total energy supplies. Commercial energy production from biomass for industry, power generation, or transport fuels makes a lower contribution: some 7 EJ per year in 2000. This share is growing. Biofuels, mainly ethanol produced from sugar cane, corn and cereals, and to a far lesser extent biodiesel from oil-seed crops, represent a modest 1.5 EJ (about 1.5%) of transport fuel use worldwide. Global interest in transport biofuels is growing, particularly in Europe, Brazil, North America and Asia (most notably Japan, China and India). Global ethanol production has more than doubled since 2000, while production of biodiesel, starting from a much smaller base, has expanded nearly threefold. (Lysen and Van Egmond, 2007)

Bio-energy seems to have a huge potential. Lysen and Van Egmond (2007) have analysed several studies. Studies show energy farming on current agricultural (arable and pasture) land could, with projected technological progress, contribute 100 - 300 EJ annually. Then the agricultural sector could also meet the demands of world's future food. Some 200 EJ in 2050 could be produced at rather low production costs (in the range of 2 €/GJ), acoording to Hoogwijk (2005b). This amount could be produced by perennial crops. Less energy (100 EJ) could be produced from biomass on marginal and degraded lands, resulting in biomass with higher production costs. Regenerating such lands requires more upfront investment, but competition with other land-uses is less of an issue and other benefits (such as soil restoration, improved water retention functions) may be obtained, which could partly compensate biomass production costs. When using the more average potential estimates, organic wastes and residues there could be another 40-170 EJ produced on biomass, with uncertain contributions from forest residues and potentially a significant role for organic waste, especially when bio-materials are used on a larger scale. [Smeets, et. al., 2007].

Global biomass potentials vary widely, see figure 1. The high biomass potential for 2050 determined by Smeets et al. (2007) shows potentials under intensive, very high technologically developed agriculture. On the contrary, the low biomass potential for 2050 calculated by Wolf et al. (2003) is caused by high population growth, high food demands and extensive agricultural production systems. The study of (Hoogwijk et al.

2005) refers to production of energy crops on abandoned, marginal and rest land assuming global and regional trends as described in the IPCC SRES scenarios, under increasing agricultural efficiency over time Finally, the study of Rokityanski et al. (in press) determines economic potentials of afforestation and reforestation, excluding other types of biomass and assuming extensive forestry management. As a result, the economic potentials for 2100 are rather low.

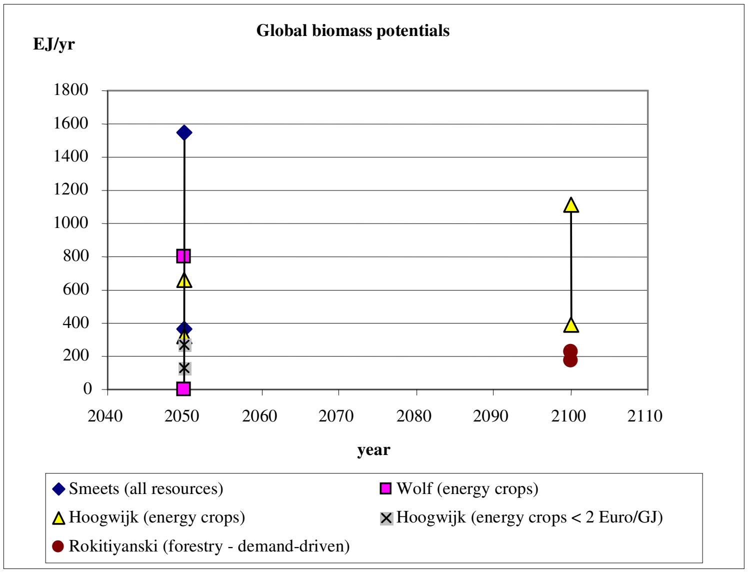

Figure 1: Ranges of estimated global biomass potentials
Source: Lysen and Van Egmond, 2007

Lysen and Van Egmond (2007) assessed the potential studies and concluded that none of al the studies done yet, do include all critical aspects. One of the important issues that remain unresolved are, of which the impact of large-scale biomass production on the prices (and subsequently) demands of land and food can be mentioned.

