Technology and economy of energy crops

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ABSTRACT: The cost modelling for growing and harvest of selected energy crops and further costs for recommended forms of energy crops processing to biofuels was conducted. Importance and effect of subsidies on resulted costs for biofuels production was assessed. The result are then total costs per unit of fuel weight which range from 469 to 1,806 CZK/t for biofuels processed to form of chopped material or pressed bales and from 881 to 2,466 CZK/t for briquettes and pellets. The result costs per energy unit in biofuel have ranged from 59 to 121 CZK/GJ. On basis of economical data is evaluated the biofuels competitive power in comparison with main competitive fuels on market. The energy crops specific costs without subsidies are higher thus their position on market will be complicated, lower specific costs can be expected only when residual biomass would be utilised (grain straw). The competitive power of the energy crops will be much better as the subsidies are utilised in 2004 and total specific costs for chopped material are from 82 to 142% of brown coal price, 95–137% for briquettes in comparison with the brown coal briquettes. The energy utilisation if winter wheat and sorghum is economically unsuitable.

Keywords: sorrel; knotweed; reed canary grass; winter wheat; sorghum; triticale; maize; economy of growing; solid biofuels; subsidies

In the Czech Republic is still growing the surplus of agricultural land which is not utilised for food production. One of significant variant how to use this land is growing of energy and industrial crops. The EU Commission has adopted on 26. 11. 1997 the document White Paper (EUROPEAN COMMISSION 1997) containing a summarised strategy for double share of renewable sources on energy production in EU, i.e. from 6% to 12% to year 2010. The main priority should be biomass as renewable sources regards, it is assuming that more than 80% of total amount of renewable energy sources would be produced from the biomass (STRAŠIL, HUTLA 2004). The Czech Republic has committed to increase total share of renewable energy sources from present 2% to 6% in 2010.

Current heat and electricity sources for biomass combustion utilise particularly residual biomass like forestry and wood waste. Because that potential is limited it will be necessary to utilise also biomass from grown energy crops to provide sufficient amount of energy from biomass. From this aspect the most important are energy crops. As the energy crops can be used either the traditional agricultural crops (wheat, triticale etc.) or not traditional crops with high yield of dry matter (e.g. reed canary grass, sorrel Uteuša).

The energy from biomass can be perspective sphere of business but it is not clear how favourable would be production of proper basic raw material – crop biomass. From view of the farmers one of the main reasons of slow development of biomass energy utilisation is unfavourable economy and hard competitiveness of other fossil energy sources.

MATERIAL AND METHODS

Selected energy crops

For evaluation were selected following energy crops:

a) perennial crops
   - feeding sorrel (newly bred variety Uteuša suitable for energy purposes),
   - knotweed Bohemica (growing period 15 years),
   - reed canary grass (growing period 10 years);

b) annual crops
   - winter wheat (utilisation of all production for energy purposes),
   - sorghum;

c) residual biomass utilisation for market realisation of main product
   - triticale (straw energy utilisation),
   - maize (residual biomass utilisation after grain harvest).

Costs for crops growing and harvest

Calculations of energy crops growing economy are realised using the data base modelling programme AGROTEKIS. Basis for costs calculation for energy crops are the model technological processes containing the time sequence of technological operations, operation repeatability, material inputs, production and operations technical assurance. The technological processes breaking up according to the technological operations gives possibility to find out in details their costs and to analyse

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easily effect of individual factors and possibility to carry out the costs calculations for different local conditions. The model technological process working up is based on average conditions of growing areas and standard production intensity. The economical calculations are made for production areas where growing of given energy crop is suitable and is based on the costs division: variable and fixed. All the calculations are established from the average statistical data and price relations of year 2003. Further there is considered realisation of all operations by own machinery. An example of detailed output programme AGROTEKIS for reed canary grass is shown in Table 1.

Costs for product processing

For calculations were chosen 4 different forms of the energy product processing: chopped material, bales, briquettes, pellets.

