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***Bioenergy – A New Chance for Czech Agriculture and its Risks***

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## **Introduction**

To increase the production and consumption of energy from renewable sources (RSE) belongs among the so-called New Challenges of the European Union (initially targets were set at European Commission's White Paper, EC, 1997, with recent review of progress presented by EC, 2011). These challenges correspond with the EU long-term objectives up to 2020 to increase the share of renewable sources in the total energy consumption to 20 % (13 % for the Czech Republic), of which the share in the consumption of fuel for transport to 10 % (EC, 2011).

Potential for RSE on agricultural land is promising: for European agriculture it represents a chance to realize a part of its production as raw materials for energy with the anticipated benefits for farmers such as increased farm-gate prices, stabilization of income situation, preservation of jobs, etc. However, the final outcomes it may generate for farmers, society or consumers are still ambiguous. To what extent the use of agricultural biomass for energy can threaten the global food security have been intensively discussed (see eg. Proceedings of the First World Conference on Biomass for Energy and Industry, 2001, or Schmidhuber, 2008). There are also risks like the higher demand for the biomass can contribute to an excessive intensification in farm practices or to an irretrievable conversion of ecologically valued areas and natural resources, thus jeopardizing environmental security of the Earth. Particularly attention was given to biofuel productions and related policies: Gorter and Just (2010) have cited tens of studies which argued that ethanol policies failed to pass an overall cost-benefits test, that they have an adverse impact on food prices and poverty-especially in developing countries or create higher greenhouse gas emissions due to indirect land use changes on one hand; on the other one they also provided a list of publications that emphasized several key benefits of biofuel policies, including reduced tax costs for farm subsidy programs, reduced fuel prices and improved international terms of trade in both corn export and oil imports, but also mentioned studies emphasizing the impact of biofuel policies on carbon dioxide emissions. These risks are also linked with discussions on the energy balances related to the use of agricultural biomass as RSE in the whole life cycle of bioenergy (e.g. Zah. et.al., 2007).

Policy-makers must understand trade-offs RSE production may bring about that they would be able to reshaping the production factor allocation properly. In the first part the article is looking at the present conditions and situation on the market and the use of agricultural biomass as RSE in the Czech Republic (CR); its aim is to identify both positive effects and the present and future risks, particularly as regards the ability of these energy sources economically and in long-run to compete with the conventional energy sources. Policies influencing the market are presented as well. Next, the linear optimization model is applied on the case of Czech bioenergy sector. It simulates the effects of various business objectives on economic, energy and consumers' spending. The aim of this part is to quantify the trade-offs between economic and energy "gains" resulting from the fact that prices of bioenergy may not fully reflect real energy contents. To the conclusion, policy measures, which can stimulate the use of agricultural biomass as RSE and in the same time mitigate the above mentioned risks, are discussed.

## **Methodology and data sources**

The analyses and assessments utilize the following methodological approaches and data sources:

- Economic assessments:
  - . macro/sector analyses of the production of energy from agricultural biomass based on the database on agricultural policy (Institute of Agricultural Economics and Information - IAEI) and on the EU databases (EUROSTAT);
  - . profitability analysis of the production of energy (biofuels) from agricultural biomass based on the methodology of costs and profitability calculations and the related databases of IAEI<sup>1</sup>, including the data from the FADN network<sup>2</sup>.
- An optimization model at sector level is used to assess and identify the trade-offs between energy and economic outputs of different bioenergy production structures. Production of energy plants and final energy products are endogenously determined; costs, prices, energy coefficients are exogenously determined. Either profit (farmers' or processors'), net energy gains or consumers utility can be maximized.

### **Conditions on the market of renewable sources of energy from agricultural biomass**

The Czech market for the RSE based on agricultural biomass forms a part of the EU single market. Some competitive advantages are given by specific national legislation and to some extent also by uneven conditions and levels of supports under agricultural or energy policies among EU countries<sup>3</sup>. Above it, European participants compete with conditions on the world market, with competitors from the third countries. The level of the tariff protection has been set for a long time by the agreements under the GATT Uruguay Round, expected without any doubt to be reduced under still continuing negotiations in the World Trade Organisation (WTO). On the other hand, under these negotiations the EU has been struggling for the acceptance of stricter environmental, social and ethical standards, which could to some extent eliminate a broader market access on the European market for goods from the third countries. Those requirements directly concern also tradable RSE commodities.

