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BIOGAS ENERGY DEVELOPMENT IN SLOVENIA

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ABSTRACT: This paper analyses the development of the biogas energy production and use in Slovenia. The major concern is given to ecological, economic and technical determinants in decision making process for selection among alternative biogas energy production plants and use of energy for heating and electricity. The investments into the biogas plants have reduced ecological problems from large environmental polluters in urban and rural areas. Among them are sewage systems, food wastes, wastes from large-scale animal farms, and some other wastes from food-processing and food consumption places. The measures of economic policy, particularly guaranteed prices for purchased electricity from biogas production plants are presented that have contributed to the development of green energy production.
KEYWORDS: biogas energy, ecology, sustainable development, Slovenia

INTRODUCTION

This paper investigates opportunities for biogas energy development in Slovenia. The sustainable biogas energy development is one of the objectives for an increase in renewable energy production (e.g. Makipelto 2009). The global warming and climate change have caused the changing patterns in energy production and consumption in sustainable economic development [1, 2, 3, 4].

The present paper is, however, the first attempt to quantify the investments opportunities and energy production from biogas plants in Slovenia. The biogas plants for supply of energy for heating and electrical energy are based on animal wastes and/or from biomass by using the fermentation processes. The energy from gas is transformed into energy for heating of residential and other different places as well as for electrical energy for use at the farm and for supply to the electrical energy network. The biogas plants are based on pure manure up to some plant substratum such as corn as supplement raw materials.

Up to 2002, production of biogas in Slovenia was limited on biogas production from the purifying plant and communal wastes. The single biogas production from manure and wastes in agriculture prior to the 2002 was on the largest Slovenian pig farm in Ihan. Since 2002, the government regulation on purchase of electrical energy from qualified producers of electrical energy has given an opportunity for producers of electrical energy to charge higher prices on electricity production produced from wastes and similar raw materials, which has provided incentives for investment into the biogas plants on the larger (livestock) farms. As a result, in Slovenia there are in operation few larger biogas plants that produce heat energy from wastes from animal products and other agricultural food wastes.

Among advantages of biogas production from agricultural and food wastes at the biogas plants are economic investment attractiveness, which at the same time can provide opportunities for ecologically less questionable uses of manure, reduction of emissions of carbon dioxide (CO_2), and can be a source of energy for heating and electrical energy. The state also supports the biogas energy supply by assuring guaranteed purchase and purchase price of electrical energy. Among disadvantages the investments in the biogas plants are relatively high intensive investment and there are possible oscillations in supply of heat energy owing from possible instabilities in the availability or delivery of wastes as a raw material. The strategic objective in Slovenia is to develop instruments and measures to increase biogas production and biogas energy supply also on small livestock and crop farms, which are prevailing in the Slovenian agriculture structures.

The structure of the paper is the following. The next section presents methodology and data used. Then, empirical results are presented. The final section derives conclusions and policy implications for green agribusiness in Slovenia within the European strategies for multifunctional rural development and the set objectives on renewable sources of energy.

METHODOLOGY AND DATA USED

The development of biogas production in Slovenia is analysed focusing on production that is based from raw materials from agriculture, particularly from the wastes in the large pig farms. The advantages and disadvantages of biogas plants and potentials of biogas production in Slovenia are critically evaluated. The analysis includes evaluation of alternative biogas plants where the decision making process is sensitive to technical, ecological and economic factors, particularly to prices of outputs (electrical energy) and government policies that are targeting for production of renewable sources of energy. The studied are properties of the decision-making process with criteria, advantages and uncertainties. As a support for the decision making in the process of the investment decisions, methods and systems for evaluation of alternatives are used with analysis and selection of alternatives. As a model for the selection of appropriate decision making, multi-parametric methods are used, which in addition to observation and mutual comparisons also offer evaluation of alternatives, namely with the Kepner and Tregoe [5] method, intended for moderately demanding decision-making issues and DEX [6] method, an expert system shell for multi-attribute decision making for the most demanding decision-making processes, with greater emphasis on a subjective judgement with the use of symbolic parameters and efficiency functions. The constructed model under the DEX method is realised with a computer programme for multi-parameter modelling DEX in three steps: creating parameters and structure, stocks of values of parameters and efficiency functions – possible also with weightings, which is expressed by the percentages.