This paper focuses on the economics of biomass and bio-energy. Agrimarkets and energy markets have an influence on the feasibility of biofuels on four points:

- Oil prices determine the feasibility of bio-energy in two ways:
  - The cost price of biofuel – due to the energy required for the production of biofuel and
  - The price for biofuel made by biomass – competing with fossil oil.
- Agrimarkets determine the feasability of bio-energy in two ways:
  - The price of the feed stock and
  - The price of by products for feed.

This paper discusses the four points of interaction.

2. Oil prices and feasibility of biofuels

Higher oil prices affect world markets for agricultural products in two ways, namely (a) higher production costs of agricultural products and (b) more production of biofuels.

The influence of oil prices on production costs of biomass

Concerning the influence of oil prices on cost price of biomass the OECD-study is relevant. According to the OECD (2006) the share of energy costs in total production costs is 25 to 43%. Furthermore, energy is required in the processing phase. Urbanchuk (2006) calculates a contribution of 25% of the cost price due to the use of electricity and natural gas.

The influence of oil prices on biofuel business

Concerning, the influence of oil prices on market prices for biofuel a number of studies can be mentioned. Figure 3 and 4 give the threshold oil prices for the bio-ethanol and biodiesel at which they are competitive to the petroleum based fuels. The figures show that Brazil is the only producer able to produce at lower costs than the marketprice of petrol-based gasoline in 2004 (USD 39 per barrel). However – when expressed in USD per litre of gasoline equivalent (taken into account the differences in the energy content) – the production costs of bio-ethanol based on maize is higher than the price of gasoline (without taxes) in 2004 (USD 39 per barrel). It would be competitive at a price of USD 44 per barrel. For bio-ethanol based on wheat or sugar beets from EU, Canada and USA the threshold price is higher: up to 60 USD per litre of gasoline equivalent. For the Canadian bio-ethanol from wheat the threshold price is even 140 USD per litre. Bio diesel production costs are almost 1,5 to 2 times the oil-based diesel price net of tax in 2004 (USD 39 per barrel). Bio diesel is competitive at a higher threshold price than bio ethanol. The Canadian bio diesel is competitive at a oil price of 60 USD per litre, but the other bio diesels from EU, USA and Brazil are less competitive. The oil price has to rise to the level of 80-90 USD per litre to be competitive.

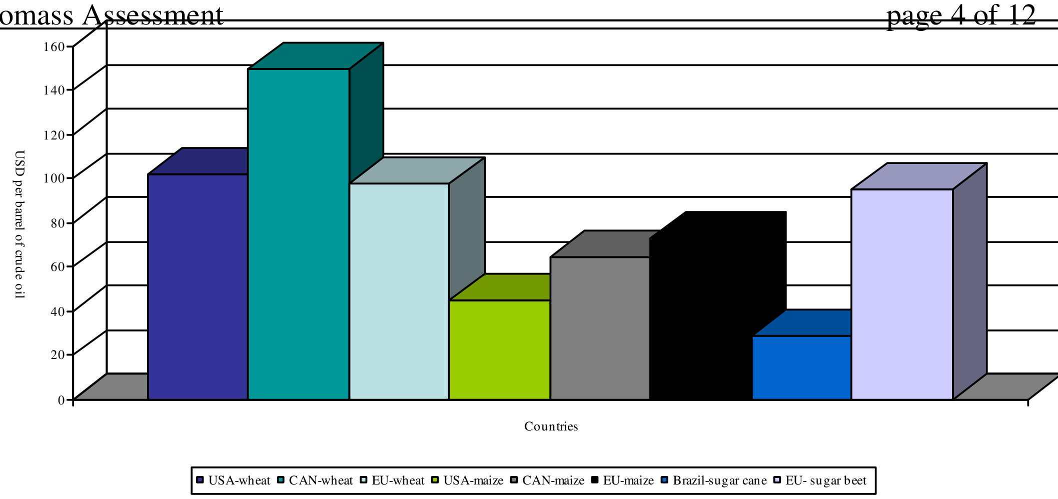

Figure 2: Threshold oil price at which bio-ethanol is competitive, in USD per barrel
Source: OECD, 2006