The product processing to the form of chopped material or big bales is involved into the technological processes and thus also the costs are incorporated in the crop growing and harvest. Costs for briquetting and pelleting are based on producers data and depend mainly on the line performance and processed raw material quality, state and moisture (SLADKÝ et al. 2002). According to the available information from the producers the costs are ranging from 600 to 1,200 CZK/t for briquetting lines and from 500 to 1,000 CZK/t for pelleting lines. Other technological and economical data are obtained from firm sources (http://www.pelletia.cz, http://www.briklis.cz).

For calculations of economy of products resulting from energy crops the average costs for briquetting are assumed 800 CZK/t and average costs for pelleting 700 CZK/t with regard to lower requirements for the raw material after-drying.

Costs for energy production unit

The energy product yield is given at standard 85% content of dry matter. It is assumed to store the harvested product in existing large-capacity haylofts where material is after dried and kept on 85% of dry matter. This results favourably in lower after-drying costs at briquettes and pellets processing.

The heating value is given at 15% of moisture for chopped material and bales, for briquettes and pellets at 12%. The resulting economical indicator therefore are costs per energy unit in CZK/GJ in given form of crop product prepared for combustion.

Subsidies

By year 2003 the energy crop acreage extension was granted by subsidies for arable land set-aside (Governmental Decree No. 86/2001). The subsidy was 5,500 CZK/ha.

Since 2004, when the Czech Republic has become the EU member, the subsidies system has changed considerably. Besides the rights for drawing on supports resulting from the EU membership, there is possible to maintain also the national supports which are in compliance with the Common agricultural policy rules. For energy and industrial crops can be therefore used in 2004 the following subsidies:

– Uniform payment per acreage (SAPS)
  For year 2004 is determined to 57 EUR/ha of agricultural land (in calculations is considered rate 1,800 CZK/ha).
– Additional direct payment (TOP UP)
  The subsidies allocation on basis of Act No. 252/1997 on agriculture-achievement of direct payments for agriculture specified by contract on the Czech Republic accession to EU for year 2004.

Table 1. Technological process of growing – reed canary grass (RCG)

Operation	Date	Extension	Repeat	Demand	Unit	Material	Unit	Amount	Total amount
Fertiliser supply	22.10.	0.20	0.10	0.02	t				
Mineral fertiliser spreading	22.10.	1.00	0.10	0.10	ha	Superphosphate 19 and K salt	t	0.20	0.20
Medium ploughing	25.10.	1.00	0.10	0.10	ha				
Combination	18.04.	1.00	0.10	0.10	ha				
Reed canary grass seedling	20.04.	1.00	0.10	0.10	ha	RCG seed stock	kg	23.00	23.00
Rolling after seeding	21.04.	1.00	0.10	0.10	ha				
Water supply	01.06.	0.15	0.10	0.20	hour				
Area spraying	01.06.	1.00	0.10	0.10	ha	Aminex 500 KMV	l	2.50	2.50
RCG moving	20.02.	1.00	1.00	1.00	ha				
RCG harvest and pressing	21.02.	1.00	1.00	1.00	ha	RCG stalks	t	7.50	7.50
Bales removal	21.02.	8.00	1.00	8.00	t				
Fertiliser supply	18.04.	0.35	1.00	0.35	t				
Mineral fertilisers spreading	18.04.	1.00	1.00	1.00	ha	NPK 15/15/15	t	0.35	0.35

Note: ATL – usual operation beginning date is presented, can be postponed in dependence on local conditions