RESULTS AND FINDINGS. Kepner-Tregoe evaluation method

The Kepner and Tregoe [5] step-by-step evaluation method is used to evaluate alternative biogas plants on the basis of the observations and mutual comparisons. The Kepner-Tregoe decision making method is a structured methodology for gathering, assessment, prioritizing and evaluating collected information for business management decision making. The main idea is to find the best possible choice based on the outcome with minimal negative consequences. The Kepner-Tregoe decision making matrix is based on four basic steps: situation appraisal to clarify the situation and outline concerns with choose a direction, problem analysis to define the problem and its determinants, decision analysis to identify alternatives and their risks, and potential problem analysis to find the best of the alternatives vis-à-vis potential problems and negative consequences in order to propose actions to minimize the risk in business type decision making.

With the Kepner-Tregoe decision analysis are prepared decision statements on the desired results and action required in order to define strategic requirements, operational objectives and restraints in the system to rank the objectives and assign relative weighs to list alternatives and score each alternative biogas plants. The alternatives one by one by individual parameters are marked with points on a scale from 0 to 10, where 10 means ideal, the best and the most desirable value, while 0 the worst, the least desirable value. Next, the weight of the objective is multiplied by the satisfaction score by points from 1 to 10 to come up with the defined weighted score by individual parameters. This is repeated for each alternative biogas plants.

The four alternative biogas plants are evaluated of different sizes and their technical and ecological characteristics, and economic determinants. The Kepner-Tregoe method is suitable for evaluation of alternatives for moderate difficult decision-making problems, where the number of parameters do not exceed 10.

Table 1 suggests that the largest biogas plant of the size 7,093 kW has received the greatest number of points (1,102). On the second place is ranged the biogas plant of the size 962 kW (1,075 points), on the third place is ranged the smallest biogas plant of the size 110 kW (1,029 points), and on the worst, the fourth place is ranged the biogas plant of the size 1,450 kW (930 points). The results revealed that the greatest effect is from the construction of the biogas plant of the largest size, if are present available certain conditions and financial means. In the case of the medium size of the bio plant, the best solution is found for the installed size up to 1 MW (in our case 962 kW) owing from better selling price of electricity than for the biogas plant, which are larger than 1 MW (in our case 1,450 kW). Considering the additional subsidies, the smallest biogas plant of the size 110 kW has achieved better results than the medium sized biogas plant of the size 1,450 kW.

In an additional step, the attention has been given to the weights of the parameters. The Kepner-Tregoe method allows to sets the weights of the parameters in two ways: first, by an agreement that the most important parameter has a constant weight, for example 10 for sale price, while the weights for other parameters are set with respect to the most important parameter to sum up to 100%. Second, total sum of 100% is distributed between all parameters.

The Kepner-Tregoe method results are sensitive to subsidization policies. If subsidies changed – operational support for production sources from renewable sources of energy, then this changed the best choice of the biogas plants. Therefore, the next step, the analysis of 'what-if', it is conducted in order to evaluate the sensitivity of the alternative results, if would change subsidy from the Public Agency for Energy: for small biogas plant up to 1 MW subsidy increased from 9 to 10 monetary units *(support for new smaller sources of energy), for biogas plants from 1 MW to 5 MW subsidy declined from 7 to 5 monetary units, and for biogas plants larger than 5 MW subsidy declined from 6 to 4 monetary units. The evaluation of the biogas plants by Kepner-Tregoe method and analysis 'what-if' the subsidy for operational support for production sources from renewable sources of energy changed, this has changed the ranging between the alternative biogas plants. The best choice is the biogas plant of the size 962 kW (1,095 points), which has overtaken the largest biogas plant of the size 7093 kW (1,082 points). On the third place is ranged the smallest biogas plant of the size 110 kW (1,039 points), and on the last, fourth place is ranged the biogas plant of the size 1,450 kW (910 points). The results confirmed the important role of the subsidisation policies for renewable source of energy, which in our case of the analysis of 'what-if' has given priority for smaller biogas plants of the installed power up to 1 MW.*