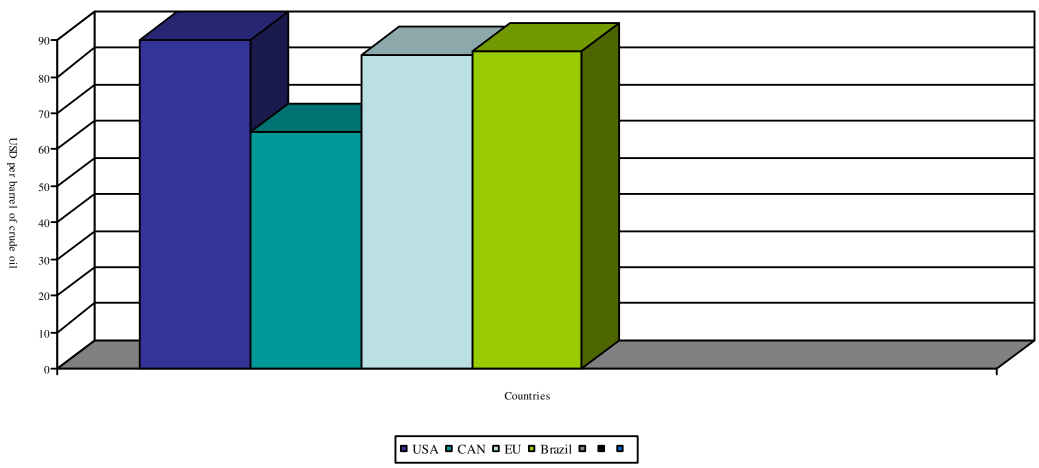

Figure 3: Threshold oil price at which bio-diesel is competitive, in USD per barrel
Source: OECD, 2006

Nowicki *et al*. (2007) have analysed the impact of the EU biofuel directive on the European agricultural and rural economy on the horizon of 2020. The results of this study (Scenar2020) indicate that crop production for biofuel purposes (including cereals, sugar and oilseeds) will increase in the coming 15 years in the EU even without the implementation of the mandatory blending obligation imposed by the EU biofuel directive. Under this scenario crop production expands in all regions of the EU and contribute 3.6 percent of total fuel consumption for transportation. Nowicki *et al*. (2007) conclude that the major uncertainty with regard to all conclusions concerning the future of biofuels is the tightness of oil/energy markets. Therefore any scenario result depends on the assumption made on future development of crude oil price[1]. Banse and Grethe (2006) come to the same conclusions. Sweden together with Germany and the Czech Republic are EU-countries with the highest share in the use of biofuels in transportation.

[1] For this study an increase of crude oil price by 1.5% p.a. has been assumed. Therefore, the impact of biofuels on European agriculture may be under-estimated.

Under a scenario which assumes no mandatory blending the use of biofuels in transportation will increase endogenously due to changes in relative prices (prices of bio-based crops versus crude oil). It becomes clear that even without a mandatory blending the share of biofuels use in transportation increases significantly. The OECD-study (2006) also mentions the importance of the crude oil prices. They expect a higher biofuel production under unchanged policies and higher crude oil prices. However, the degree to which biofuel quantities would increase strongly depends on parameters that are yet unobserved. The FAPRI-Outlook (2006) explains the increased price of ethanol by the increased demand for ethanol and the high gasoline prices. Within the ethanol chain based on sugar-cane the influence of the gasoline price is also indisputable, according to Tokgoz and Elobeid (2006).