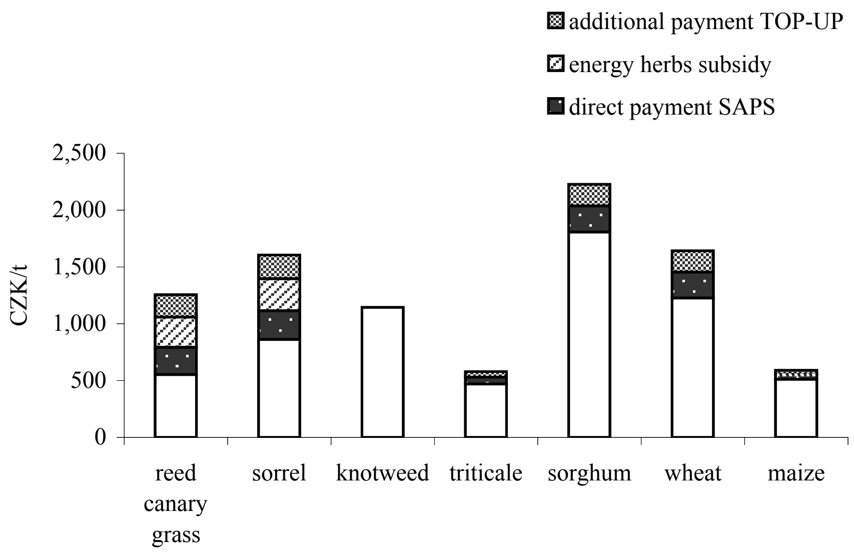

Fig. 1. Subsidies significance for energy biomass costs reduction

For year 2004 the subsidy is granted to 2,500 CZK/ha of arable land, real subsidy was only 1,477 CZK/ha of arable land.

– Subsidy under the grant title *Establishment and maintenance of herb covers for energy utilisation and grown on arable land*.

The subsidy is allocated only for selected types of energy herbs. From aspect of this publication content, the subsidy regards only the feeding sorrel and reed canary grass. For year 2004 the subsidy was determined at 2,000 CZK/ha of arable land utilised for these herbs growing.

RESULTS AND DISCUSSION

Results of economy modelling of selected energy crops and their following processing into different forms suitable for combustion are presented in Table 2 and are based on the following data structure:

– material costs – organic, industrial and calcium fertilisers, seed stock and seeding, chemicals for crop protection etc;
– costs for mechanised work – based on recommended machine sets and extension of the sets utilisation in model technological processes, include costs for machine operations and innovation (fuel, repairs and maintenance, depreciation, machine insurance and housing) and also personal costs for operators. From point of view of machine operation economy the depreciation, insurance and housing of machine are typical fixed costs (ABRHAM et al. 1998) but regarding current system of costs accounting of mechanised operations per crop these costs have character of variable costs for evaluation of resulting product economy;
– variable costs – sum of material costs and those for mechanised work, crop insurance is not considered;
– fixed costs – land rent, taxation, buildings depreciation and repairs, interests on credit and other costs associated with foreign capital utilisation, production and administrative overhead. The fixed costs were determined by method of professional estimation according to available information from statistical survey and agricultural enterprises overview;
– total costs – sum of fixed and variable costs spent on crop growing and harvest. For maize are considered only costs for machine straw harvest;
– subsidies – in calculations are comprised all useable subsidies valid for year 2004. For crops where is considered market utilisation of main product and energy utilisation of residual biomass (triticale, maize) the crop total subsidy 15% is assumed only for the residual biomass. For knotweed the possibilities of growing areas extension are so far limited by the permanent disagreement if knotweed is suitable energy crop or invasion weed. For these reasons no subsidies are considered in calculations for knotweed;
– costs for energy biomass – total costs for crop growing and harvest reduced by subsidy and market production value of main product.

The subsidy significance in total costs per energy product unit are presented in Fig. 1.

The costs per unit of biomass basic energy product (chopped material, pressed bales) of purposefully grown energy crops without subsidies are from 1,000 to 1,600 CZK/t (exception is sorghum with costs over 2,000 CZK/t and it is considered unsuitable energy crop). By using of the subsidies the total costs per unit of energy product drop down to about 550–1,200 CZK/t. Suitable is utilisation of residual biomass from economical aspects after harvest and market utilisation of main product (triticale, maize) where costs per unit of energy product reach about 500 CZK/t.

These results are comparable with publication (STRAŠIL 2000) presenting total costs (variable and fixed) per tone and year without subsidies amounting to 1,140 CZK for miscanthus and 1,200 CZK for canary reed grass.