Table 1 – Evaluation of biogas plants by the Kepner-Tregoe method

Parameters (i)	Weight (w_i)	Size 110 kW		Size 962 kW		Size 1,450 kW		Size 7,093 kW	
		Points (t_i)	Weight x points ($w_i t_i$)	Points (t_i)	Weight x points ($w_i t_i$)	Points (t_i)	Weight x points ($w_i t_i$)	Points (t_i)	Weight x points ($w_i t_i$)
Size (technical and actual)	8	3	24	5	40	7	56	10	80
Age	3	1	3	2	6	5	15	8	24
Modernization	5	1	5	4	20	5	25	6	30
Receiving centre of substratum	3	3	9	4	12	5	15	6	18
Anaerobic reactor with gas-warehouse	4	3	12	4	16	5	20	7	28
Engine - co-production of heat and electrical energy unit	7	3	21	4	28	5	35	6	42
Supervision and rudder-controls of system	3	4	12	7	21	6	18	9	27
Remote control	3	1	3	7	21	6	18	9	27
Monitoring	2	2	4	8	16	4	8	4	8
Technological temperature	1	4	4	6	6	2	2	2	2
Safety of equipment	6	3	18	5	30	4	24	6	36
Human factor	7	8	56	4	28	4	28	5	35
Joint use of heat and electricity	5	7	35	2	10	2	10	2	10
Manure and liquid manure	8	9	72	5	40	7	56	3	24
Energy plants	6	7	42	3	18	4	24	2	12
Biological wastes	4	6	24	4	16	5	20	2	8
Supplements: glycerol	5	2	10	7	35	4	20	3	15
Location, distance from residential settlements	6	4	24	7	42	3	18	5	30
Smell in air	5	6	30	8	40	7	35	10	50
Health impact: on underground water	7	3	21	5	35	4	28	9	63
Impact on quality of rivers (creeks)	4	3	12	5	20	4	16	9	36
Appearance of landscape	5	4	20	6	30	3	15	7	35
Noise and other disturbances in environment	6	2	12	5	30	1	6	3	18

Table 1 - Evaluation of biogas plants by the Kepner-Tregoe method (continue)

Education and promotion	*3*	*5*	*15*	*4*	*12*	*2*	*6*	*1*	*3*
Promotion of good practices	*4*	*3*	*12*	*7*	*28*	*2*	*8*	*1*	*4*
Public opinion	*6*	*5*	*30*	*6*	*36*	*1*	*6*	*3*	*18*
Communication support	*2*	*1*	*2*	*4*	*8*	*5*	*10*	*3*	*6*
Price of electrical energy	*10*	*9*	*90*	*8*	*80*	*7*	*70*	*6*	*60*
Useful use of heat	*6*	*7*	*42*	*5*	*30*	*3*	*18*	*3*	*18*
Content of substratum - supplement for 30% of agricultural substratum	*5*	*10*	*50*	*5*	*25*	*8*	*40*	*9*	*45*
Supplement for agricultural biogas plants up to 200 kW	*4*	*10*	*40*	*0*	*0*	*0*	*0*	*0*	*0*
Operational costs	*6*	*6*	*36*	*4*	*24*	*4*	*24*	*5*	*30*
Labour costs	*5*	*7*	*35*	*5*	*25*	*5*	*25*	*8*	*40*
Transportation costs - transport to biogas plant	*4*	*6*	*24*	*8*	*32*	*7*	*28*	*4*	*16*
Distance to the market	*3*	*6*	*18*	*8*	*24*	*5*	*15*	*3*	*9*
Other costs, including sponsorship in a town	*1*	*4*	*4*	*7*	*7*	*5*	*5*	*3*	*3*
Development potential and opportunity for transfer of technology	*7*	*2*	*14*	*5*	*35*	*4*	*28*	*6*	*42*
Internal rate of return	*6*	*5*	*30*	*3*	*18*	*5*	*30*	*7*	*42*
Indicator of profitability of investment	*5*	*3*	*15*	*6*	*30*	*4*	*20*	*6*	*30*
Indicator of ratio of costs to revenues	*3*	*3*	*9*	*7*	*21*	*5*	*15*	*6*	*18*
Sum			*1,029*		*1,075*		*930*		*1,102*
Ranging		*3rd place*		*2nd place*		*4th place*		*1st place*	

Source: Own calculations.