3. Production costs of biofuel

Production costs of bio-ethanol

The OECD-report "Agricultural market impacts of future growth in the production of biofuels" (2006) aimed to look at the economics of biofuel production. The study is based on available data on production technologies and costs; many assumptions has been made due to a lack of data. In the report the production costs of agricultural based fuels have been calculated for several countries. Those production costs have been compared (a) across countries and (b) to the oil-based fuel prices. The OECD mentions a "rough" estimation of the functional relationship between fuel prices, production costs and biofuel production. Table 1 gives the production costs of bio-ethanol based on agricultural feedstocks.

Table 1: Production costs of bio-ethanol based on wheat, maize, sugar cane and sugar beet, in USD per litre fuel

	Wheat	Maize	Sugar cane	Sugar beet
USA	0.545	0.289		
Canada	0.563	0.335		
EU-15	0.573	0.448		0.560
Poland	0.530	0.337		0.546
Brazil			0.219	

Source, OECD, 2006

The production costs of bio-ethanol vary widely. Firstly, they vary across regions. One can conclude that mainly for bio-ethanol based on maize the production costs vary between 0.289 USD per litre fuel in the USA up till nearly 155 % more in the EU-15. Secondly, they vary according to the feedstock that has been used. Using sugarcane in Brazil leads to production costs of 0.219 USD per litre fuel, while the used of wheat in the EU-15 leads to production costs of 260% more: 0.573 USD per litre fuel. The differences in production costs are not related to different cost prices of technology; they are based on the differences in costs of (a) feedstock, (b) energy used and (c) prices that are received for the co products from the production process. It is clear the costs of feed stock have a high impact. Another study underlies some of these conclusions. Table 2 also shows the costs of production of bio-ethanol in several countries. Again the difference between countries and between feed stock is clear. However, the final cost prices differ from table 1. For bio-ethanol based on USA-corn the cost price is lower, while for bio-ethanol based on EU-feed stocks (wheat as well as sugar beets) the cost price is higher. As the calculated method is not quite clear, it is difficult to explain the causes of the differences.

Table 2: Production cost of bio-ethanol based on several feed stocks from several regions in the world, in euro per litre

	Bio-ethanol based on US corn	Bio-ethanol based on EU sugar beet	Bio-ethanol based on EU wheat	Bio-ethanol based on Brazil sugar cane
Feedstock cost	0.20	0.23	0.25	0.06
Operating cost	0.11	0.23	0.20	0.08
Co-product credit	-0.10	0.00	-0.11	0.00
Capital repayment	0.04	0.00	0.09	0.04
Factory gate cost	0.26	0.45	0.42	0.18
Cost per gas-oline-eq.litre*	0.38	0.68	0.64	0.27

*adjusted for the lower energy content of bio-ethanol
Source: International Energy Agency (2004)

According to Urbanchuk (2006) corn is the largest expence in the production of ethanol, representing about 57% of total ethanol production costs in 2006. McAloon *et al.* (2000) calculated the operation costs of a corn to ethanol process of a 25 MM gallon per year and concluded that the costs of the corn take 77% of the total production costs.

The studies show also the necessity to sell by products at good prices. Urbanchuk calculate a 11% contribution to the overall revenue and McAloon *et al.* (2000) figured out that the byproducts contribute 30% to the production costs.

Production costs of bio diesel

Table 3 show the production costs of bio-diesel based on vegetable oils. According to the OECD (2006) the production costs for bio-diesel are the lowest in Canada. His (2004) comes to a lower cost price of bio-diesel: 0.35 to 0.65 euro per litre (10.5 to 20 euro per GJ).

Table 3: Production costs of bio-diesel based on vegetable oil, in USD per litre fuel

USA	0.549
Canada	0.455
EU-15	0.607
Poland	0.725
Brazil	0.568

Source: OECD, 2006

The OECD (2006) concludes that the production costs for bio-diesel are within or close to the range of production costs for ethanol from wheat and sugarbeets. They are higher than the production costs for ethanol from maize and sugarcane. In the biodiesel production, the cost of raw materials i.e. vegetable oil makes up about a high share of the total production cost.

