ECO-BIO BRIQUETTES – ECOLOGIC AND ECONOMIC EVALUATION OF BIOMASS TECHNOLOGIES

J. Švasta, J. Získal

Czech University of Life Sciences, Faculty of Economics and Management, Department of Operation and Systems Analysis, Prague, Czech Republic

The paper concerns utilization of variant multicriterial approaches within resolution of selected groups of decision-making problems in product vertical of agrarian manufacturing complex. The decision-making range is determined by options of effective and ecological acceptable definitive utilization of biomass of crop production, esp. cereals as key commodity of the Czech agrarian primary production. The paper focuses on energetic and non-food exploitation of brans for bio-briquette production. The methodology of multicriterial evaluation through methods of complex variant analysis was used for this problem solution.

cereal biomass; bio-briquette; multicriterial approach; ekological criteria; system impacts of resolution; fossil fuel; multicriterial comparation; fuzzy aspects

INTRODUCTION

Biomass and its energetic utilization were not given so much consideration in the past in the Czech Republic, even if it deserved so. Energy obtained from combustion of biomass is the oldest energy used by people. Mass incineration of organic origin means the lower burden for global clime and offers cost minimalization of combusting technologies. This approach offers both ecological effects and the higher economic effectiveness in comparison with the classic fuels.

This paper reflects the need to solve the utilization of mill by-products, esp. brans which are cumulated in the mills and the consumption is increasingly problematic. This situation is caused by decreasing interest of farmers used brans as feed due to decline in count of polygastric animals. The negative situation impacts on the storage of the bulk quantity of biomass.

The idea of production from surplus brans and other parts of bio-briquette and obtaining energy from cereal biomass by thermo chemical conversion arose on the Department of Operation and Systems Analysis in the Czech University of Life Sciences. The authors have been occupied with these issues for a few years. The research contains well-done experiments on compression tests of particular structure parts of bio-briquettes, comparative analysis on utilization relations proportion, ecological and residual characters etc. The results turned up well.

The renewable resources of energy, in which biomass belongs, influence importantly on employment and national economy. The great significance contains not only reaching a new energy resource by combustion, improve region ecology and offer special commodity production which does not serve for the food purposes. Instead of food production, agriculture and food industry could produce energy which will be always necessary for people.

Goals and methodology

The paper aim is to pay attention to possibilities to use a cereal biomass as energy resource. The result affects on the general interest in looking for the substitutions for the fossil energetic resources which are not unlimited. However it could provide the possibility of multicriterial view of this field.

We can expect that the interference between the ecological and economic aspects will escalate in the social economic and technological systems. The most decisions with global impacts are the source of conflicts and that is why it is necessary to pay special attention to the particular methodology.

The selection of the best alternative of bio-briquette structure (i.e. the variant matching the criteria choice) is based on the method of complex variant analysis. These methods arise from analysis of preference comparison between two options in which are utilized the characters of relation of composition within the particular set. The compositing relation could be formulated by the different approaches. It offers the reciprocal relations among the considerated components. The selection of best (optimal) variant from the particular variant set is very complicated because the definition "best" contain the very strong intuitive meaning. On the other hand the crucial problem is to find the criteria selection for evaluation. There are a lot of specific problems in the implementation of multicriterial approach in the field of agriculture and food industry. The final success of multicriterial evaluation depends on the structure of assumptions.

The group of variants for the decision selection is a basic condition. The structure of variants could be defined by the two different ways: 1st one in explicit form (i.e. final count of alternatives) and 2nd one in implicit form by condition specification (i.e. the degree of variant fulfilment for evaluation as acceptable).