Merging of groups of parameters

At 41 criteria at the 4th level of merging of groups of parameters in the tree structure it has been obtained 17 groups at the 3rd level, 7 groups at the 2nd level and 3 main groups - efficiency, ecology and economics - at the 1st level. With merging of the groups of parameters there is gained equilibration. Table 2 presents the important variables, which are used to when built the structural model of the biogas plants. The calculations are used for defining of the relations between individual variables in individual groups. Between the main groups are calculated. The most important are: economics (grade 5.56), technical efficiency (5.16) and ecology (4.63).

The results are sensitive to the subsidy criteria, which is changing the ranging of the most successful alternative. The support mechanism to the renewable sources of energy development can be through tax supports, direct supports, funding with low interest rate, supports for development of small and medium sized enterprises, which are active in the field of renewable sources of energy, low tax rates for electricity from renewable sources of energy and investment and other loans at low interest rates with government guarantees.

Table 2 –Equilibrated merging of groups of parameters

Technical efficiency: 5.16	*Energetic-technical characteristics: 4.56*	*State of building: 5.33*
		Technology: 4.67
		Automated: 2.25
		Importance of maintenance and management: 6.00
	Use of substratum: 5.75	*Natural - agricultural factors: 7.00*
		Wastes and supplements: 4.50
Ecology: 4.63	*Environmental aspect: 5.50*	*Location: 5.50*
		Influences and disturbances: 5.50
	Consciousness: 3.75	*Marketing and education: 3.50*
		Communication: 4.00
Economics: 5.56	*Revenues: 7.50*	*Guaranteed price: 10.00*
		Mark up to price: 5.00
	Costs: 3.33	*Costs of production: 5.50*
		Logistics: 3.50
		Other costs, including sponsorships in a town: 1.00
	Development and effects: 5.83	*Development potential and opportunity for transfer of technology: 7.00*
		Economic indicators: 4.67

Source: Own calculations.

DEX methods

The DEX method is a representative of a qualitative (symbolic) multi-parametric methods, where instead of numerical are used symbolic parameters [7, 8, 9, 10]. Instead of weighted sums, the utility functions are defined in tabulated form or with rules "if-then". The DEX allows modelling of the most complex decision making processes with large number of parameters and alternatives. The DEX advantage is in the strengthened subjective judgment in decision making. In the development of the DEX model structure, it is recommended that the derived parameters do not have more than four subordinated parameters. Even better if have two or three. Due to this, the DEX models are more blowing away.

In the scales of measuring and stocks of values of parameters, which are symbolic, each parameter can take values from final and normally small stocks of values, which are described by words. Stocks of values are arranged from worst to better, which increases intelligibility of the model. The number of values of individual parameter should be as much as possible smaller. Parameters, which are in the three immediately under the top (efficiency, ecology and economics) can also take four values, while final product object up to five values. With words are expressed numerical parameters for use of substratum, revenues, costs and similar. The intervals are written in the explanation road. The utility function is defined with tables, which have all combinations of values. With each combination are defined values, which are taken by the higher rank parameter.

The DEX program and its use with four alternatives are built to be realized with the selected program for multi-parametric DEX modeling in four steps:

- *Creation of parameters and structures,*
- *Stocks of values of parameters and*
- *Utility functions – possible also with weights, which are expressed in the percent.*

This is used for evaluation of four alternative biogas plants of the sizes 110 kW, 962 kW, 1,450 kW and 7,093 kW. The evaluation is conducted from bottom up, with procedure of merging of values in their consistence with utility functions.

