10th IAEE EUROPEAN CONFERENCE

IAEE
INTERNATIONAL ASSOCIATION *for* ENERGY ECONOMICS
WWW.IAEE.ORG

7-10 September 2009 in Vienna, Austria

Energy, Policies and Technologies for Sustainable Economies

Executive Summaries

Austrian Association for Energy Economics
AAEE

Reinhard Haas, Christian Redl, Hans Auer, Marion Glatz (Editors)
Energy, Policies and Technologies for Sustainable Economies. Executive Summaries of the 10th IAEE European Conference 7-10 September 2009 in Vienna, Austria.
Published 2009 by: International Association for Energy Economics, Cleveland OH

ISSN 1559-792X

The 10th IAEE European Conference was hosted by the Austrian IAEE Affilitate Austrian Association for Energy Economics

Printed in Austria.

Does bioenergy contribute to more stable energy prices?

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1. Introduction

One of the core arguments for promoting renewable energy sources is that they do not only contribute to mitigation of greenhouse gases but also lead to a higher diversification of the energy mix. Moreover, they would show lower price volatilities, which fosters more stable economic conditions in the energy system. Further it is argued that the substitution of volatile fossil energy carriers by renewable energy sources can also show significant macro economic benefits by disburdening trade balances of industrialized countries with low amount of domestic fossile resources (see e.g. Ragwitz et al., 2009). In particular, the utilization of biomass fuels is often associated with the creation of regional value added and employment which can lead to corresponding macro-economic benefit in case that price volatile imported fossil fuels are substituted (Kranzl et al., 2007).

However, bioenergy prices partly turned out to be volatile as well and not fully independent from the oil price. Several regions showed significant price fluctuations between 2006 and 2008 for different bioenergy fractions. This is especially true for agricultural commodities. Thus, the following questions arise: To what extent can the presumption of stable bioenergy prices be justified? To what extent do bioenergy prices contribute to stabilizing economic conditions in the energy system?

These lead to the following sub-questions:

- To what extent are the volatilities of bioenergy prices relevant for macro-economic indicators and balances?
- Have prices of biomass fuels been less volatile than fossil fuel prices in the last years and decades?
- What are the system and markt linkages between oil and bioenergy prices?
- What are the strategies leading to more stable bioenergy prices and – finally – to more stable prices of energy services?

The analysis contains the following steps:

- Literature review regarding biomass and fossil fuel price volatility and their correlation.
- Description of the macro-economic impact of bioenergy price volatility in a formal framework. Results will be shown both for characteristic generic regional examples and in particular for the case of Austria. Based on standard input/output multipliers we quantify macro-economic indicators for full coupling of bioenergy and fossil energy prices compared to the case of no linkage between these prices.
- Analysis of price volatility of bioenergy products based on empirical historical data. In particular we investigate the cases of conventional agriculatural commodities, pellets price and other wood-based energy price indices. Particularly in the case of agricultural commodities it has to take into account direct and indirect market interventions. Based on this analysis we identify sources and reasons for price volatility.
- A special part of the analysis of bioenergy price volatility is dedicated to the question of correlation and linkage between historical bioenergy and fossil energy prices. Therefore, we analyse linkages between bioenergy production costs and fossil energy prices. The share of energy related costs on agricultural bioenergy products is indentified.
- In the last step we derive conclusions and discuss strategies for reducing bioenergy price volatility and dealing with unavoidable price volatility.

2. Literature review

A broad range of literature exists dealing with the analysis of **fossil energy price volatility**, in particular with respect to the historic and recent oil price shocks and the challenges of oil price analysis and scenarios (e.g. Schrattenholzer, 1998; Plourde et al., 1998; Regnier, 2007; Wirl, 1990; Wirl, 2008; Kranzl et al., 2008). Some of them are especially focusing on patterns and correlation with geopolitical incidents.

Others are dealing exclusively with comparing price volatility of different commodities and energy carriers. E.g. Plourde et al., 1998 examine aspects of price volatility for two marker crude oils and nine other widely traded commodities. They come to the conclusion that that between 1985 and 1994 crude oil is in the upper end of the range of all measures of price volatility studied, but is not clearly beyond the bounds set by other commodities.

Regnier, 2007 is testing the hypothesis whether oil and energy price volatility are unusually high (or low) among commodities. For this purpose, the price time series of a wide range of commodities in the American economy are investigated. The basic approach is the comparison of price volatility which is measured as the standard deviation over a 5-year period of log-differences in monthly price values. The analysis comes to the result that before 1970 oil prices were significantly less volatile than about a third of all other products' prices before 1970. Since 1986, oil prices turned out to be significantly more volatile than at least 93% of all other product prices. However, compared to other crude commodities, oil prices in the last investigated period from 2001-2005 are more volatile than about 60% of other products. What is most striking for our paper is the relation between crude oil price volatility and crude commodities in the sectors "farm products" and in particular "foods and feeds". For the same time period in these two sectors, oil price volatility is significantly higher than 44% and 33% of all farm product prices and foods and feeds prices, respectively. Whereas oil price volatility is significantly *lower* than 31% and 67% of farm product prices and foods and feeds prices, respectively. This leads to two main conclusions which are quite relevant for the question of our paper: First, among all crude commodity sectors, the agricultural commodities show the highest price volatility compared to the oil price volatility. Second, the agriculture sector itself is quite inhomogenous. Compared to other sectors, a relatively high share of commodity price time series statistically significantly shows higher volatility than the oil price and at the same time also a relatively high share shows lower price volatility than the oil price.

Another broad range of literature is investigating the impact of energy and **oil price volatility on the macro-economic performance**. E.g. Awerbuch et al., 2006 compare the macroeconomic costs of oil price volatility with the macroeconomic costs of renewable energy which – in their argumentation – act as a diversification tool reducing the energy price volatility.

Also the **volatility of agricultural commodity prices** is investigated in a long list of studies. With respect to the linkage of energy and agricultural markets we can identify a strong focus on the question how support policies for liquid biofuels influenced agricultural markets and food security in particular in the last few years. Here we can mention the studies Heißenhuber, 2006, Doornbusch et al., 2007, Fischer et al., 2009, European Commission, 2007, Schmidhuber, 2007, Von Lampe, 2007, Mitchel, 2008, Thompson et al., 2009.

From a methodological point of view, the term "**volatility**" in the literature is not used in the same way and different measures and indicators are applied. On the one hand we have to distinguish long term volatility and short term volatility. Where long term volatility can be understood as the price deviations over years or even decades where short term volatility can be understood as the price deviations over months, days, or even hours or minutes. This aspect can be covered by the time frame that we apply and the time distance between two data points. Regnier, 2007 points out that the commonly used measure of commodity price volatility is the standard deviation of price differences. However, she used standard deviation of log price differences over a five year period which she concludes to be the "best general measure of volatility and an indicator of changes in volatility over time." However, the choice of a "best model – and therefore measure – of stochastic volatility remains an open question and might differ across commodities" (Regnier, 2007).

Compared to the topics mentioned above, the **linkage and correlation of fossil and bioenergy prices and in particular their price volatility** has not been addressed in many publications in detail. Many papers dealing with renewable energy and bioenergy in particular refer to the common assumption that bioenergy leads to more price stability compared to fossil prices. However, the authors are not aware of many publications dealing with this question in a really comprehensive and profound level in the sense of integrating the full range of bioenergy fractions and resources. Schmidhuber, 2007 is dealing with the question of price effects and price transmission from (bio)energy to agriculture also taking into account the level of market integration between the energy and the agriculture market. Thompson et al., 2009 investigates the impact of a biofuel obligation on the volatility of oil, corn and ethanol prices.

We do not claim to provide such a fully comprehensive and profound analysis in this paper. Rather, we want to raise the relevant questions and identify the main aspects and issues. In this sense, we understand this paper as a starting point of discussion.

3. Price volatility of bioenergy and macro-economic impact

In this section of the paper we investigate to which extent price volatility of bioenergy actually matters for macro-economic impacts and balances. Thus, we provide the basic motivation for the whole paper: (Why) do we really have to matter about price volatility?

3.1. Methodology and formal framework

As a main step, we describe the current bioenergy utilization by a series of representative technologies. These technologies include heating, electricity and transport-biofuels. The current status of utilization of various biomass technologies is taken from official statistics and own investigations.