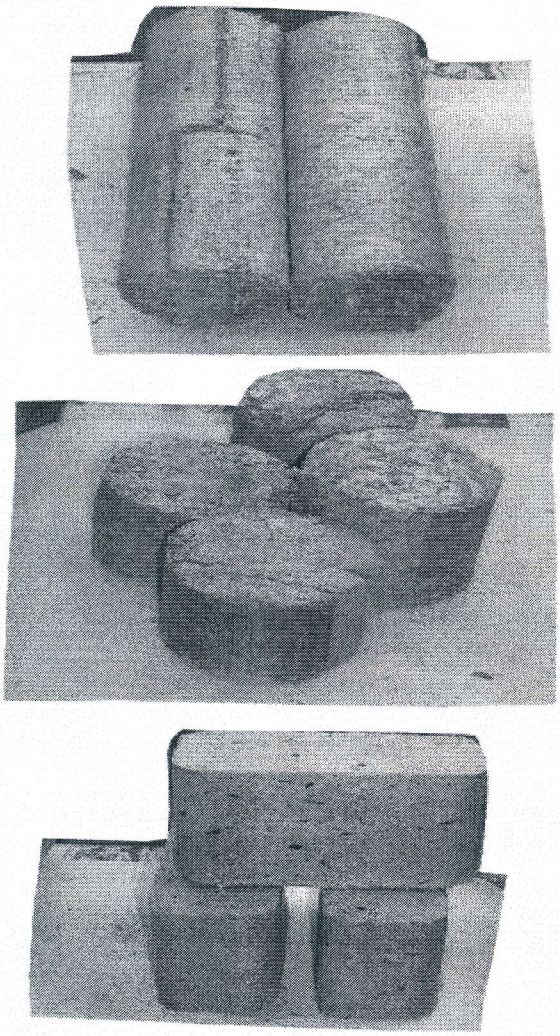

Fig. 1. Bio-briquette produced from soft wood
Fig. 2. Bio-briquette produced from hard wood
Fig. 3. Bio-briquette produced from a combination of two previous structures
(Figs 1–3 was made by M. Táborský – September 2003)

The list of criteria for particular variant comparison is the key condition. The criteria impact indirectly on the goal which will be reached. Evaluation criteria selection and definition of its influence have to correspond to economic, ecological and technological views. Criteria selection and the proper analysis of relation impacts are the important presumption for the successful problem solving. The relation analysis is necessary for the count reduction (i.e. acceptable level) and criteria group selection, which has impact on the final result. The method GUHA is considered as very useful and provides full information about object structure and its features in the case of 0/1 matrix description.

The next step is to evaluate the final decision making if we have the structure of variants and criteria. We do not concentrate on the best bio-briquette selection but ordering the particular bio-briquette in compliance with the best bio-briquette structure.

We can use a large scale of methods regarding complex variant analysis. AGREPREF and ELECTRE belong to the methods which are based on the paired comparison of variants. Method PRIAM requires information about the aspiration criteria level and are based on the heuristic search of the variant group and finds only one no-dominative solution. Method ORESTE requires only ordinary information about criteria.

We decided to employ methods TOPSIS (Technique for Order Preferences by Similarity to Ideal) with the cardinal information about criteria. The method seeks for distance minimalization from the optimal variant AHP (Analytic Hierarchy Process) and maximalization of the benefit displayed by linear function. The main advantage of TOPSIS is simplicity and clarity (Získal, Havlíček, 2006).

Photo-documentation shows some samples of tested biomass on the basis of wood mass (Figs 1–3).

ANALYSIS AND DISCUSSION

On the basis of expert evaluation of the primary test (see Table 1), the possible (feasible) variants of ecological pure and saving (combined) variants of biomass was defined the following variants of bio-briquettes.

The group of criteria including ecological, economical, marketing and technological aspects is showed in Table 2.

Table 1. Components and elements

	1	2	3	4	5
	Cereals bran	Binding agent	Oil beanin extracts	Coal dust	Wood fibre substance
V1	X				
V2	X	X			
V3	X		X		
V4	X	X	X		
V5	X			X	
V6	X	X		X	
V7	X		X	X	
V8	X	X	X	X	
V9	X				X
V10	X	X			X

Table 2. Criteria for evaluation of Bio-briquettes variants

Criteria	Characteristic	Type	Specific unit
K1	Production costs	Min	CZK
K2	Expected realization price	Max	CZK
K3	Term energy resources	Max	Rel. KJ
K4	Residual effects – CO	Min	GMJ rel.
K5	Residual CO_2	Min	GMJ rel.
K6	Residual SO_2	Min	GMJ rel.
K7	Residual NO_X	Min	GMJ rel.
K8	Need of surface pressure	Min	KP
K9	Biomass durability	Max	Points rel.
K10	Physical biomass consistency	Max	Points rel.
K11	Expected marketability	Max	Points rel.
K12	Total effects	Max	Points rel.

Input data for multictriterial evaluation by TOPSIS method are showed in Tables 3 and 4.