Somewhat different way of energy crops economy consideration use. They deal only with own economy of energy crops growing. On basis of uniformly chosen realisation price (900 CZK/t) they assess contribution for fixed costs and gross profit reimbursement. Both the

Table 2. Costs structure for growing, harvest and processing of selected energy crops

	Index	Unit	Triticale		Reed canary grass			Knotweed		Sorrel		Sorghum		Wheat	Maize
			press	pick-up semi-trailer	press	cutter	pick-up semi-trailer	press	cutter	press	cutter	press	cutter	cutter	cutter
Growing and harvest	Material	CZK/ha	4,235	4,235	3,068	3,068	3,068	5,541	5,541	3,098	3,098	7,734	7,734	5,698	–
	Mechanised operations	CZK/ha	6,516	5,058	3,706	3,944	2,366	4,074	5,997	5,287	5,866	5,555	6,382	4,838	3,664
	Variable costs	CZK/ha	10,751	9,293	6,774	7,012	5,434	9,615	11,538	8,385	8,964	13,289	14,116	10,536	3,664
	Fixed costs	CZK/ha	2,430	2,430	2,404	2,404	2,404	2,430	2,430	2,430	2,430	3,250	3,250	2,430	–
	Costs in total	CZK/ha	13,181	11,723	9,178	9,416	7,838	12,045	13,968	10,815	11,394	16,539	17,366	12,966	3,664
	Unified payment (SAPS)	CZK/ha	270	270	1,800	1,800	1,800			1,800	1,800	1,800	1,800	1,800	270
	Subsidy per arable land (TOP-UP)	CZK/ha	222	222	1,477	1,477	1,477			1,477	1,477	1,477	1,477	1,477	222
	Subsidy energy plants (PGRLF)	CZK/ha			2,000	2,000	2,000			2,000	2,000				
	Subsidy in total	CZK/ha	492	492	5,277	5,277	5,277			5,277	5,277	3,277	3,277	3,277	492
	Market production in total	CZK/ha	9,120	9,120											
Bales chopped m.	Yield of energy product	t/ha	4.5	4.5	7.5	7.5	7.5	12.2	12.2	7.1	7.1	7.8	7.8	7.9	6.2
	Total costs for fuel	CZK/t	793	469	520	552		987	1,145	780	862	1,700	1,806	1,226	512
	Heat value	MJ/kg	14.27	14.27	14.43	14.43		15.35	15.35	15.35	15.35	15.03	15.03	14.98	14.33
	Price of energy in fuel	CZK/GJ	56	33	36	38		64	75	51	56	113	120	82	36
Briquettes	Costs for briquetttes production	CZK/t		800			800		800		800		800	800	800
	Total costs for fuel	CZK/t		1,269			1,141		1,945		1,662		2,606	2,026	1,312
	Heat value	MJ/kg		14.86			15.03		15.98		15.98		15.64	15.59	14.93
	Price of energy in fuel	CZK/GJ		85			76		122		104		167	130	88
Pellets	Costs for pellets production	CZK/t		700			700		700		700			700	
	Total costs for fuel	CZK/t		1,169			1,041		1,845		1,562			1,926	
	Heat value	MJ/kg		14.86			15.03		15.98		15.98			15.59	
	Price of energy in fuel	CZK/GJ		79			69		115		98			124	