Investment, operation and maintenance and fuel costs of these representative technologies are distinguished in the main components. These components are assigned to typical commodities according to the Input-Output-table and NACE classification. Subsequently, we apply I/O-Multipliers in order to derive direct, indirect and induced value added and employment impact. Substitution effects are considered by the means of conventional, fossil reference systems. The impact of additional costs, either as private willingness-to-pay or by public subsidies is assessed as corresponding private or public budget effects.

Hence, we are considering the following effects (more detailed description of methodological aspects see also Kranzl, 2007):

- Direct effects
- Indirect effects
- Secondary, induced effects
- Substitution effect
- Private budget effects
- Public budget effects

Apart from these overall economic impacts, the social and regional distribution has high relevance for the overall societal benefits. They can give more information about which regions and which social groups gain most from bioenergy systems. Moreover, bioenergy results in a series of additional ecological, social, structural and other effects

3.2. Examples for the case of Austria

In this section we show the impact of the price development within the last few years on the macro-economic impact by the case of three different bioenergy fuels biodiesel, pellets and wood log for the case of Austria.

Price relations both of fossil and biogenous energy carriers have a very high impact on the overall economic effects of bioenergy.

The following in an exemplary manner shows the impact of the recent price increase of pellets in the year 2006. In addition to the domestic increase in demand the foreign demand, in particular from Italy has been added. Together with the constraints in production capacities which did not grow quickly enough this led to a price increase of about 60% within one year. This higher price level first of all resulted in higher operation surplus of the pellet producers. Operation surplus are a component of total value added and thus lead to secondary, induced effects. Simultaneously, employment and compensation of employees (wages) remain constant, since the production of one tonne of pellets does not require more or higher qualified labour input. On the other hand, the higher prices lead to higher expenses and additional costs for the consumers, which – under the assumption of restricted private budgets – leads to a reduction in private consumption (= negative private budget effect). Moreover, the public authorities, as far as they are interested in keeping the incentive for pellet heating systems attractive, have to grant higher subsidies for pellet boilers – in order to maintain the positive, increasing effect of pellets for climate change mitigation. These higher public expenses in the next years lead to related negative public budget effects. In total, this results in a reduction of the positive employment effects, because the increased value added effect is not accompanied with the related employment. Simultaneously, we are faced with increased negative impacts due to the shift of private and public expenses.

Concretely, we investigated the impact of price increase by comparing the effects of pellet production and consumption in Austria 2005 under prices of 2005 with those of 2006: Under prices of 2005 the private bubget effects resulted to 8.5 M€. This is the sum of reduced cost, which occurred at the pellets consumers in comparison to a oil or gas heating system. Under prices in 2006, additional costs of 22M€ occurred. The difference is more than 30 M€ of private budget effects that are due to the higher pellet prices. The costs which will occur in the future to the public budget for higher required subsidies (which also have to include a risk-premium for the uncertainty in the pellets markets) are not included in this figure.

However, summing up we have to conclude that the total effect on the overall economic balance of bioenergy use remained quite low, because the share of pellets on the total bioenergy use is still quite low. Regarding increasing resource prices (fossil and biogenous) we cannot exclude that such cases of price increase will occur also for other biomass fractions. An important aspect will remain, how biomass prices will develop compared to fossil energy prices and whether biomass can be considered to be more stable and less risky from a price volatility point of view compared to fossil energy carriers.

Hence, the impact of fossil energy prices has to be considered equally important as that of biomass. The following figures show the sensitivity of the employment effect of bioenergy systems in Austria with respect to the conventional energy price. It turns out that the macroeconomic effects are increasing with rising fossil reference energy carriers and decreasing with rising bioenergy prices.

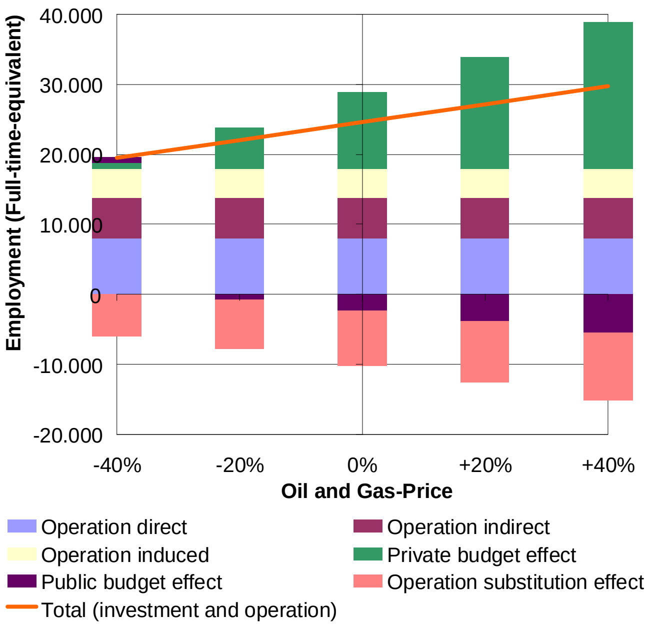

Figure 1: The impact of oil and gas price on the employment due to bioheat utilization in Austria. 0% reflects the price level of the year 2005.

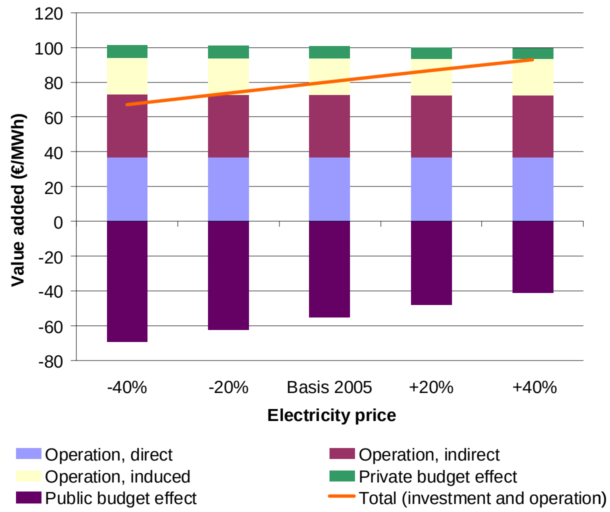

Figure 2: The impact of the electricity price on the value added due to electricity generation from biomass in Austria. 0% reflects the price level of the year 2005.

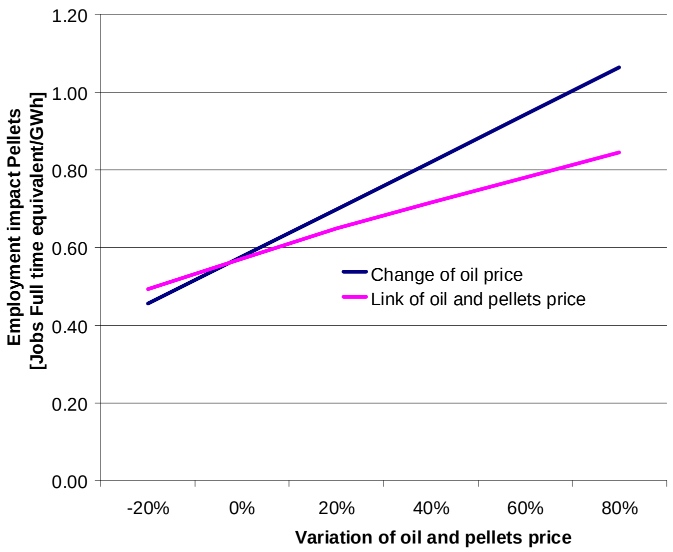

Figure 3: The impact of oil and the pellet price on the employment due to bioheat utilization in Austria. 0% reflects the price level of the year 2005.