The order of variants shows the convenience of bio-briquette produced from brans and binders, optionally from brans, wood comminutions and binders. All briquettes with the coal dust adulterants are unacceptable in the view of considered criteria. Obtained result solves the problem of strategy selection as for the bio-briquette structure. It means if the pure one (i.e. only plant bio-briquette) or mixed one with the utilization of brans, wood comminutions, coal dust and binders (Table 5).

System impacts and possible contributions of bio-briquette production

We can expect that the structure of the Czech mill production will not dramatically change in the future. The

Table 3. The basic model of variants and criteria (NORM)

	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11
	Prod. costs	Real. price	Resources	CO	CO_2	SO_2	NO_X	Pressure	Duration	Consistency	Marketing
V1	1.3	2.3	8.5	1	0.5	0.1	0.2	8	4	5	7
V2	1.4	2.4	8.6	1	0.5	0.1	0.2	5	5	6	8
V3	1.5	2.5	9	1.5	1	0.15	0.25	7	5	6	8
V4	1.55	2.4	9.2	1.5	1	0.15	0.3	4	6	7	9
V5	1.35	2.4	9.5	3	1.5	2	0.3	8	5	5	6
V6	1.6	2.4	9.6	3	1.6	2.15	0.35	3	7	7	6
V7	1.65	2.5	10	3	1.7	2.2	0.35	7	6	9	6
V8	1.7	2.5	10	3	1.5	2.1	0.4	4	7	9	6
V9	1.55	2.6	9	1.5	1	0.4	0.25	6	6	5	7
V10	1.6	2.6	9	1.5	1	0.4	0.25	3	7	8	8
Type	min	max	max	min	min	min	min	min	max	max	max
Comparative criterium	0.7	0.6	0.8	0.6	0.7	0.9	0.9	0.9	0.5	0.5	0.5

Table 4. Composition of transformed coefficients of analysis for EURO-BIO Briquette model (NORM)

	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11
	Prod. costs	Real. price	Resources	CO	CO_2	SO_2	NO_X	Pressure	Duration	Consistency	Marketing
V1	0.053	0.023	0.031	0.038	0.05	0.051	0.057	0	0.014	0.015	0.02
V2	0.04	0.024	0.031	0.038	0.05	0.051	0.057	0.036	0.018	0.019	0.023
V3	0.027	0.025	0.032	0.029	0.029	0.05	0.043	0.012	0.018	0.019	0.023
V4	0.02	0.024	0.033	0.029	0.029	0.05	0.029	0.048	0.021	0.022	0.026
V5	0.047	0.024	0.034	0	0.008	0.005	0.029	0	0.018	0.015	0.017
V6	0.012	0.024	0.035	0	0.004	0.001	0.014	0.06	0.025	0.022	0.017
V7	0.007	0.025	0.036	0	0	0	0.014	0.012	0.021	0.025	0.017
V8	0	0.025	0.036	0	0.008	0.002	0	0.048	0.025	0.028	0.017
V9	0.02	0.026	0.032	0.029	0.029	0.044	0.043	0.024	0.021	0.015	0.02
V10	0.013	0.026	0.032	0.029	0.029	0.044	0.043	0.06	0.025	0.025	0.023
Ideal variant	0.4	2.6	10	2	1.2	2.1	0.2	5	7	9	9
Basal variant	0	2.3	8.5	0	0	0	0	0	4	5	6

Table 5. Modified TOPSIS analysis – the results of variants

	EURO-BIO-briquette	
	Distance	Order
V1	0.641348	3
V2	0.787454	1
V3	0.57055	6
V4	0.632477	4
V5	0.356672	8
V6	0.397938	7
V7	0.172267	10
V8	0.322554	9
V9	0.579645	5
V10	0.664872	2

Relatively low nutric figures of brans determine that this product could be taken as the important feedstuff for the agricultural animals but could be a resource of alternative and ecological pure energy.

The important problem with brans utilization in the chick ration is the contents of both chemical residua resulted as the chemical treatment of the wheat and micro parasites. These aspects in not contained in this presented paper.

Environmental deterioration in the Czech Republic caused by combustion of the high quality coal over the period 1918 and 1987 (Fig. 5).

The anthracite mining development after the 2nd world war in the selected European countries is mentioned bellow Table 8.