The following criterions and stocks are employed:

1. *Production building (evaluation of feasibility for investment): bad, acceptable, good, very good, and excellent.*
2. *Efficiency: bad, acceptable, good, and excellent.*
3. *Energy-technical characteristics: weak, suitable, and strong.*
4. *Stage of building: worse, suitable, and better.*
5. *Size (technical and actual: small up to 200 kW, medium from 200 kW to 1 MW, and large from 1 to 5 MW.*
6. *Age: old (10 years and more), medium (5 to 10 years), and new (0 to 5 years).*
7. *Modernization: without modernization, for reconstruction, modernized few years ago, and modernized.*
8. *Technology: suitable, more suitable, and very suitable.*
9. *Receiving centre of substratum: minimal, small, medium, and large.*

10. *Anaerobic reactor with gas-warehouse: small, greater, large, and very large.*
11. *Engine – co-production of heat and electrical energy unit: minimal requirement, standard accomplishment, advanced accomplishment, and high-technological accomplishment.*
12. *Automatic control: crew, automatic, and smart-grid.*
13. *Supervision and rudder-controls of the system: simplest system, complex system, and advanced system.*
14. *Remote control: without remote control, local control, and automatic control.*
15. *Monitoring (monitoring of data on production): without monitoring, simple system, and on-line connection of the system.*
16. *Technological temperature: less suitable, suitable, and more suitable.*
17. *Importance of maintenance and monitoring of equipment: not important, important, and very important.*
18. *Reliability of equipment: unreliable, reliable, and very reliable.*
19. *Human factor (professional knowledge, presence at the production plant building): less important, important, more important, and very important.*
20. *Co-use of heat and electricity: current maintenance, revision of equipment by need; current maintenance, periodic revision individual equipment considering the standards; and current maintenance, systematic revision of all equipment by prepared operational-maintenance guidelines.*
21. *Utilisation of substratum: small utilisation, reasonable utilisation, greater utilisation, and high utilisation.*
22. *Natural – agricultural factors: weak, suitable, and strong.*
23. *Manure and liquid manure: less suitable, suitable, and more suitable.*
24. *Energetic plants: not used, partially used, often used, and regularly used.*
25. *Wastes and supplements: less used, partial used, often used, and regularly used.*
26. *Biological wastes: low rate, medium rate, and high rate.*
27. *Supplements – glycerol: without use, partial use, and permanent use.*
28. *Ecology: less considered, considered, more considered, and most considered.*
29. *Ecological aspect: minimal, small, medium, and large.*
30. *Location: unsuitable, suitable, and very suitable.*
31. *Location, distance from residential settlements: unsuitable, partly suitable, suitable, and more suitable.*
32. *Smell in air: low, temporary, stronger, and strongest.*
33. *Impacts and disturbances: small, medium, and large.*
34. *Health aspect: on underground water (through fields) and with this on drinking water: no impact, little impact, medium impact, and large impact.*
35. *Impact on quality of rivers (creeks): no impact, little impact, medium impact, and large impact.*
36. *Appearance of landscape: very disturbing, medium disturbing, and not disturbing.*
37. *Noise and other disturbances in environment: damaging disturbances (biogas plant is situated in residential settlements), partial disturbances (biogas plant is situated in the suburb of residential settlements), small disturbances (biogas plant is near residential settlements), and imperceptible disturbances (biogas plant is situated away from residential settlements).*
38. *Consciousness: low, medium, and high.*
39. *Marketing and education: bad, suitable, more successful, and very successful.*
40. *Education and promotion: not organized, temporary, from time to time, and regularly systematically.*
41. *Presentation of good practices of biogas plants: no cases, temporary, and often.*
42. *Communication: bad, suitable, more suitable, and very successful.*
43. *Public opinion: unfavourable, neutral, positive, and very favourable.*
44. *Communication support: little, medium, greater, and large.*
45. *Economics: weak, suitable, good, and excellent.*
46. *Revenues: low, medium, and high.*
47. *Guaranteed price: low, medium, and high.*
48. *Price of electrical energy (only energy without subsidies): low (small quantities of supply), medium (medium quantities of supply), and high (large quantities of supply).*
49. *Subsidy – operational support: low (biogas plant of installed power above 5 MW), lower (biogas plant of installed power from 1 to 5 MW), medium (biogas plant of installed power from 200 kW to 1 MW), higher (biogas plant of installed power from 50 to 200 kW), and highest (biogas plant of installed power up to 50 kW).*
50. *Subsidy to price: low, medium, and high.*