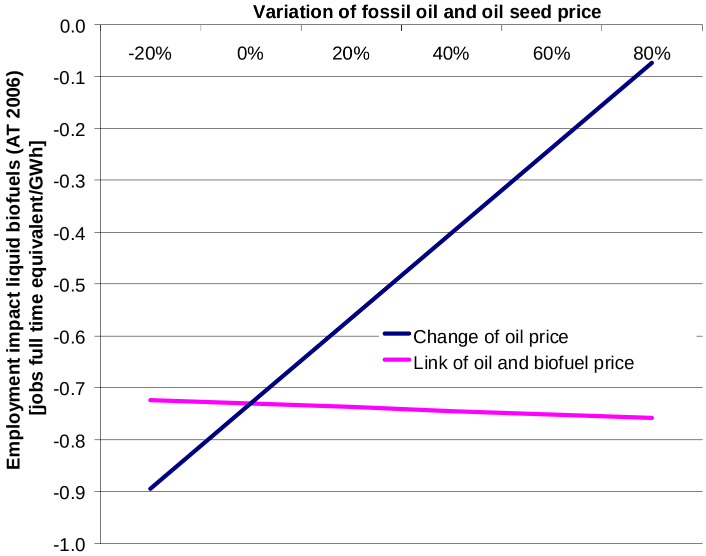

Figure 4: The impact of oil and oild seed price on the employment due to bioheat utilization in Austria. 0% reflects the price level of the year 2005.

3.4.Synthesis

We have identified a considerable macro-economic impact of bioenergy price correlation to fossil energy prices for all major bioenergy systems. Important drivers are the private and public budget effects. In the case of pellets substituting fossil heating systems and transport biofuels in Austria we derived the following results: If oil prices increase from about 40$/bbl to about 60$/bbl and without any bioenergy and oil price coupling, the employment impact (as an exemplary macro-economic indicator) generally increases by more than 50%. However, with a full coupling of these prices, the impact is 15% and 60% less for pellets and transport biofuels, respectively. It emphasis the macro-economic relevance of bioenergy price volatility.

Another important aspect that has not been covered in the analysis above is that a continuos market development requires stable investment conditions for households and investors. If this is not the case, public support has to be even higher in order to overcome the risk costs due to (expected) price volatility.

4. Price volatility of bioenergy: empirical data

The objective of this section of the paper is to identify and discuss basic sources and reasons for bioenergy price volatility. For this purpose, we will document and present empirical, historical data and describe the surrounding conditions of the specific cases. Moreover, we are discussing qualitative aspects of these price developments. Finally, we are deriving conclusions regarding the cause and basis of past bioenergy price volatility.

We will carry out these steps for three clusters of bioenergy resources: Agricultural commodity prices, retail pellet price and other wood based price indices on a monthly basis. For this analysis we used the following sources: IMF, 2009, Index mundi, 2009, Pro Pellets Austria, 2009, Statistik Austria, 2009c, Association of the Austrian Wood Industries, 2009.

4.1. Agricultural commodities

The following figure compares the historical development of crude rapessed oil (FOB Rotterdam), crude palm oil (Malaysia palm oil futures), wheat (FOB Gulf of Mexico), corn (FOB Gulf of Mexico) and crude oil (dated Brent). All prices are given as monthly nominal values in US$. The figure contains the corresponding price index (January 2000 = 1).

Two basic conclusions can be drawn:

1. In some historic periods the price volatility of agricultural commodities was considerably higher than that of crude oil prices.
2. The drastic price increases in the last few years went quite parallel between the considered commodities.

Some of the reasons for that will be discussed in section 5 of the paper.

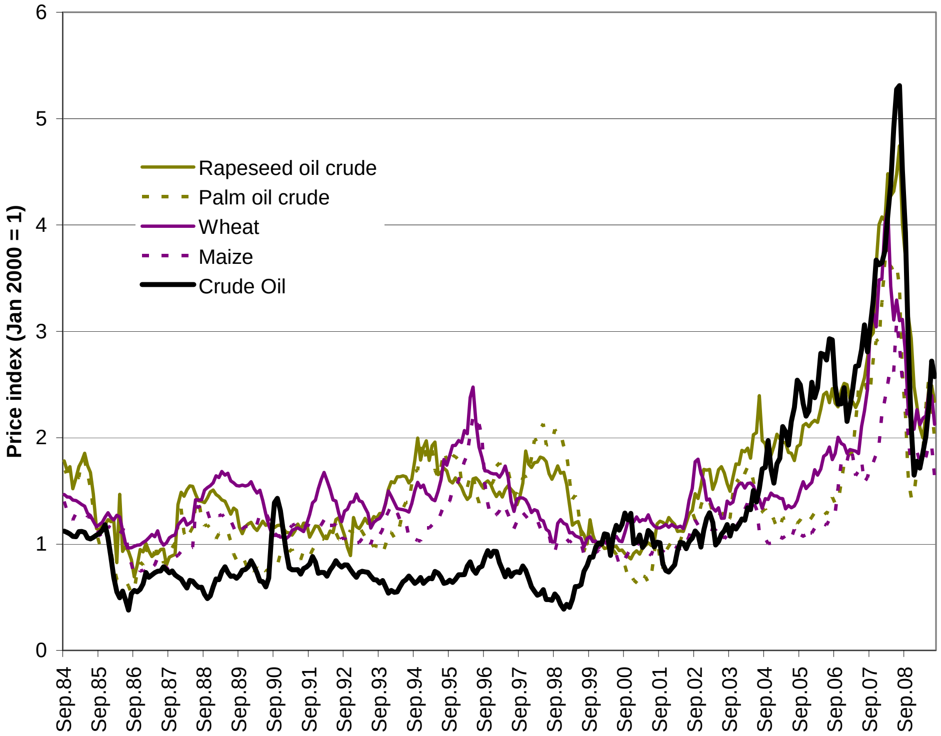

Fig. 5: Comparison of market prices for crude oil, rapeseed oil, wheat and maize in US$/metric ton.
Source: Index mundi, 2009

4.2. Pellets

Up to now residues from the sawmill industry are the main feedstock for the production of wood pellets. Traditionaly the wood and forest industry plays an important role in Austria since World War II. From the 1960’s to the 1990’s there has been a significant rise in the productivity of sawmills due to technological progress. As a reason there was a phase of consolidation and market concentration, accompanied with a decrease of prices for saw mill residues. As shown in Figure 6 the price of wood residues decreased by more than 40% in the period 1986 to 1996. In this period the prices of other commodities that are used in the building and construction industry like steel and cement were more or less constant.

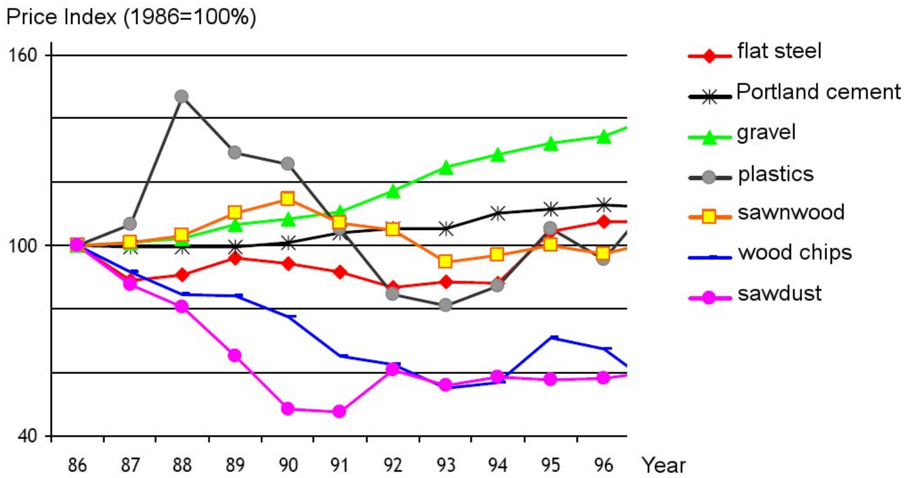

Fig 6 Development of price indices of different commodities in Austria;
Source: Association of the Austrian Wood Industries, 2009; Statistik Austria, 2009a

Low prices were one of the main reasons for sawmill industry to actively look for other markets for their residues. In the period after the first and the second oil crises, and during the development and introduction phase of pellets in Austria in the middle of the 90’s, the oil price has more or less stabilised at a relatively low level. For this reason, the price of oil is not generally regarded as the trigger for the break-through of pellets in late 1990s. Later of course the rise of energy prices from 1998 onwards supported and accelerated the growing demand for pellets.