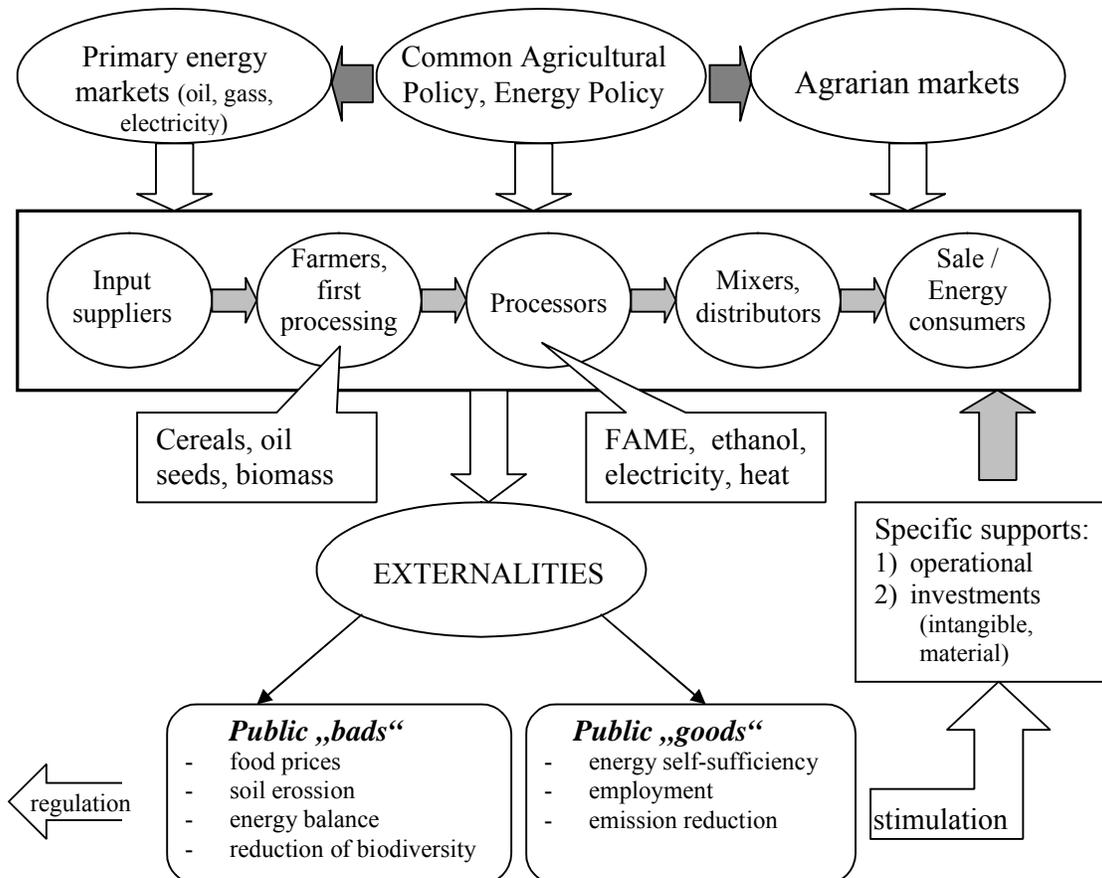
The structure of participants and relationships on the Czech energy market based on agricultural biomass is presented on Figure 1.

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<sup>1</sup> See Poláčková, J. et al., 2009.

<sup>2</sup> See Hanibal, J. et al., 2009.

<sup>3</sup> As an example it is possible to mention compulsory financial guarantees for the Czech producers of ethanol for biofuel. For the Czech producers it usually brings additional costs, lowering their competitiveness on the European and global markets. However, it is the example of institutional failures on the market: by this regulation the government is fighting against the misusing of the ethanol for other purposes.