The importance of low prices of feed stocks and good sales of by products
Despite the differences in precise share, it's clear that feed stock cost are responsible for a huge part of the cost price. Furthermore, the sales of by products of corn-ethanol and by products of bio diesel is important to compensate costs of production. Both displace corn and soybean meal in livestock ratios.

4. Agromarkets and the feasibility of biofuels

A huge area of biomass is required to meet policy goals
As illustrated in chapter 4 prices of feed stock and byproducts have a high impact on the feasilibity of biofuel. At the same time, these prices are influenced by the markets of biofuel themselves. Nowicki *et al.* (2007) find that meeting 10% of the EU energy requirements for transport in 2010 requires 43% of current land use for cereals, oilseeds, set aside and sugar beet. Meeting the 5,75% goal requires 15.03 million tonnes biofuels, equivalent to 12.02 million hectare or 9,4% of EU-25 agricultural land demand – when all feed stocks for the biofuel is domestically grown. The European Commission (2006) estimates that 0.75 mio hectare oil seeds and 2.5 mio hectare is necessary to meet the goals of the biofuel policies. The OECD (2006) has figured out that replacing 10% of the transport fuel consumption by biofuels requires 30% to 70% of the current crop area in United States, Canada and European Union (15). This is the case assuming unchanged production technologies, feedstock shares and crop yield. Furthermore, is assumed there is no international trade and no marginal or fallow land is used. These figures are convincing in the influence of the biofuel policies and the (potential) impact on agri-food markets.

Economic models show the effects on agro commodity markets
Within the study of Lysen and Van Egmond (2007) some economic studies have been assessed. They all show the impact of the higher demand on agrocommodity markets.

De La Torre Ugarte and Ray (2000) used the Policy Analysis System (POLYSYS) to conclude for the US-case that an increase of 1% of middle distillate fuels replaced by biodiesel would result in higher prices of several agro crops. Prices of soybean oil would rise with 37,7%. At the same time prices of soybean meal would fall with 12,4%. They assumed that farmers would maximize their net returns above variable costs (including seed, fertilizer, pesticide, machinery services etc.) selecting from available crop enterprises and subject to policy and flexibility constraints. The POLYSYS-model contains crop demand modules with utilization for each crop by use: food, feed, industrial, export and stock carryover and fuel. The additional demand requires oilcrops. The area of soybeans is increasing while the area of corn decreases. The demand results in higher prices of vegetable oils. Higher prices for oil and soybeans can be expected. However, due to the fact that the feed market is not increasing while the supply of soy bean meals is growing, the price of soy bean meals declines. This would results in only a small increase of the price of soybeans.

The OECD (2006) conducted the study "Agricultural Market impacts of future growth in the production of biofuels" which aimed to look at the economics of biofuel production and the likely impacts of an expected growth in biofuel-related demand for agricultural products on commodity markets. The OECD assessed the impact for three scenario's[2]. The study clearly shows the additional demand for agricultural commodities is likely to substantially affect the outlook for their markets. Besides the effects on export and import volumes, there is an impact on world market prices. The strongest impact on international price levels are expected for sugar where world prices could increase by up to 60% in 2014 compared to a situation with constant biofuel quantities at their current levels. Other prices would respond less dramatically, but could still gain some 4% in the case of cereals and up to 20% in the case of vegetable oils.