However, the sawmill industry was faced with a situation of sawmill residue supply exceeding demand, and therefore the value of sawmill residues was constantly decreasing. In 1986-90 prices for sawdust fell by more than 50%, and prices for wood chips fell by 20% to remain at a low level (Association of the Austrian Wood Industries, 2008). Because of falling prices the sawmill industry looked for new channels of sale for their residues. Besides using residues as material for animal bedding (e.g. cat litter) and material for binding oil, the production of wood pellets was considered as an interesting opportunity.

Although pelletising is well known in the fodder industry since the 19th century, wood pellets are a very recent energy carrier. In Austria the production of pellets started slowly with an estimated volume of 5,000 tons in 1995. As demand for pellets increased, the volume of pellets produced and the number of pellet producers rose annually. Whereas in 1998 there were 7 companies producing pellets, in 2000 there were already 12 production facilities (Haas J. et al., 1998; Geißlhofer A. at al., 2000). According to the Market Actor Database on the pellets@las homepage (Pellets@las, 2009), there are 30 pellet manufacturers in Austria at the moment. The production capacity has been increased from zero to nearly one million tons per year in 2008. This development clearly indicates that the pellets market is a very immature and dynamic market.

After the introduction of pellets to the Austrian heating market, from 2001 to 2005 saw dust nearly doubled in price because of severe competition of pellet producers and the pulp and panel industries for the same raw material. However, the pellet market was in oversupply of pellets resulting in a continuous fall of pellet prices in that period, due to technological learning and due to economies of scale.

In 2005 the situation started to change (see Figure 7). First of all there was an enormous increase in the number of new pellet boilers until 2006. As long as demand for pellets grew steadily along with production capacity this was no problem. Because of a very long winter in 2005/06 the heating period was long too and therefore there was a great ongoing demand for pellets.

This very long and snowy winter in 2005/06 caused shortages in the supply of round wood to saw mills by 20-30%, and with it shortages in the supply of sawmill residues. These shortages could not be compensated for by imports because neighbouring countries had to face a similar situation. There was a great demand for pellets in other countries, especially in Italy and the Netherlands. So, the market faced an increase in demand (domestic and abroad) and a decrease in supply. Some pellet producers saw the chance of a short-term economic profit, exacerbating the situation. This led to a rise of pellet prices in Austria in 2005 and resulted into exorbitant increases in 2006.

Pellet prices in November 2006 were at an average of € 265 per ton. All customers could be supplied, but had to accept partial shipments and considerable waiting times in many cases.

The situation was eased The windstorm Kyrill that affected Western Europe in January 2007 caused widespread forest damage through wind throw and as a result there was plenty of round wood. At this time, pellets prices fell to a lower level of 190€/t. Similarly, windstorms Paula and Emma in 2008 caused prices for pellets to go down again to approximately 174€/t.

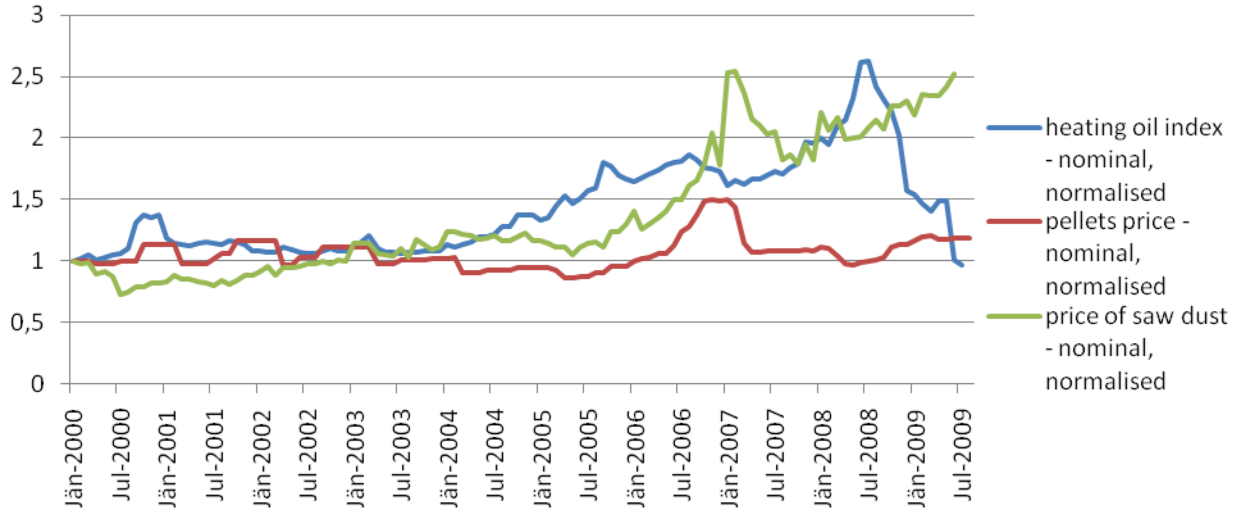

Fig 7 Comparison of the development of nominal crode oil, saw dust and pellet prices on a normalised basis (January 2000 = 1);
Sources: crode oil price: US Energy Information Administration 2009; Saw dust price: Association of the Austrian Wood Industries, 2009; pellet price: Pro Pellets, 2009; Pellets@las, 2009

At the moment it seems that the pellets industry is well on its way. Building up larger stock capacities and production capacities are important for reaching price stability. International trading of pellets will be another chance for securing supply and demand and could benefit the market stability and the competitiveness of prices.

4.3. The example of other wood based price indices

The following figure shows indices of the price development of crude oil price (dated Brent), wood chips and saw residues (Association of the Austrian Wood Industries, 2009). The graph clearly shows that the price of saw resides almost doubled in 2006. In absolute terms, since 2007 the price of saw residues is in the same range as that for wood chips. In section 5 it will be discussed that the integration of two markets (e.g. the energy and the food market) leads to the fact that a floor price and an upper price cap is set. Thus, the price level of saw residues since 2007 can be understood as a floor price that has developed due to the relatively new integration of the energy and the wood market. Of course, this price level is also strongly influenced by the price level of wood chips.

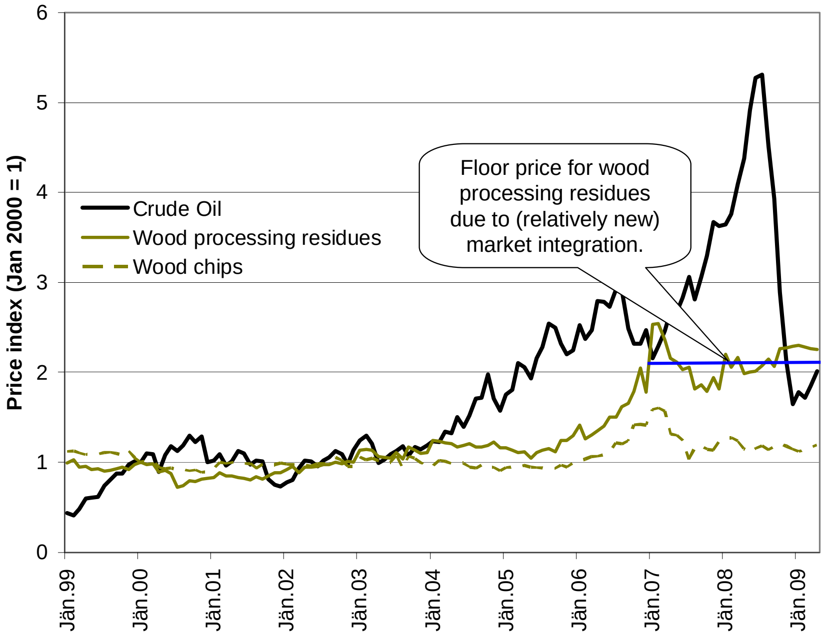

Fig. 8: Comparison of market prices for crude oil, wood processing residues, wood chips (Index Janury 2000=1). Source: Index mundi, 2009; Statistics Austra, 2009a; Association of the Austrian Wood Industries, 2009

4.4. Synthesis

As the last step in this section, we are comparing the price volatility of different energy carriers and commodities. As indicator for the price volatility, the standard deviation of the difference to the mean of the whole considered period is defined. Monthly price time series are used. On the left hand side of the follwogin graph we show this indicator for overlapping three-year periods from 1999 to 2009. On the right hand side for the whole period from 1997 to 2008. The figure depicts the volatility of the following selected price time series:

- Fossil oil (Crude oil, retail price of heating oil)
- Plant oil (Rapeseed oil, palmoil)
- Starchy products (wheat, maize (corn))
- Woody biomass (wood chips, saw residues)
- Biomass heating fuels (retail prices of pellets, wood log)

We are aware that the outcome may differ for different definitions of the volatility indicator and in particular for different time slots taken into account. However, the results are clear enough to draw some basic conclusions:

- The price volatility of all considered commodities has increased during the last years.
- Retail prices in general show a lower price volatility (partly due to price components independent of the world market for the crude commodity).
- The oil price shows a high volatility. However, it is not in a much higher range than for plant oil (rapeseed oil and palm oil) and starchy products (wheat and corn). This is in line with the restuls from Regnier 2007.