**Fig. 1 – Participants and links on market with the RSE based on agricultural biomass**

Products on the RSE market consists of raw materials as intermediate goods (cereals, oil seeds, energetic plants, straw, hay, silage maize, etc.) and final products (biofuel, gas, electricity, heat). These are private good realized on the market by the following participants:

- Suppliers of external inputs for the whole chain (energy, fertilizers, labour, land, etc.).
- Farms as producers of biomass, specified also by the legislation as the raw material for the production of energy (cereals, oil seeds, sugar beet, short-term woods and other specified plants).
- Processors, transforming the biomass into final or intermediate products (FAME, ethanol, gas, electricity, heat). By-products or wastages (oil cakes, glycerine, digestives, etc.) can be re-used as feed or fertilizers.
- Firms dealing with the distribution or with the transformation of intermediate products into final products (mixers of fuel, distributors of energy or heat).
- Merchants distributing and selling final products to consumers.

The whole chain is affected by regulations and stimulations under the EU policies (including authorised measures of national policies), particularly by measures of the EU Common Agricultural Policy (CAP), the energetic and environmental policies. These policies together with conditions on oil/primary energy markets influence prices and other factors on the agrarian market and hence conditions on the RSE markets.

Nevertheless, the chain does not produce only private goods, but also externalities. The

externalities can be both positive and negative. The production of positive externalities (or the reduction of negative externalities, respectively), represents the main goal of the policies in this field. This is especially a question of the reduction of green-house gas (GHG) emissions (the balance of accumulated and emitted CO<sub>2</sub>), of the increase of the EU energy self-sufficiency (the substitution of the diminishing conventional sources of energy, or the lowering of the dependence on energy imports, respectively) or of the preservation of incomes or employment on farms/in rural areas. The stimulation of the positive externalities in the form of investment and/or operational supports for private participants transforms the externalities into paid public goods. These supports are necessary only if the RSE products from agricultural biomass are more costly than the products from conventional sources of energy.

Just in the opposite way the society react (or should react, respectively) to negative externalities generated by the actors in a chain. The negative externalities (public „bads“) especially relate to environmental issues (the reduction of biodiversity by an intensive production of the biomass or the energy imbalances between inputs and outputs of the chain) and in the recent years also to the global food security (including risks of higher food prices). In agriculture the society tries the negative externalities to reduce by regulative or semi-regulative measures (e. g. through the Good Agricultural and Environmental Conditions under the Cross-Compliance conditions for direct payments and some other supports).

Understandably, the producers struggle for the economic return of their investments, for job opportunities and to some extent also for proper balances between costs of input energy and returns for sold energy. On the farm level there is a competition in the use of biomass, reflected in the competition for production factors, particularly for land <sup>4</sup>.

The decision-making on the farm level is influenced by opportunity costs in the use of biomass. These costs in the mid-term horizon are usually determined by previous investments and currently representing sunk costs<sup>5</sup>. However, the opportunity costs are also influenced by applied measures of agricultural, energy and environmental policies. The present stimulating measures of these policies are as follows:

Investment supports:

- direct: measures of Axes 1 and 3 from the Programme of Rural Development and selected measures from the operational programs of the Ministry of Industry and Trade and the Ministry of Environment (especially supports for investments in biogas stations);
- indirect: supports of research and technological development (the reduction of costs and environmental pollution in the production of the RSE, improvement of energy balances, development of the so-called second generation of biofuels, etc.).

Operational supports:

- Supports paid by tax payers (supports stimulating supply):
  - . EU supports for energetic plants (“carbon credit”), being gradually reduced from the original level of 45 €/ha and actually abolished;
  - . zero excise related to 100% biofuels (with a marginal present significance owing to

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<sup>4</sup> *The use of agricultural land for solar and wind energy is not considered, in spite of the fact that particularly the land use for solar energy is in a rapid progress at present.*

<sup>5</sup> *For example, the use of biomass as feed for recently renovated or new investments in the cattle breeding competing with the use of biomass as the raw material for the bio-gas stations.*

a relatively low use of those fuels in the domestic transport).

- Supports paid by consumers (supports stimulating demand):
  - . binding share of bio-elements in fuels for transport (minimum at 10 % by 2020);
  - . minimum purchase prices of electricity differing by used raw materials and by the size of processing units;
  - . tariffs related to imported bio-elements from the third countries.