The OECD/FAO-study (2007) clearly illustrate rising prices for several kind of agrocommodities, which might result in higher prices for feed (and thus meat) and food (see table 5). Those high prices won't decrease on short term. They are expected to be high in the nearest future: "prices will be above the historic equilibrium levels during the next 10 years" (OECD/FAO,2007). However, these prices do not only rise due to biofuel policy. This seems to be an important factor, but it's not the only one. Another factor with impact is the rising income in a number of developing countries. These countries show higher incomes, resulting in a higher demand for meat – and therefore feed, like grain. Together with the growing world population the demand for grain as feed is rising. Secondly, there are the consequences of weather conditions. During 2006 there was a serious drought with a huge impact on cereal production. These weather conditions might occur more often. Finally, there is the speculation with it's own effect on prices. The percentage of rising highly depend on the assumptions that have been in the models. It's clear that a new economic equilibrium has to be found: an equilibrium between supply and demand.

Table 5: World prices of some commodies, in USD per ton

	Average 2001/2002-2005/2006	2016/2017	Price of 2016/2017 related to price of 2001/2002-2005/2006
Wheat	152,0	183,2	120%
Coarse grain	103,6	138,2	133%
Oilseeds	266,0	299,6	113%
Oilseed meals	201,0	200,8	100%
Vegetable oils	520,6	613,9	118%
Sugar	217,6	242,5	111%

Source: OECD/FAO, 2007

Banse and Grethe (2006) assessed the effects on production and prices of grain and oilseeds due to the blending obligation of 5,75% or 11,5% within the EU. They formulated several scenario's based on two criteria: reduction of the market prices

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- A constant biofuels scenario including an exogenous assumption of biofuel production, crop demand for biofuels and by product generation at their 2004 level throughout the projection period (of ten years). It's a no-change scenario with respect to biofuels.
- The policy-target scenario: the scenario that includes growth of biofuel quantities in line with the officially stated goals given baseline prices for agricultural commodities.
- The high oil price scenario: the scenario in which the oil price is assumed to be high: 60 USD per barrel from 2005. This high price will affect the agricultural markets in two ways. First it will increase the production costs of agricultural commodities. Secondly it will increase the demand for biofuels.

support and change in the income report. Figure 5 shows that the EU biofuel policy is likely to have a significant impact on agricultural prices. Biofuel policies may heavily affect the price level for agricultural products.

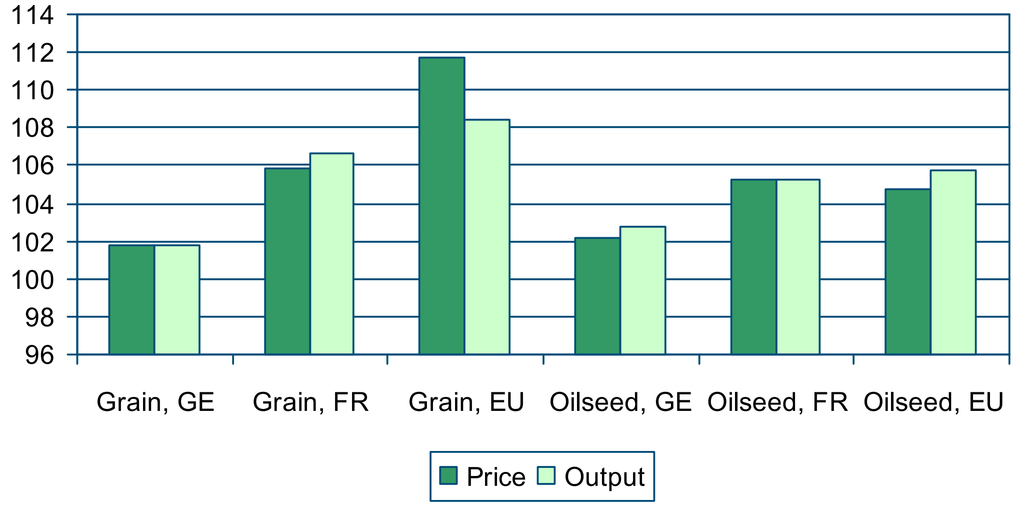

Figure 5: The impact of biofuel directive on production and price
Source: Banse and Grethe, 2006

Finally, the Scenar2020 study shows how non-food demand of agricultural products (e.g. energy) competes with food demand. This implies that first, increasing food prices with possible adverse effects on food importing (developing) countries; and second, a land expansion with implications for the environment. A trade-off between lower greenhouse gas emissions and adverse effects of this expansion and intensification in terms of for example biodiversity.