- The lowest price volatility can be observed for woody biomass retail products (price examples taken from Austria). This is also the case for pellets, although the showed a considerable increase in price volatility in the last period 2006-2008.

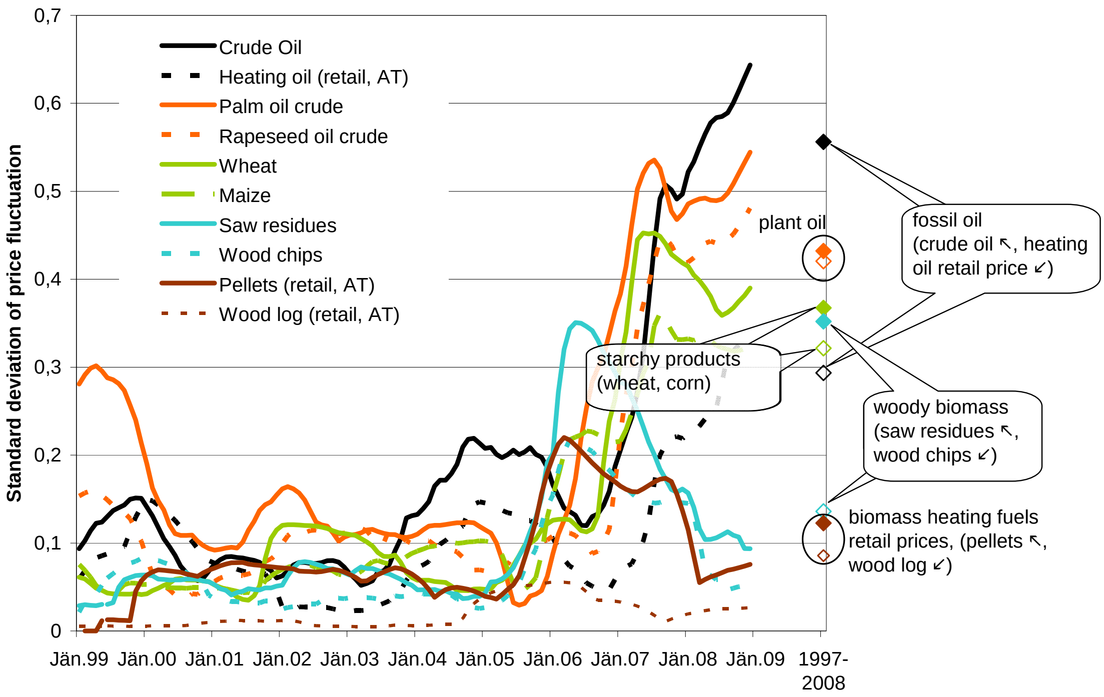

Figure 9: Comparison of price volatility of different commodities
Sources: IMF, 2009; Index mundi, 2009; Pro Pellets Austria, 2009; Statistics Austria, 2009a

We can conclude that volatility of biomass prices differs significantly between different fractions of bioenergy. We observe that the more standardised a product is, the higher its energy density and the more (international) trade of this product exists, the higher is the price volatility. The products with a higher price volatility in general are also those for which a integrated market exists. In particular the products with non-formal market structure (as it is the case of wood supply in many rural regions globally) show a significantly lower price fluctuation.

5. The link between fossil energy and bioenergy prices and the different sensitivity of various bioenergy systems

There are two main links between fossil and bioenergy prices:

First, the oil price has an *impact on input prices* for agriculture and forestry. This mostly refers to the production costs (and prices) of fertilizers and pesticides as well as diesel. Thus, fossil energy prices increase production costs in agriculture and forestry and thus increase bioenergy production costs. Hence, ceteris paribus this effect would result in a decline in the production level with increasing oil price.

Second., the oil price has an *impact on the output prices* of agricultural products. In the case of a completely integrated market and as soon as the oil price is higher than the energy equivalent of agricultural products, the energy market creates additional demand for agricultural commodities and thus increase the prices. Ceteris paribus this effect would result in an incline in the production level with incraseing oil price. (Schmidhuber, 2007)

However, there is another aspect that has an relevant impact on the “effective” volatility of energy prices. This could also be called the “vulnerability” or “sensitivity” of different energy systems to volatile energy prices. In general, the higher the share of investment cost on the total energy generation costs and the lower the fuel cost on energy generation costs, the less sensitive or vulnerable an energy system is towards an increase of fuel prices.

In the following chapter, we will have a closer look on each of these three aspects:

5.1. Fossil energy as input for bioenergy production

Production costs for agricultural commodities are influenced by crude oil prices and hence, of energy prices. Three cost components are mainly affected: costs for fuel, costs for nitrogen fertilizers and costs for grain drying. Therefore, crops with higher needs of machinery, nitrogen fertilizer, and grain drying are mainly influenced by changing crude oil price. Our results show that if crude oil prices increase, for instance, from 50$/bbl to 100$/bbl, the variable production costs increase between 11% and 32% (Figure 10). The variable production costs of cereals increase by about 20%.

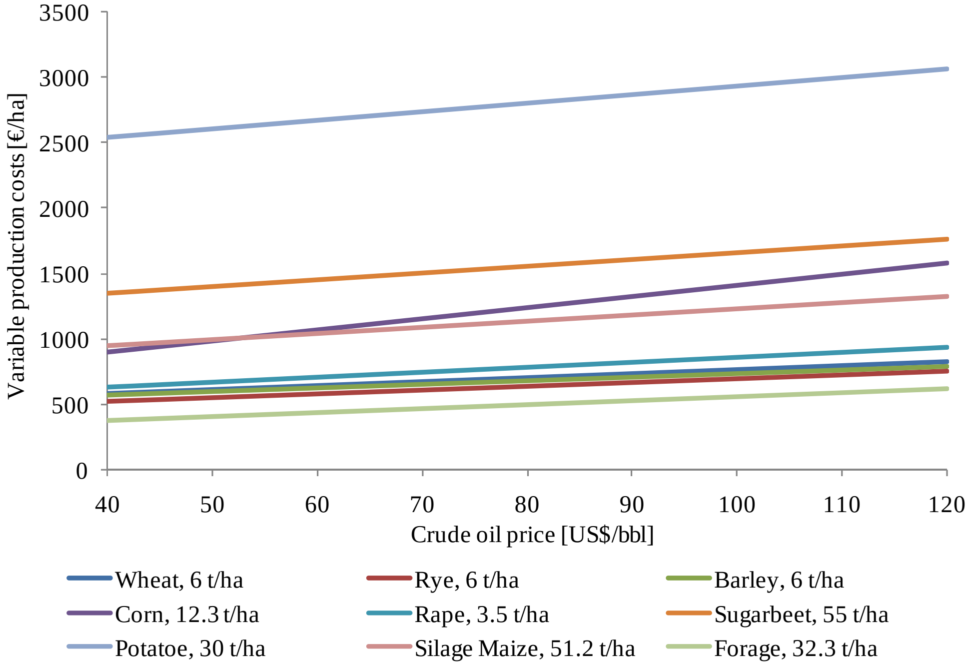

Fig 10: Impacts of changing crude oil prices on variable production costs of major crops.

5.2. Fossil energy as driver for bioenergy demand and prices

Currently, many countries are boosting bioenergy production to reduce CO2 emissions and energy dependencies. For example, with the directive 2001/77/EC (European Commission, 2001), the share of renewable energy sources for electricity production should increase in the EU member states. The directive 2003/30/EC (European Commission, 2003) set a non-binding target for biofuels to achieve a 5.75% market share on the overall fuel supply by 2010. An expansion of the energy production based on biomass is seen to be more advantageous because of the possibility of universal application: electricity, heat and biofuels.