Among specific regulations, aimed at the reduction of negative externalities, belong EU regulations requiring a minimum reduction of the GHG emissions (up to 60 % in 2018). Cross compliance conditions represent specific “semi-regulative” measures. Farms have to comply with defined good farming practices as a condition to receive direct payments and some other supports.

In the competition for agricultural biomass it is necessary to consider quite different economic and market conditions for biofuels and for the production of electricity (and heat). The support of demand for biofuels is independent on the origin of the supply. The supply can be realized by imports from other EU countries or from the third countries. On the other hand, Czech competitive producers can export their products to those countries. Contrary to those measures applied in the CR before EU accession, nor purchase prices neither other sale conditions are today guaranteed to investors and to producers.

Investors and producers of electricity from the biogas stations (BGS) may utilize not only direct investment supports, but also operational supports in the form of obligatory take-off of products and in the form of minimum purchase prices. Such conditions, being even accompanied by low prices of biomass for food use, are significantly influencing the use of production sources on farms. This is the reason for rapid development of BGS currently. However, technical problems (e.g. in the connection to distributional networks for electricity), which are often artificially provoked by competitors, can form barriers for the entry of private participants on the market.

In summary, the present market of RSE from agricultural biomass is influenced by conflicting factors. Stimulating factors are especially as follows:

- relatively high prices of primary sources of energy, particularly of crude oil;
- EU and Czech bindings in the field of the RSE, provided also by policy measures, including supports for research;
- surpluses of agricultural products, leading to lower farm-gate prices of commodities for the food production;
- sufficient production potentials of the Czech Republic (up to 3,7 mio. ha of agricultural land being theoretically able to generate up to about 30 thousands GWh of energy);
- still existing reserves in the diversification on farms and in their effort to preserve/create job opportunities in rural areas<sup>6</sup>;
- developing ownership and other relations of farms with processing capacities; this leads to a stabilization of the biomass supply for the energy use.

The main barriers and risks for the development of the market of the RSE from agricultural

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<sup>6</sup> *The utilisation of the reserves can be, however, reduced by the level of „internalisation of externalities“ in the field of employment. In the Czech agriculture with prevailing large farms and with a high share of hired labour, this level is relatively low.*

biomass are as follows:

- the above mentioned uneven conditions between the market of biofuels and the market of other kinds of energy;
- fluctuation on the market of agricultural commodities (growing prices of agricultural biomass for food, increasing opportunity costs for energy use of the biomass);
- environmental limits/standards, e. g. minimum levels of savings for emissions;
- expected better market access for imports of bio-energy from the third countries (EU predictions for 2020: up to 50 % of biofuels would be imported to the EU);
- still unsolved questions related to the utilisation of the heat produced from agricultural biomass and to operational supports in this field;
- technical and other problems with the connection of producers of electricity to distributional networks;
- keeping with or enforcement of contracts between producers of biomass and processors.

As a whole, the market segment for the energy made of agricultural biomass is closely linked with other markets (with the market of energy based on conventional sources, with the feed and food markets), which positively or negatively influence conditions for the production of the RSE from agricultural biomass. Possible negative impacts on the environment, if they are not eliminated by effective governmental regulations, form another risk category. The conflicts of the markets or of private and societal interests in this field have to be addressed. The EU reacts to the conflicts by the new directive of the European Parliament and the Council 2009/28/EC. The directive preconditions the fulfillment of the binding objectives and supports in this field by the observance of given level of savings of the GHG emissions and by the production of biomass from other than environmentally sensitive regions.

### **Production of energy from agricultural biomass in the CR – state of the art**

The importance of the RSE based on agricultural biomass has been growing, forming the growing segment of the Czech agrarian market. The volume of the renewable energy in biofuels grew annually by 35% between 2006 and 2009. The share of agricultural land for biomass production represents currently about 140 thousand ha – i.e. 4% of utilized agricultural area.