51. *Joint use of heat and electricity: negligible (less than 15% share of entry energy of biogas (no supplement), suitable (more than 15% share of entry energy of biogas – supplement of operational support in an amount of 10%), and exceeded (quantity greater than 30% share of entry energy of biogas – supplement of operational support in an amount of 10%).*
52. *Contents of substratum – supplement for more than 30% share of manure and liquid manure in substratum: negligible (less than 30% share of manure and liquid manure in substratum for production of biogas in biogas plant with installed power up to 200 kW – no supplement), suitable (more than 30% share of manure and liquid manure in substratum for production of biogas in biogas plant with installed power up to 200 kW – supplement of operational support in an amount of 10%), and exceeded (quantity greater than 50% share of manure and liquid manure in substratum for production of biogas in biogas plant with installed power up to 200 kW – supplement of operational support in an amount 10%).*
53. *Supplements for agricultural biogas plant of installed power up to 200 kW: negligible (less than 70% of manure and liquid manure in substratum for production in biogas plant with installed power up to 200 kW – no supplement), suitable (more than 70% of manure and liquid manure in substratum for production in biogas plant with installed power up to 200 kW – supplement of operational support in an amount of 10%), and exceeded (quantity greater than 80% of manure and liquid manure in substratum for production in biogas plant with installed power up to 200 kW – supplement of operational support in an amount of 10%).*
54. *Costs: high, medium, and low.*
55. *Production costs: high, medium, and low.*
56. *Operational costs: high, medium, and low.*
57. *Labour costs: high, medium, and low.*
58. *Logistics: high, medium, and low.*
59. *Transport costs to biogas plant: high, medium, and low.*
60. *Distance from market: long distance, medium distance, and short distance.*
61. *Other costs, including sponsorship in town: high, medium, and low.*
62. *Development and effects: not important, important, and very important.*
63. *Development potential and opportunities for transfer of technology: small, medium, and large.*
64. *Economic indicators: low, medium, and high.*
65. *Internal rate of return: low, medium, higher, and highest.*
66. *Indicator of profitability of investment: low, medium, higher, and the highest.*
67. *Indicator of ratio costs to revenues: low, medium, higher, and the highest.*

The conducted analysis and the selection of four alternative biogas plants show that the biogas plant of the size 110 kW is very good, while the other three sizes of the biogas plants are good: 7,093 kW, 1,450 kW and 962 kW. By technical efficiency the biogas plant of the size 7,093 kW is good, while the other three sizes of the biogas plants – 1450 kW, 962 kW and 110 kW – are acceptable (Figure 1).

Considering ecology, the biogas plant of the size 962 kW is excellent, while ecology is very good also in the other three sizes of the biogas plants (Figure 2). Considering economics, the biogas plant of the size 110 kW is excellent, the size 1450 kW is good, and the sizes 7093 kW and 962 kW are acceptable (Figure 3).

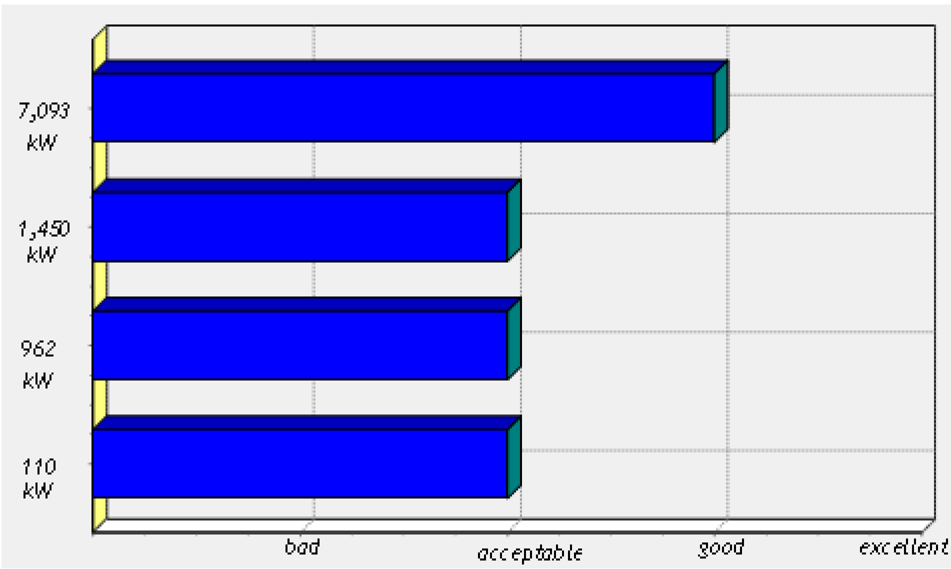

Figure 1 – Criteria of upper level for technical efficiency
(Source: Own calculations)