Recent developments on agro commodity markets
The Food and Agricultural Policy Research Institute (FAPRI) yearly presents the world agricultural production, consumption and trade. In 2006 they present "The FAPRI 2006 US and World Agricultural Outlook" in which the new bio-energy policies in several large countries have been included in the 2006-baseline. Other major drivers of the 2006 baseline include the EU-sugar policy reform, the sanitary and phytosanitary shocks in livestock and poultry markets and the movements in the exchange rate. FAPRI concluded the corn prices increased by roughly 5% above baseline levels, with smaller price increases for other grains. Prices of corn by products fell due to increased ethanol production. By products of corn-ethanol contribute to 10% reduction in soybean meal prices.

Blom (2007) analysed the developments in the grain market. He observes a substantial increase in prices and he explains this increase by several factors. First, the higher income, especially in the developing countries results in a rise in demand for meat – and therefore feed based on coarse grains. The higher demand of pig and poultry increased even more than 3% a year. Also the impact of weather conditions on the agricultural sector is a factor, according to Blom (2007). There has been a serious drought during 2006 in Australia, resulting in less supply. IPCC expects such phenomena to occur more often. However, they expect an overall slight positive effect on production due to climate changes. Finally, there is the extra demand from the biofuel industry.

5. Conclusions

The importance of understanding the dynamics of the relationship between biofuel and agricommodity markets

This paper started with the statement that a huge amount of biomass would be available to produce biofuel, meeting the desire of producing and using sustainable bio-energy. Those potentials didn't take into account the economic dynamics of the agro markets. This paper discussed the four points at which agromarkets and energy markets relate to the feasibility of biofuels. It clearly shows the influence of oil prices on the feasibility of the biofuel business. The feasilibity of biofuel is also highly affected by the prices of agro feed stocks. Finally, the extra demand of biomass has an impact on the agro commodity markets. Higher prices of several agro crops are observed, yet and they don't will decrease on short term. One has to have three comments in mind. First, the high prices are not caused by only biofuel policy. Secondly, models and practice are based only on the first generation biofuel, while the second generation biofuel might have other consequences. Finally, the agro markets needs time to find new equilibriums, for example concerning the use of by products of bioethanol and biodiesel.

Higher world price are felt by several market actors

The higher prices are felt by several market actors.

Farmers growing arable crops receive higher prices for their biomass. For example the market perspectives appear to be moderately positive for most EU cereals, according to the European Commission (2006). The emerging bioethanol and biomass demand is one of the factor responsible. Market perspectives for the EU oilseed sector seem to be positive also due to the increasing demand for biodiesel in the European Union.

Animal farms – however – are negatively affected by the higher prices of crops. Feed prices are rising. On the other hand, demand for meat is rising and corn can be replaced by (cheaper) protein feed from byproducts of biodiesel and bioethanol production. It requires a change in composition of animal feeds towards more protein rich feeds at the expense of cereals. The feed industry is rather flexible in using several feedstocks, so after some time a new equilibrium is expected to be found.

Producers of biofuel are confronted with higher prices of feedstock which has a negative impact on their viability. For example the US (bron vermelding) announces the first negative returns on bioethanol due to high corn prices.

Agribusiness is facing higher prices, retail is worried and consumers have to pay higher prices for food. In the *well developed* countries there is worry about the higher food prices and the question "will food manufacturers and energy companies compete in the future?" is relevant. Furthermore the question "do consumers want cheaper food or cleaner fuels in their cars?" becomes relevant. In the *less developed* countries there is the more fundamental question: "what impact do biofuels have on our food supply and food prices?". The OECD and FAO (2007) state "the higher commodity prices are a particular concern for net food importing developing countries as well as the poor in urban populations".

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