Table 6. Nutric count of brans

	Dry matter	Nitrogen substances	Ruminant		Pigs	
			SNL	Starchy feed unit	SNL	Starchy feed unit
Wheaten	88.0%	14.9%	9.9%	41.8%	11.0%	56.4%
Rye	88.0%	15.1%	11.3%	49.4%	10.3%	61.9%

production of food cereals fluctuate between 1300 Mio and 1550 Mio t in the Czech Republic. The structure contains approx. 1200–1350 Mio t wheat and approx. 200–280 Mio t rye. These volumes mean approx. 200–280 Mio t acquired brans.

The important marketing problem is a different share of large, middle and small mill for the food cereals processing. The particular shares according to the expert estimate for the period of 2002/2003 is showed in Fig. 4.

The increasing volume of brans in the mill and delay in late bran consumption could caused the significant running problems of the mills including a few days flour production stop. The sharp decline in the count of polygastric animals (esp. Stock, see Table 7) have been since 1990.

After the count of spoil volumes to specific fuel we could find that nominal increase in mining of fossil fuels does not correspond with the real energetic contributions. The main reason is based on the long-term decreasing trend of heat value of coal, as mentioned in Table 9.

The negative impact is connected with both the decline in heat values and downturn of the other geological and qualitative parameters. The lignite contains the increase of stripped ratio, sulphur content, ashes, water and other detrimental components. The situation turns to be worst due to the large engines, which mine not only coal but ground as well. The result affect obtaining a low quality energetic material production instead of the high quality products made from quality coal.

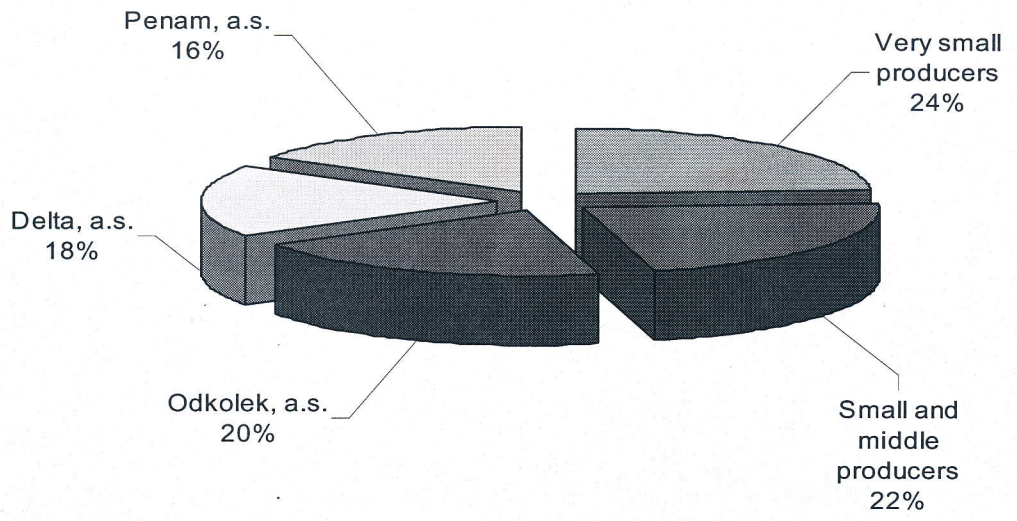

Fig. 4. The share of mill producers on the cereals processing

Table 7. Count of stock development in the Czech Republic as the main purchaser of brans in the feed rations (data are introduced in thousand units)

Category	Period							
	1989	1997	1998	1999	2000	2001	2002	2003
Total stock	3480.0	1866.0	1701.0	1657.0	1574.0	1582.0	1520.0	1490.0
Cows share	1248.0	702.0	647.0	642.0	615.0	611.0	596.0	530.0
Cows with the milk production	–	–	–	–	515.5	483.4	470.1	1465.0

Source: Zelena zprava published by Ministry of Agriculture, 2002, pages 193 and 54

Table 8. The anthracite mining development (in Mio tonnes)

	1945	1955	1960	1970	1975	1980	1985	1990	2000
Great Britain	220	225	197	147	123	130	91	105	95
FRG	111	132	143	116	97	94	89	87	94
France	51	55	56	38	24	21	17	19	17
Belgium	27	30	23	11	8	6	6	7	5
Czechoslovakia	18	21	26	28	28	28	26	23	19*

* Czech Republic

Above mentioned factors negatively impact on the environmental deterioration in the Czech Republic. The perspective significance of alternative and recoverable resources utilization including all kinds of bio-briquette becomes more and more meaningful.