Sorghum yield corresponds with date of harvest in February–March

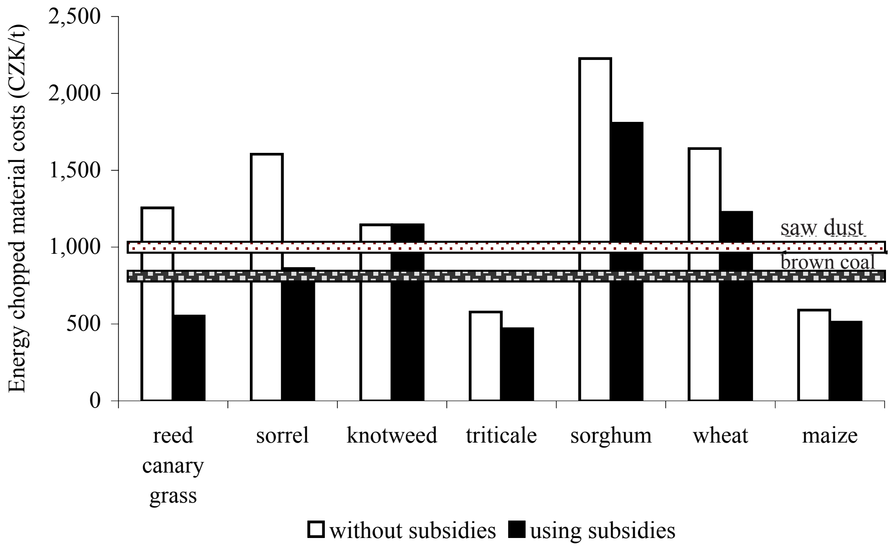

Fig. 2. Comparison of costs for energy chopped material with main competitors on fuel market

variable and fixed costs per 1 ha of crop do not very significantly from the result presented in this publication. Nevertheless these costs vary in subsidies amount which have changed considerably with our country entrance in the EU.

For application of this fuel on market the main competitors are saw dust and brown coal. In graph in Fig. 2 the costs for product from biomass are presented in comparison with price of these competitors.

From the graph is evident that without subsidies are economically suitable only energy products from residual biomass (triticale, maize), other are not economically competitive on current fuel market. By utilisation of existing subsidies the competitive power of these crops is significantly higher.

With regard to fact, that the compared energy products from biomass have not equal heating value, it is suitable to evaluate also resulting costs per energy unit in fuel. Competitive level of energy products from biomass is worse under these terms. The energy products competitiveness from biomass does not change considerably from this aspect. The costs per energy unit in fuel are shown in Fig. 3.

Energy product in form of chopped material or pressed bales is suitable for combustion mainly in the place of creation. Transport for longer distances considerably