The relative competitiveness of energy production based on biomass is given by the price of crude oil (and hence, of energy price), the cost of the agricultural products used as inputs plus subsidies or tax credits. In case of rising energy prices, production costs increase and agricultural biomass production will decrease. The lower supply leads to higher prices for agricultural commodities and consequently production of feedstock for bioenergy production decrease (OECD, 2008). However, high energy prices makes bioenergy more competitive (von Lampe, 2007). This effect found expression in rising numbers of sales at heating systems based on wood and wooden products (LK-NÖ, 2008). Currently, bioenergy production from agricultural crops needs to be subsidized, because the production costs exceed the costs for allocation of energy from non-renewable energy sources (Heißenhuber et al., 2006; von Lampe, 2007). Even the use of residues, such as slurry or straw, leads to not negligible production costs. Therefore, many countries have to support bioenergy production to achieve the different political energy targets (OECD, 2008). Nevertheless, because of correlations between energy prices and bioenergy production costs with a lower gradient, the competitiveness is expected to rise with increasing energy prices.

Thus, oil price drives bioenergy demand in case that oil price exceeds bioenergy production costs. The following figure describes the interaction of the energy and the non-energy market in a fully integrated market: The left hand side of the graph shows the market equilibrium on the energy market. It is characterised by the intersection of the supply and the demand curve. In our case, the supply curve is the sum of the supply of fossil resources and biogenous resources. The level of the total energy demand thus leads to a certain demand of biogenous resources. On the right hand side of the graph we can observe that this increase of bioenergy demand increases the total demand for biogenous resources on the non-energy market (either food or wood products etc.). In a fully integrated market the price of biomass resources on the energy and the non-energy market have to be the same. Therefore, the demand on the of biomass for energy utilization on the non-energy market increases until on both markets the same price level is achieved.

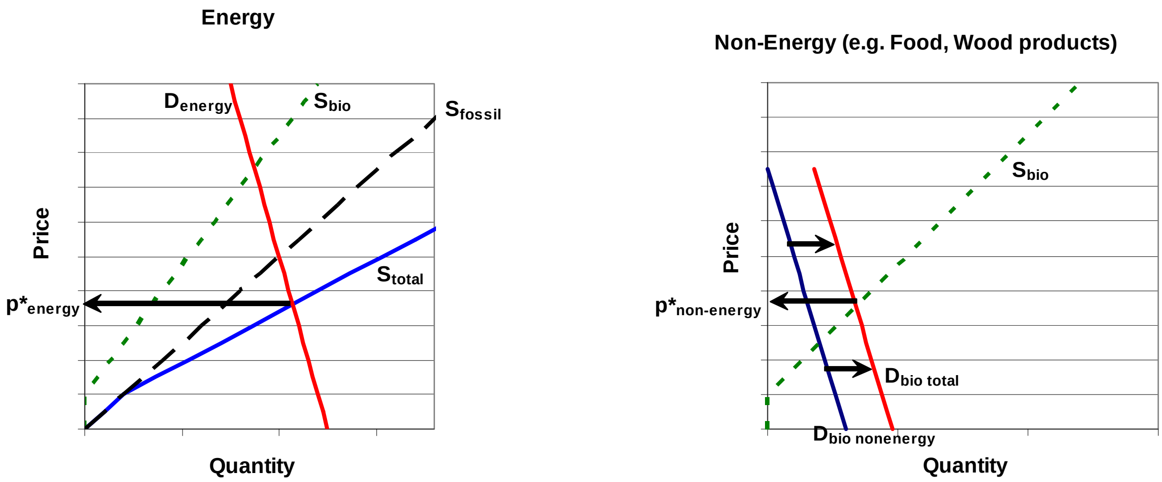

Figure 11: Market interaction and market equilibrium in a fully integrated energy and non-energy market

Of course, policies can have a dramatic impact on this picture by driving S_{bio} to the bottom (financial incentives) or to $D_{bio\ total}$ to the right (biofuel quotas).

This market interaction in fully integrated markets leads to two effects (see also Schmidhuber, 2007):

1. The oil price creates a floor price for biomass products. As soon as the oil price exceeds a certain level (the energy equivalent price of biomass products) this creates a new demand for biomass. In case that the demand from the energy sector is big enough, this creates a floor price for biomass products.

2. The oil price creates an upper ceiling for biomass products (e.g. food and other agricultural commodities). For the case that a certain amount of biomass is used in the energy sector, the energy price level also works as a price cap: If the biomass price exceeds a certain level, less energy will be demanded by the energy sector thus stabilizing the biomass price.

Thus, the demand in the energy sector links energy price to the bioenergy price. On the other hand the supply of biomass links bioenergy price to non-energy price (e.g. plant oil, sugar, wood products). In the end, energy prices are linked to non-energy prices.

However, this is only true for fully integrated markets. In practice, the demand for bioenergy is not infinitely large due to a variety of constraints. Only a few markets are currently integrated on a high level (e.g. the Brazilian ethanol market and to some extent the Austrian pellets and wood chips market). Schmidhuber, 2007 lists some characteristics of the almost fully integrated ethanol and sugar market in Brazil:

- High market penetration of FFV
- Country wide system of ethanol filling stations
- Growing share of flexible sugar mills and of specialised ethanol plants
- High-tech conversion and energy production system

An important issue is the antagonism of energy production and food production. As Heißenhuber et al., 2006 illustrated at ethanol production based on wheat, the price for wheat rise with higher possible biofuel price (Figure 12). If the market price for food production is lower than the equilibrium price for bioenergy, the agricultural commodities will be used for bioenergy production. The lower supply of agricultural commodities for food production will raise the market price. Especially in case of a low level of self-sufficiency, the market price will react immediately. Political targets on rising energy production from renewable energy resources exacerbate the situation by additional demand commodities for bioenergy. In Austria, wheat is the only cereal with a level of self-sufficiency over 100% (Statistics Austria, 2009b). The high level of self-sufficiency at beef (145%) and milk (152%) (Statistics Austria, 2009c) give scope for using agricultural area for bioenergy production. Hence, in regions with historical high ratios of animal husbandry, in combination with good conditions on biomass production, bioenergy production is expected to increase. Above all, joint-products of bioenergy production, such as oil meal or DDGS can be used as food for animals. It can be seen, for example, in the corn belt (USA), which is historically an important pork, beef and milk production area and the main ethanol production of the USA is located at.

In this regard, a shift from agricultural commodities for food production to energy production takes place. In Germany, for example, the cultivation area for wheat, rye, rape and especially silage maize has increased by 685,000 ha in the last four years, whereas fodder production is decreasing (DESTATIS, 2009).