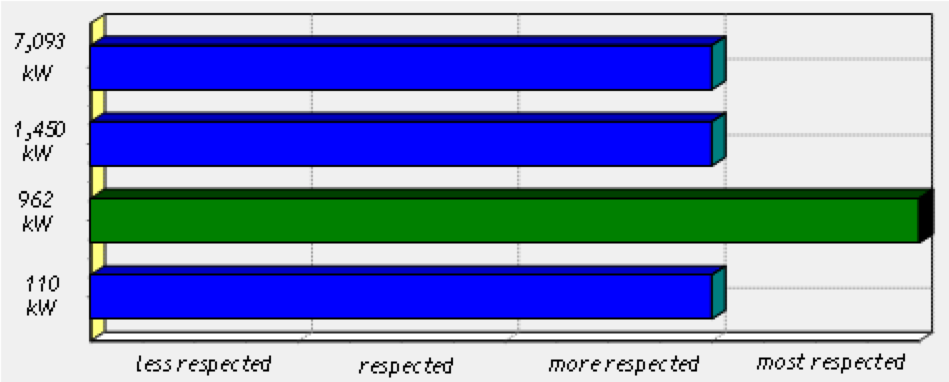

Figure 2 - Criteria of upper level for ecology (Source: Own calculations)

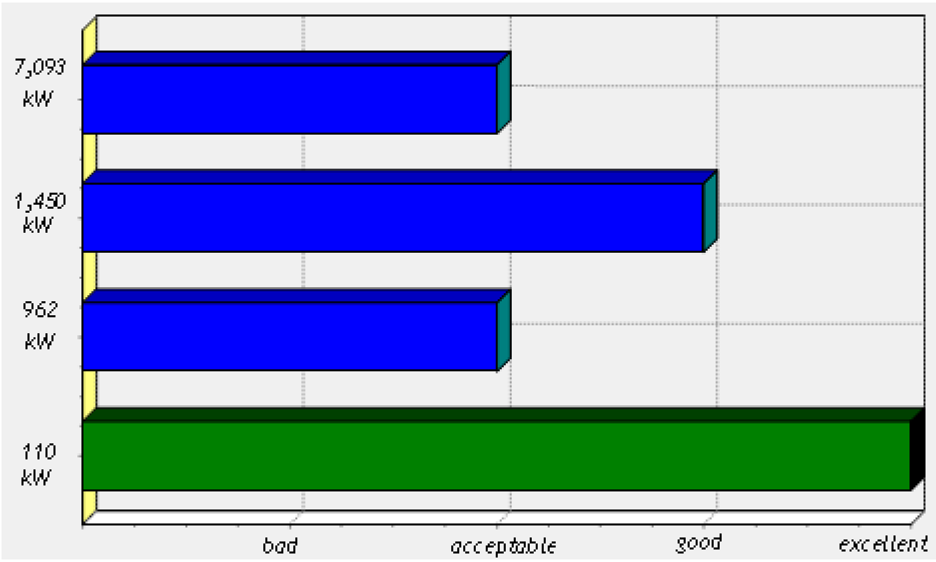

Figure 3 - Criteria of upper level for economics (Source: Own calculations)

A strong energy-technical characteristics has the biogas plant of the size 7,093 kW, a suitable the sizes 1,450 kW and 962 kW, and a weaker the smallest one of the size 110 kW. By the use of substratum has the highest utilisation the biogas plant of the size 110 kW, which is a result of self arrangements by the family farm owner. A reasonable utilisation has been achieved by the biogas plants of the sizes 1,450 kW and 962 kW. For the biogas plant of the size 7,063 kW, which uses imported corn from Hungary, is estimated utilisation of combination of different substratum the lowest. By ecological aspect, the best are evaluated the biogas plants of the sizes 7,093 kW with the most advanced and settled equipment and the size 962 kW, which has dealt systematically with ecological problems for more years. Medium ecological results are achieved by the biogas plants of the sizes 1,450 kW and 110 kW.