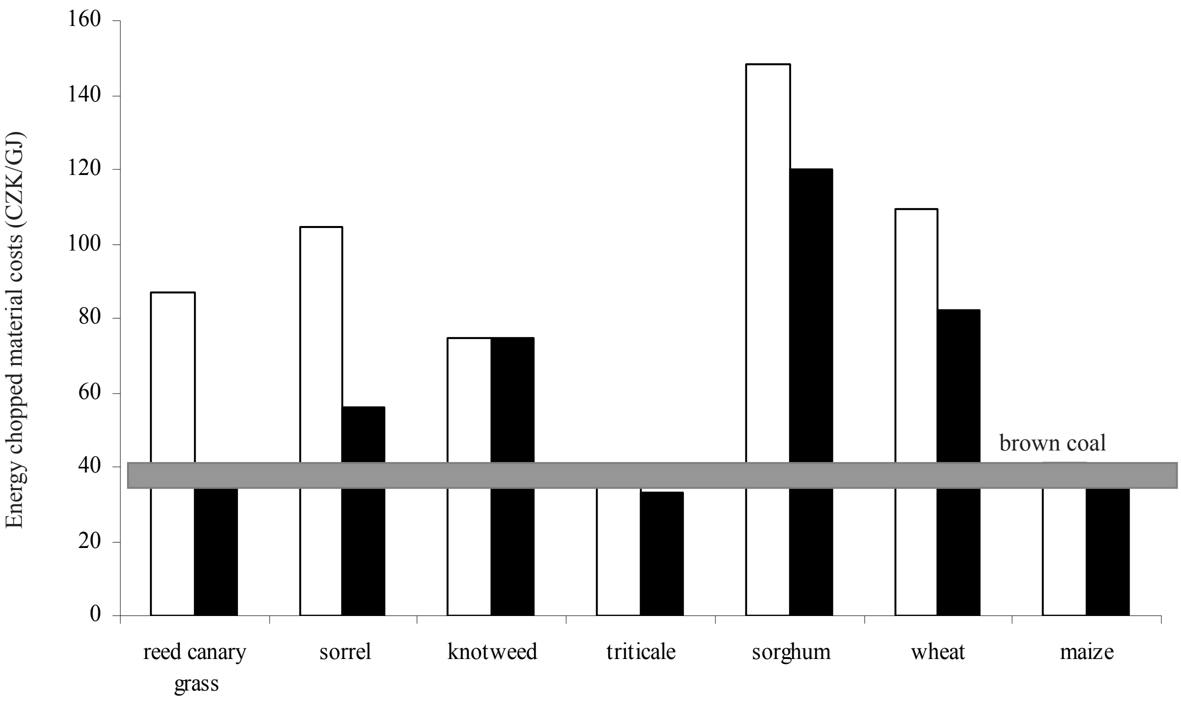

Fig. 3. Cost comparison per energy unit in fuel

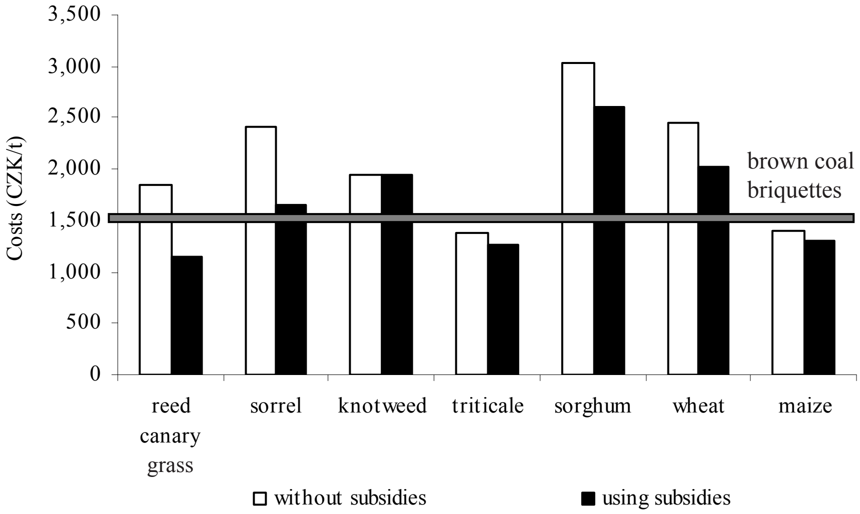

Fig. 4. Comparison economy briquettes and pellets from biomass with main competitor on fuel market – per weight unit

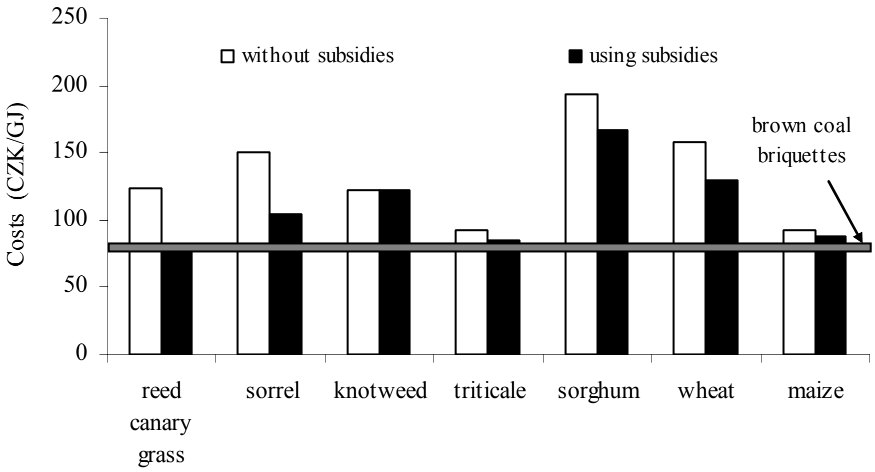

Fig. 5. Comparison economy briquettes and pellets from biomass with main competitor on fuel market – per energy unit

deteriorates economy. Technologically it is then suitable for boiler rooms of local remote heating or for large scale power stations and heating plants.