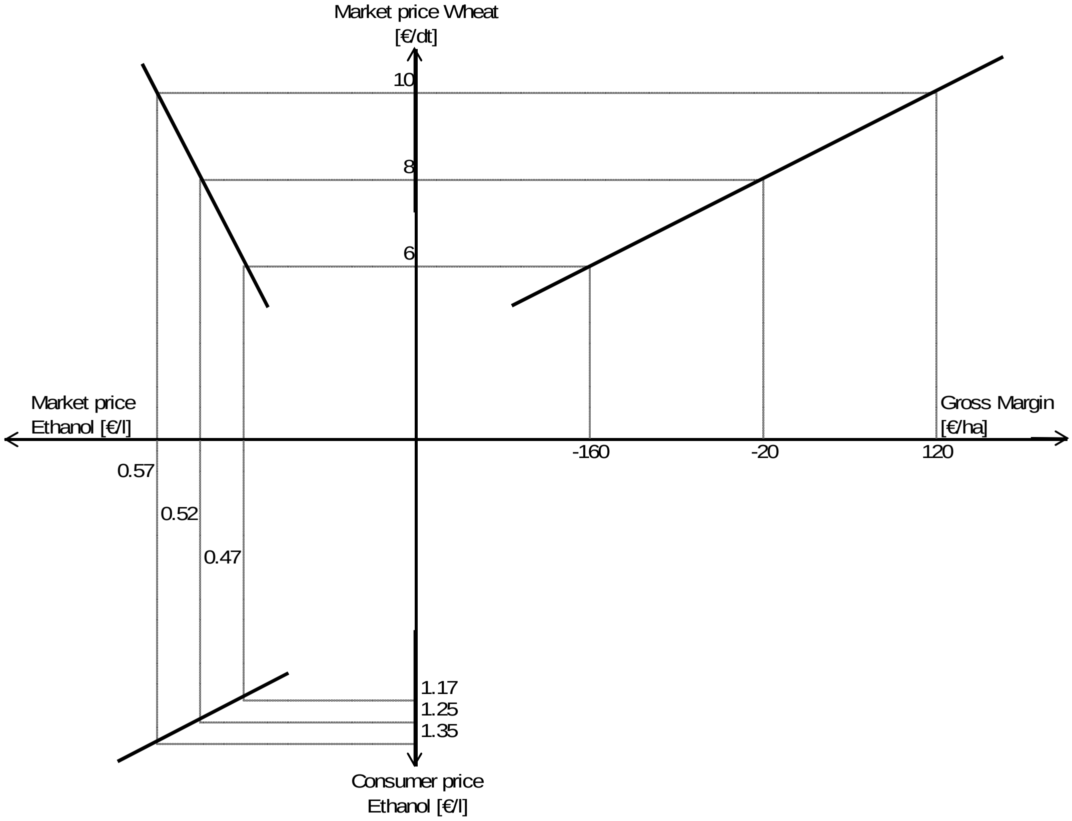

Fig 12: Equilibrium price Wheat – Ethanol.
Source: Heißenhuber et al., 2006

Another impact on production costs are the land renting prices. Increased competition between bioenergy production and food production on limited land area usually leads to higher land renting prices.

5.3. The sensitivity of energy generation costs to fuel price volatility

In this section we will show that not all bioenergy systems show the same share of biomass primary energy costs on total energy generation costs. However, actually this is a crucial difference both with respect to the comparison between bioenergy and fossil and between various bioenergy systems. Therefore, in the following part we will describe the share of primary energy costs on total energy generation costs as one indicator for the sensitivity of a technology or energy system with respect to primary energy price volatility.

The sensitivity of energy generation costs (heat or electricity generation or transport fuel production costs) varies widely among different technologies. This is due to varying shares of the fuel/feedstock costs in the total energy generation costs (long-run marginal costs). In the following, this is illustrated by two examples: typical heat generation costs of oil and pellet boilers in Austria and the production costs of biodiesel and Fischer-Tropsch-diesel.

Figure 13 shows the typical heat generation costs of oil and pellet boilers in Austria in the year 2008. The total costs include the capital costs (boiler, fuel storage and thermal storage for the pellet boiler), operation and maintenance (O&M) costs, fuel costs and taxes. Even without taxes, typical heat generation costs of oil boilers were higher than those of pellet boilers in 2008 (due to the exceptionally high fossil fuel prices in the year 2008). Fuel costs accounted for about 70% of the heat generation costs of the oil boiler (taxes excluded) whereas in the case of the pellet boiler they accounted for 50%.

Figure 14 illustrates that the higher share of the fuel costs in the generation costs of the oil boiler results in a higher sensitivity to fuel price volatility. For example, a relative fuel price increase of 50% results in a cost increase of 25% in the case of the pellet boiler and 35% in the case of the oil boiler. Hence, even if we assume a uniform relative price increase for both fossil and biomass fuels, the competitiveness of pellet boilers is increasing as Figure 14 (heat generation costs in €/MWh) illustrates.

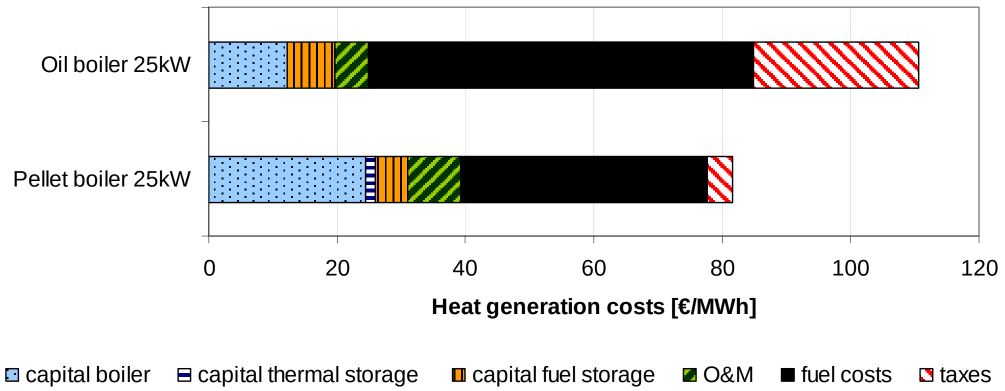

Figure 13: Structure of the heat generation costs of typical 25 kW oil and pellet boilers
Sources: Fachagentur Nachwachsende Rohstoffe, 2008; Austrian Energy Agency, 2004; Statistik Austria, 2009a; Pro Pellets Austria, 2009

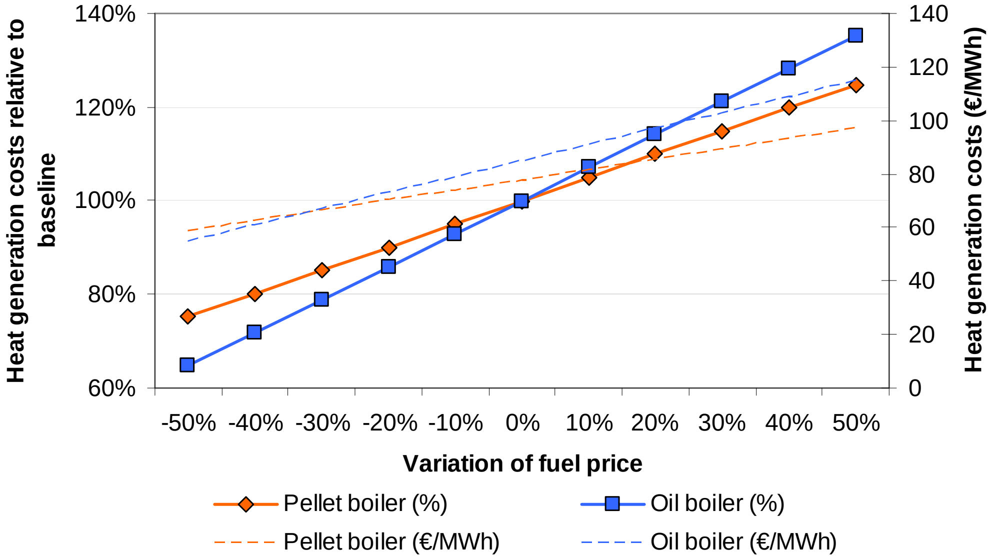

Figure 14: Sensitivity of the heat generation costs (without taxes) of typical 25 kW-boilers to variations of the fuel price

Sensitivities to fuel price volatility sometimes also differ significantly among bioenergy technologies. The sensitivities of “first-generation” biofuel production technologies biodiesel, bioethanol etc. are generally high due to the high production costs of the required crops. With advanced (“second generation”) biofuel production technologies (e.g. Fischer-Tropsch diesel, lignocellulosic ethanol) more types of feedstock like wood wastes, straw or grasses are in principle suitable for transport fuel production. In the following figures the production costs of biodiesel and Fischer-Tropsch-(FT-)Diesel are compared with regard to the cost structure (Figure 15) and the sensitivity to feedstock price volatility (Figure 16). The reference year for investment costs for both biodiesel FT-Diesel is 2030, where projections according to Hamelinck et al., 2006 have been used. FT-plants are more capital-intensive but due to lower feedstock costs it is often assumed that production costs will be lower than those of biodiesel in 2030. Figure 16 illustrates the clearly higher sensitivity of biodiesel production costs to fuel price volatility. Hence, technological development can contribute to reduced sensitivity to fuel/feedstock prices.