Table 9. Heat values of coal development ($kJ.kg^{-1}$)

	1970	1980	1987	2002
Pit-coal	25 205	24 870	24 391	23 950
Brown coal and lignit	13 477	12 510	12 208	12 035

CONCLUSION

Multicriterial evaluation methods are useful in the field of agriculture. The paper contains only one option which could be utilized in the product vertical within the agriculture industrial complex. Theory of multicriterial decision-making is based on the mathematical modelling. Its advantage consists in elementary knowledge of maths. System and complex view of this issue is contained in the multicriterial approach.

Option selection of the best bio-briquette structure is depended on the impact quantification according to the particular criteria in the case of multicriterial evaluation. The group of variants and criteria consists of ecological,

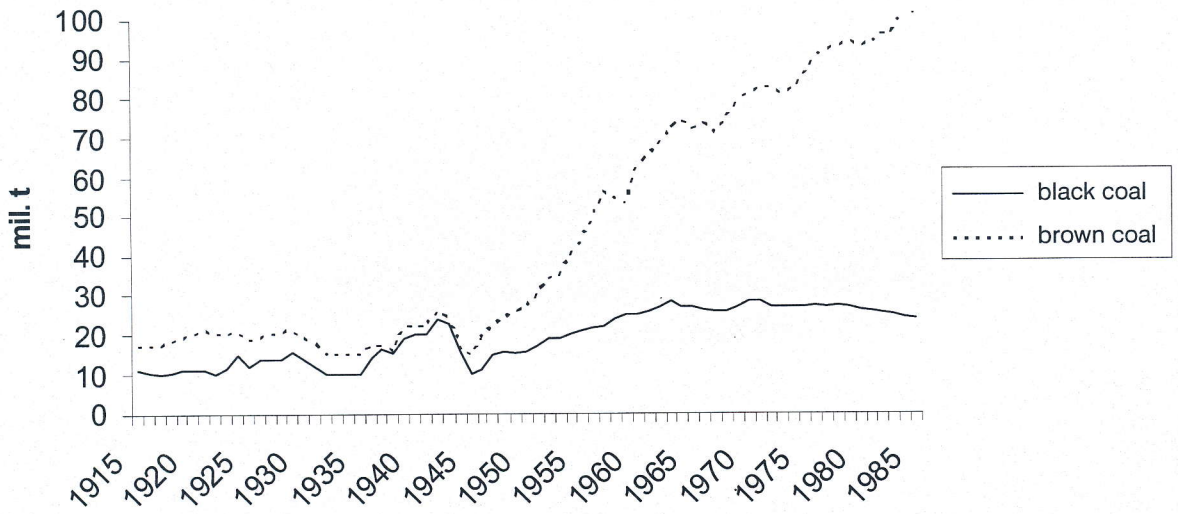

Fig. 5. Coal consumption development in the Czech Republic

economic and technological aspects which are determined by expert estimations. The quality of expert estimations depends on the quality of expert selection.

Alternative energetic production, which utilize cereal biomass belongs to the group of fuzzy problem fields and could be subject of several ecological acceptable variants. It is necessary to realize that no algorithm or method can substitute the real manager in the process of decision making. On the other hand this approach could offer the full information and help to take optimal decisions.

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Příspěvek se zabývá problémem využití variantních multikritériálních přístupů při řešení vybrané třídy rozhodovacích problémů ve výrobkové vertikále agrárně-průmyslového komplexu. Rozhodovací prostor je vymezen na možnosti efektivního a ekologicky přijatelného finalizačního užití biomasy rostlinné produkce, především obilovin, jako klíčové komodity zemědělské prvovýrobní produkce v ČR.

Těžiště příspěvku je zaměřeno na energetické a nepotravinářské využití otrub pro výrobu biobriket. Pro řešení daného problému byla použita metodologie vícekriteriálního hodnocení pomocí metod komplexní analýzy variant.

obilní biomasa; biokriketa; vícekriteriální přístup; ekologická kritéria; systémové dopady řešení; fosilní paliva; multikriteriální komparace; fuzzy aspekty

Contact Address:

Doc. Ing. Jaroslav Švasta, CSc., Česká zemědělská univerzita v Praze, Fakulta provozně ekonomická, katedra operační a systémové analýzy, Kamýcká 129, 165 21 Praha 6-Suchdol, Česká republika, e-mail: svasta@pef.czu.cz