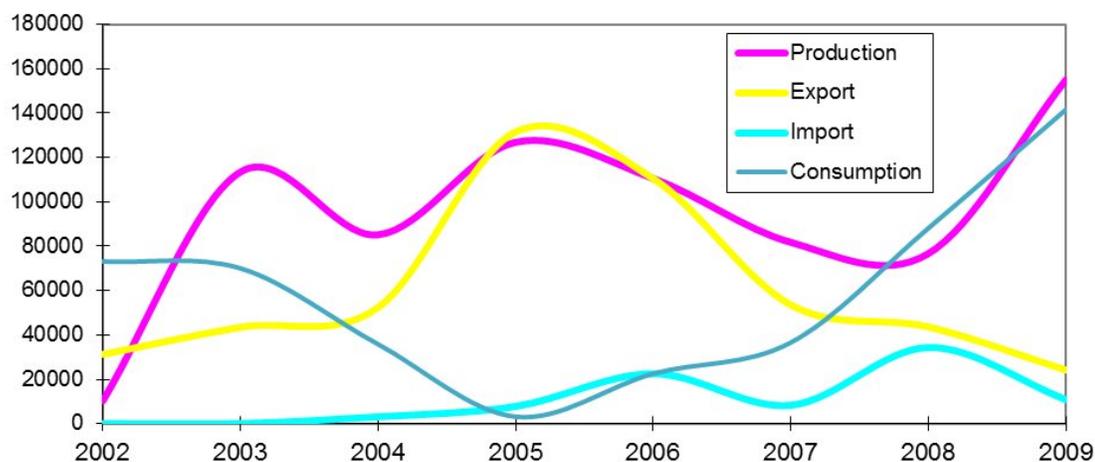
In spite of the development, the share of the RSE in the total energy sources amounted to about 5,6 % in 2009, of which more than 80 % represented the combustion of biomass, including the non-traded biomass used in households. As regards the electricity, the share of biomass in its consumption reached to 1,6 %. For heat this share amounted to about 6 %. The share of the vegetable biomass in the production of heat amounted to 1,7 % and in the production of electricity amounted to about 5 % (MoI, 2009). The main obstacle in this field (but also an opportunity from the point of view of rural development) is undoubtedly the request to consume the biomass locally, because with the growing distances from the places of its production the total costs of final products significantly increase. However, there are still low yields: the present yields of biomass less than 10 t/ha are economically insufficient. According to Sladký, 2009 it is necessary to increase yields up to 20-50 t/ha. Without an outstanding progress in the breeding of energetic plants there would be a risk from an excessive intensification in the use of resources (particularly of land) and from the application of environmentally unfriendly farm practices.

Nevertheless, the supported investments in the construction of local biogas stations (BGS) on

farms and in municipalities, which needs particularly agricultural biomass (especially silage maize) has been quickly developing at present. In 2009 these BGS (without municipal stations, large waste treatment plants and dumping gas) accounted for 34% of electricity production and in the production of heat it accounted for 21 % from the total consumption of the biogas for energy. About 160 of these stations are functioning at present. The long-term visions of the Ministry of Agriculture (MoA, 2010), supported by the Czech Agrarian Chamber, predict up to 1 000 of the stations by 2020, with the total capacity of about 7,4 MWh. The production of electricity (and heat) from the BGS, supported by prices and sale conditions by the government has been become a significant factor for diversification on farms, especially in the connection with the economic problems in livestock production. The acreage of agricultural land for energetic use (and particularly of arable land) originally used for forage has been quickly growing.

The situation in the production of biomass for biofuels to some extent differs. Up to 2006 the state measures supported the production. Since 2007 only supports of demand have been applied. This is reflected in the development of this market segment of biodiesel (see Graph 1). Under these conditions the production and imports have grown by 2006. A turnover on the market – the reduction of exports and the growth of imports – has occurred since 2007, when the production supports were abolished and the compulsory use of biodiesel was introduced. The decline in the consumption of biodiesel after 2002 to almost zero level in 2005 reflects the temporary reduction of supports for the production of biodiesel and the growth of consumer prices (compared with prices for “conventional” fuel). The domestic production of biodiesel amounted to about 155 000 tons in 2009, compared with the total production capacities about 500 000 t<sup>7</sup>. Such insufficient utilization of production capacities, previously built with the state supports, is one of the examples of the failures of the governmental measures.