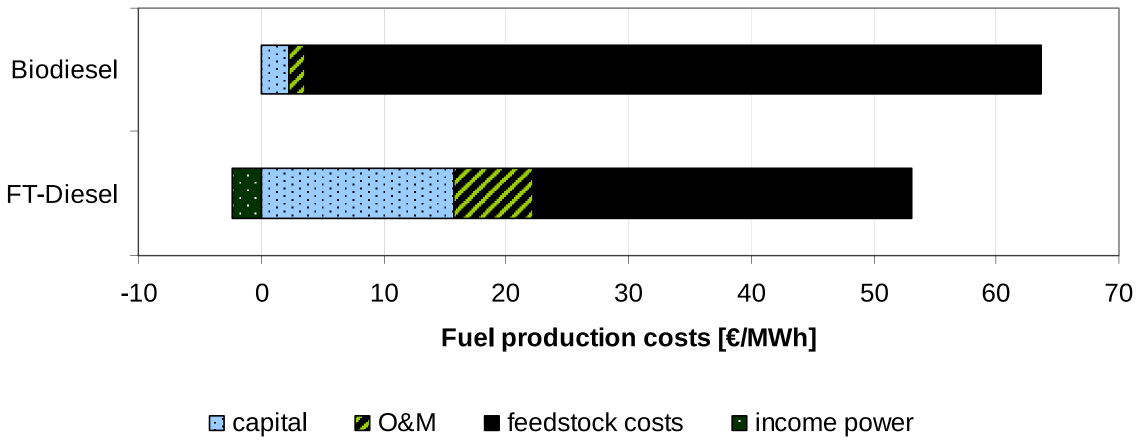

Figure 15: Structure of the production costs of biodiesel (price for rapeseed oil assumed 60 €/MWh, revenues for the by-product glycerine are considered within O&M costs) and Fischer-Tropsch-Diesel (technology data for a 1.600 MW(input)-plant in 2030 according to Hamelinck et al., 2006, feedstock costs 13 €/MWh representing a typical price for industrial wood residues in 2008 in Austria)
Sources: Hamelinck et al., 2006; Kranzl et al., 2008

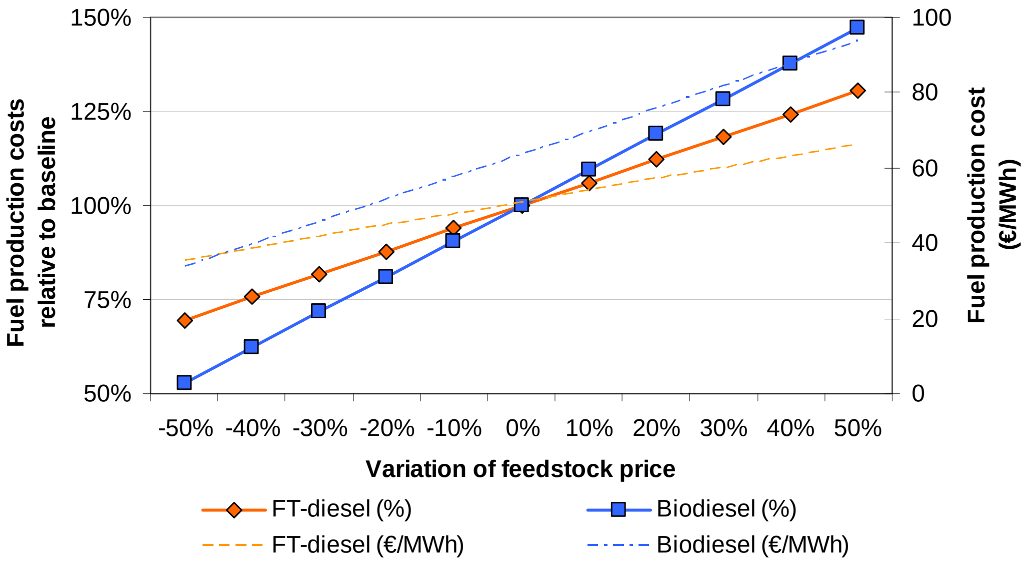

Figure 16: Sensitivity of the production costs of biodiesel (2008) and FT-diesel (2030) to variations of the feedstock price

Thus, we can conclude that the shares of investment costs and fuel costs in the long-run marginal costs of energy technologies differ widely. In the case of bioenergy systems the share of the fuel costs is usually lower than in the case of fossil energy systems. (e.g. the share of investment costs on total heat generation costs for small scale fossile heating systems: 20%-27% and for biomass heating systems of the same capacity: 40-55%). This leads to the fact that fuel price volatility in general affects fossil energy systems stronger than bioenergy systems. Among bioenergy technologies, there are also significant differences (e.g. for biomass CHP plants the share of investment costs on total energy production costs is in the range of 50%-60%, whereas for first generation biofuel plants 10%-25%).

6. Conclusions

- Increasing the share of bioenergy in the energy mix leads to more diversification of energy sources. However, in terms of energy price stability part of it is offset due to the correlation of bioenergy prices with oil prices.
- We have identified four major reasons for biomass price volatility:
  - Volatile fossil energy prices *are* indeed a cost factor for the production of biomass,
  - Growing demand (partly driven by corresponding policies) and discontinuous development of biomass supply (together with capacity restrictions for transport and production), and
  - speculation,
  - the coupling of energy markets (i.e. Bioenergy is used as substitute of fossil energy. Thus, price volatility on one market (e.g. oil) impacts the price stability on the other market (e.g. vegetable oil)).
  - Natural phenomens (bad harvest due to drought etc)
- Volatility of biomass prices differs significantly between different fractions of bioenergy. We observe that the more standardised a product is, the higher its energy density and the more (international) trade of this product exists, the higher is the price volatility. The products with a higher price volatility in general are also those for which a integrated market exists. In particular the products with non-formal market structure (as it is the case of wood supply in many rural regions globally) show a significantly lower price fluctuation.
- Not only volatility of biomass fractions differ, but also the sensitivity of bioenergy systems with respect to price volatility. This first of all is due to considerable differences in the share of the feedstock price in the total energy generation costs.
- Looking at the results for price volatility and price sensitivity of the different bioenergy fractions, we can observe that there is no trade off between these two indicators. Rather, those systems with a high volatility also show a high sensitivity. This relation is presented in the Figure 17.
- Therefore we should promote biomass fractions with low price volatility as well as support methods and strategies for dealing with bioenergy price volatility (e.g. storage capacities for bioenergy as a means of national energy security).
- However, if we want to increase the amount of bioenergy substantially, also other biomass fractions will be required. Therefore, replacing fossil fuels with biomass without reducing energy consumption will not lead to a future with substantially more stable energy prices and higher energy supply security. Thus, bioenergy can only contribute to significant higher energy price stability if it is combined with a correspondingly high level of energy and resource conservation.

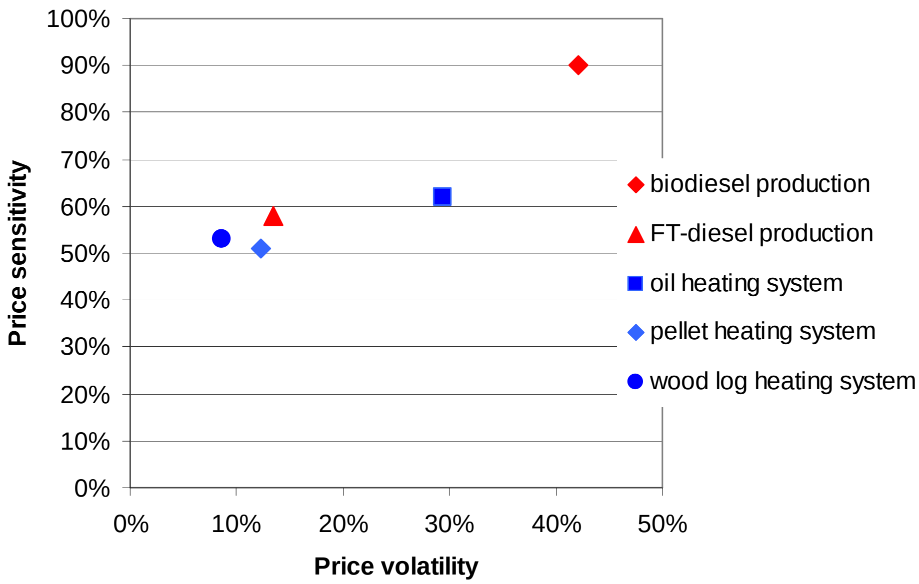

Figure 17: Price sensitivitiy and price volatility of selected (bio)energy systems

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