To create large market of biofuels and to foster their utilisation for local heating of family houses biomass in form of briquettes or pellets is more suitable. The costs for briquettes or pellets production are from 500 to 1,000 CZK/t depending on line size and raw material quality and moisture. Average data used for economical evaluation of this biofuel are presented in Table 2.

Comparison of briquettes or pellets economy produced from biomass with main competitor on fuel market is presented in relationship per weight unit in Fig. 4 and in relationship per energy unit in Fig. 5. For comparison are used producer fuel prices without VAT (http://www.mus.cz, http://www.suas.cz).

CONCLUSION

Results of modelling and analyses have shown that in the field of crop biomass is suitable to use residual biomass after harvest and market utilisation of main product. Purposefully grown energy crops will have complicated position on fuel market without subsidies. Current system of subsidies in framework of Common agricultural policy of EU has enabled in 2004 to use unified direct payment per 1 ha of agricultural land (SAPS – from EU source), additional payment per 1 ha of arable land (TOP UP – from national sources) and further additionally approved subsidy for selected kinds of energy crops. By utilisation of these supports the economy of energy crops and their competitive power on fuel market will be significantly better. The perennial plants have shown more favourable economical results.

For preparation and implementation of the business plan for longer time period remains partial problem certainty and height of these subsidies.

Except this narrow view on the energy crops economy there is necessary to note that their benefit and significance is also in other spheres:
– rational utilisation of agricultural land, weed infestation reduction,
– creation of new jobs opportunity,
– increasing of economical stability of agricultural enterprises,
– savings of non-renewable energy sources,
– favourable effect on living environment.

In the field of crop biomass and utilisation for energy purposes there exist many challenges and issues to be solved. The most considerable are:

– Looking for suitable energy crops and saving technologies of their growing, harvest and processing (e.g. research of possibilities and conditions for knotweed Bohemica, giving high yields of matter and its marking as invasion crop being not justified).
– Significant aspect is the so far unsolved biofuels standardisation for large increasing of biomass utilisation. It is important for biofuel producers, for heating plants and boiler producers but also for commercial companies and final users.
– Logistics and distribution of biofuels to final user is not solved. It may represent a significant item in biofuel final price (at present are suitable mainly the variants, when biomass producer is also energy producer and its main consumer).
– Attention should be paid to verification and development of new technologies for biomass transformation to energy, their economy and emissions impact on environment.

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Technologie a ekonomika energetických plodin

ABSTRAKT: Bylo provedeno modelování nákladů na pěstování a sklizeň vybraných energetických plodin a dale vyhodnoceny náklady na doporučené formy zpracování produkce energetických plodin do formy biopaliva. Byl posouzen význam a vliv dotací na výsledné náklady na produkci biopaliv. Výsledkem pak jsou celkové náklady na jednotku hmotnosti paliva, které se u biopaliv zpracovaných do forma řezanky nebo lisovaných balíků pohybují od 469 do 1 806 Kč/t, u briket a pelet od 881 do 2 466 Kč/ha. Výsledné náklady na jednotku energie v biopalivu se pohybují od 59 do 121 Kč/GJ. Na základě ekonomických podkladů je posouzena konkurenceschopnost biopaliv ve srovnání s hlavními konkurenčními palivy na trhu. Bez dotací mají energetické plodiny vyšší měrné náklady, a proto se budou na trhu jen obtížně prosazovat, nižší měrné náklady lze očekávat jen při využití zbytkové biomasy (sláma zrnin). Při využití dotací dostupných v roce 2004 se konkurenceschopnost energetických plodin výrazně zlepší a celkové měrné náklady se pohybují u řezanky od 82 do 142 % ceny hnědého uhlí, u briket od 95 do 137 % ceny hnědouhelných briket. Jako ekonomicky nevhodné se v tomto srovnání projevilo energetické využití pšenice ozimé a čiroku.

Klíčová slova: šťovík; křídlatka; chrastice; pšenice ozimá; čirok; tritikale; kukuřice; ekonomika pěstování; tuhá biopaliva; dotace

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