**Graph 1 – Balance of production and consumption of biodiesel in the CR in 2002 – 2009 (tons)**



Source: Ministry of Industry and Trade, 2009

The production of bioethanol has been developing only since 2007, in the connection with the compulsory use of bio-elements also in petrol (2% since 2008, 3,5% since 2009 and 4,1% since half of year 2010). The Czech production of the ethanol for fuels amounted to 90 000 t

<sup>7</sup> Above it the capacities of the two new factories (about 170 000 t) were installed in 2009.

in 2009, with the consumption of about 75 000 t. The agricultural raw materials used for this purpose are represented mainly by cereals and sugar beet in the proportion 1:4. In the CR actually there is neither support for production nor tax-relief for consumption of bio-ethanol therefore the Czech producers face dramatic increasing imports especially from Pakistan and Brazil because of lower price than domestic one (currently the difference is roughly 0,1€ per liter of bio-ethanol).

### **Bioenergy in Czech agriculture – modeling approach**

In this part we illustrate the effects of different decision objectives on producers, energy production and consumers. It is shown on a stylized example, where three types of interests are examined: the first one is private and represents the economizing of private profits (here producers and processors of RSE, “Var. A”), the other one is so called social and represents the maximizing of total net energy gain (difference between energy outputs and inputs, “Var. B”) and the third one is consumers aspect representing the interest of consumers to reduce the impact on their spending which is related to price differences between conventional and bioenergy (“Var. C”). The effects resulting from changes of market prices on bioenergy production is next option to be calculated.

The model represents sector of bioenergy with 9 crops (five energy plants to be processed for burning, two for fermentation in biogas station and two used as a biofuel source) which are used for production of three energy modes: crop pellets used for burning, biogas converted into electricity in BGS and biofuel (bioethanol and methylester) used in combustion engines<sup>8</sup>. These crops “compete” for land and other factors available and so the processing capacities must be utilized properly. Total available land was set at one million ha of agricultural land which is considered as a hypothetical area possibly exploited for energy crop cultivation in the Czech Republic. Process consists of raw material production (in agriculture) and its processing which may be realized either in agriculture or in upstream sector depending on the product characteristics (however, two separate “accountings” are kept).

The model quantifies farmers income (profit), energy flow (gross and net gain) and potential costs or benefits for consumers resulting either from higher or lower, respectively bioenergy prices. These costs or benefits can be viewed as shadow prices of producing “clean” energy. Unfavorable effect to consumers is not always the case: negative consumers costs shows that consuming conventional energy is more costly and vice versa. Furthermore, observed difference may not be borne fully by consumers, in some cases as eg. biofuel production where higher costs can be compensated by tax released and thus lost for budget, not for consumers. Therefore the important step is what kind of conventional product (respective price) is considered; a conventional alternative for pellets is price of brown coal without taxes, for electricity produced in BPS average market price of electricity without taxes was used and for biofuels we considered price of conventional fuels also without taxes. The following table shows the results from three modeling alternatives (types of interests) mentioned above.

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<sup>8</sup> Hereinafter marked as „burning crops“, „gas crops“ and „fuel crops“.

**Table 1. Results from the optimization of various decision objectives regarding production, profitability, energy and consumers**

Indicator	units	Basic module: RSE on one million hectares		
		Var. A	Var B	Var C
<b>Production</b>				
- pellets	Mio tons	2,6	4,4	2,6
- gas	Mio m3	1 347	2 427	3 507
- fuels	Mio hl	11,886	4,8	4,8
<b>Profit total</b>	€/ha	526	465	443
<b>Net energy gain</b>	GJ/ha	76,5	116,8	107,8
<b>Cost for consumers*</b>	Mio €	795,8	344,5	221,4
- crop pellets	Mio €	48	117,5	48
- biogas	Mio €	-66,8	-120,4	-174
- biofuel	Mio €	814,6	347,4	347,4
<b>“Burning” crops</b>	%	25	40	25
<b>“Gas” crops</b>	%	20	35	50
<b>“Fuel” crops</b>	%	55	25	25

*\*It shows how much consumers would have to pay more (+) or would gain (-) by substituting certain amount of conventional energy by bioenergy. Source: own calculations.*

Each option (objective) produced different results regarding profitability and energy gains and impacts on consumers. As expected maximizing total profit is the best economic option for both farmers and producers as well; it is worth to mention that about 2/3 of the profit is generated by farmers, the rest by processors. This is achieved through maximizing the area of “fuel” crops. Contrary to that the least profitable option is that following the highest consumers’ benefits (Var. C). Notable, farmers would not be affected in this way, but processors would face the private profit diminishing. This is because of shift from biofuel production into usage in BGS which is the only activity that would not impose higher costs on consumers<sup>9</sup>. If profit objective is followed the lowest product energy gain would be achieved; in other words the energy loss is the highest meaning that one hectare would produce slightly more than half of the potential net energy gain that would be otherwise achieved under “maximizing” energy option.

The shadow price of withdrawing from profit maximizing behavior in favour of energy optimization would be about 1,5 € per one GJ of net energy gain (private profit loss). In the example studied the least optimal energy gains display bioethanol and biodiesel which are prioritized by producers and processors due to effects (profit) it would bring, particularly to the processors. Due to positive energy gains of crops for pellets (burning), production of these crops is the highest (namely at technology limit) in the “energy” option (Var. B). Contrary biofuels production is due to unfavourable energy relation reduced. The option that “seeks” the best results to consumers – minimizing spending (Var. C) is characterized by maximum production of “gas” crops (specifically silage maize); in such a case consumers would “safe”

<sup>9</sup> BGS operators got a guaranteed price, so these in fact bear the risk resulting from input price volatility themselves. Under current conditions BGSs produce the electricity for lower guaranteed price than is the price on the market.

up to 72 % compared to the profit oriented option (Var. A). Analogously, net energy gain would be higher by some 41 %.

Farm price volatility has intensified in recent years, thus the effect on bioenergy sector is relevant not only to policy-makers but mainly to producers (those who bear business risks). Assuming 50 % of price increase<sup>10</sup> could clearly result in drop of processors' profits bringing them into loss (up to -100 €/ha). Close link between agricultural price change and consumers' spending change is due to significant share of biofuels in production structure. Also consumers' spending would rise by up to 47 % above the level existing before price increase.

### **Discussion and conclusions**

There are ambiguous conclusions from the assessment of the four aspects of the utilization of agricultural biomass for energy under the present economic, market and technological conditions.

The utilization of agricultural biomass for energy can undoubtedly and significantly contribute to the fulfillment of the EU objectives, as regards the raising of the energy security. The production of agricultural biomass can become a significant part of the diversification of agricultural activities, reducing ever growing climatic and market risks of farm businesses and contributing to the rural employment. Positive social effects are higher if we consider the local production and at the same time the local consumption of the biomass for energy.

As the model shows there is large potential for bioenergy production with different economic, energy (implicitly means environmental) and consumers' impacts. It must not be also omitted still unfavourable energy balances in the whole chain of the use of agricultural biomass for energy, particularly as regards its use for biofuels. The stimulation to a further intensification of the production of the biomass and the present quick development of the BGS based on the enlargement of the acreage of wide-space crops are linked with excessive environmental risks. Undoubtedly decisions about production structure are responsibility of producers and processors, but the elimination of the negative effects in this field has to result in new policy measures. Profit oriented behaviour (most likely to expect) could be the most expensive for consumers (currently mainly for public budget – tax slump). At the same time such behaviour would lead to loss of energy gain (represents the efficiency to which sun energy is transformed into products). Contrary, following maximization of energy gains would reduce producers' and processors' income, but not significantly. For consumers, such option would be fairly acceptable.

It is especially a question of higher supports for research and technological development, but also of the abatement of stimulations in areas where an intensive production of the biomass is not desirable (e. g. by stricter cross-compliance conditions related to the soil erosion and the growing of wide-space crops), or of the increase of stimulations for the enlargement of more extensive production of the biomass, respectively. In that way, the opportunity costs of the utilization of agricultural land for food and non-food use can reach a better equilibrium.

Another problem is overcompensation of certain RSE caused by policy stimulations like is the

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<sup>10</sup> *An option in which price of rape seed, maize and wheat raised by 50 %. In fact, that only three out of nine commodities have changed might be rather strong assumption but this is due to that these prices display comparable higher fluctuations than the remaining ones. There is not clear price development of "burning" crops (price was not changed) but historically their prices tend to be correlated with the conventional energy prices.*

case for the Czech photovoltaic industry. This risk shall be eliminated by a cautious monitoring of the development in the RSE and an early adjustment of the adequate policy measures.

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