From point of view of consciousness the best results have been achieved by the biogas plant of the size 962 kW, medium results by the biogas plant sizes 1,450 kW and 110 kW, and the lowest by the biogas plant of the size 7,093 kW. Revenues (price per unit) is the highest for the biogas plant of the size 110 kW, medium by the sizes 962 kW and 1,450 kW, and the lowest by the size 7,093 kW. Costs are the lowest for the biogas plant of the sizes 1,450 kW owing from gains from the economy of scale and 110 kW owing from gains from supplementary activity of biogas and electrical energy production from renewable sources of energy at the farm. Medium level of costs has achieved by the biogas plants of the sizes 7,093 kW and 962 kW. The best results in development effects have been achieved by the biogas plant of the size 7,093 kW, while the other three biogas plants have faced the following difficulties: the size 1,450 kW has faced problems of expansion owing from conflict and disagreement by the local population, the size 963 kW owing from takeover of the biogas plant by the company Petrol, which does not invest enough and considered takeover as purely entrepreneurial investment, which should provide sufficient profit; and the size of biogas plant 110 kW, which is relatively old and needs modernization. The economic indicators confirmed that the economic results are low for each of the biogas plants.

In the analysis "what-if" are used assumptions about the subsidy changes. The economic results and weighted level of production are the best for the biogas plants of the size 963 kW owing from subsidies and the size 7,093 kW owing from economies of scale. Finally, the evaluation model results *provided evidence for the comparisons of the biogas plants for the decision making. The results of the alternative biogas plants are sensitive on the subsidies as operational supports.*

CONCLUSIONS

Electricity production from renewable sources of energy in Slovenia has increased a slightly. It is still below the set objective. The gap between the objective and actual renewable energy production over time has increased. In 2006, there is an increase in renewable energy production, which is based on investments in the biogas plants from raw materials from agriculture. Since 2002, the key instrument to support production of electrical energy from renewable sources of energy in Slovenia is the system of guaranteed electricity energy prices. The increase in prices for electrical energy from renewable sources of energy and growing demand for electrical energy in the market have improved economic position for producers of electrical energy from renewable sources of energy. The procurement prices for electrical energy for qualified biogas electricity plants are set at a similar level as in other EU countries, which adopted similar system of purchases for supply of electrical energy based on feed-in tariffs.

More specifically, this paper has analysed the biogas production in Slovenia focusing on production of heat and electrical energy, which are based from raw materials from agriculture, particularly from the wastes in the large-scale pig farms and with additional raw materials that are delivered to the biogas plants at the pig farms from food-processors and food wastes from larger food consumption places. Production in one out of the four analysed biogas plants is based on corn mostly imported from Hungary.

The analysis has confirmed the sensitivity of the decision making process on the results, which are biased to prices of outputs (electrical energy) and government policies that are targeting production of renewable sources of energy at the costs production-side. Namely, since 2002, the advantages of biogas plants and potentials of biogas production in Slovenia have been recognized by government policy and thus supported by the guaranteed purchase price of electrical energy from the qualified producers and subsidy payment for produced electrical energy from the renewable sources of energy. However, on the bases of only few years of the biogas plant operations, there are still limited experiences with development and use of biogas plants in Slovenia. Particularly, there are less used opportunities for production of heat and electrical energy from biogas plants on small-scale farms, which have been prevailing in the Slovenian agricultural structures. This is a potential for future development of heat and electrical energy in villages with important role of agriculture, particularly animal production.

The decision making process regarding biogas plants requires up-to-date and comprehensive information on complexity of factors. In order to identify alternative opportunities for decision making process, it has been conducted the assessment of conditions and risk assessment of the four biogas plants in order to study properties of the decision-making process with criteria, advantages and uncertainties. As a support for the decision making in the process of the evaluation of the four biogas plants, the methods and systems for evaluation, analysis and selection of alternatives have been used. As a model for the selection of appropriate investments, the multi-parametric methods were used, which in addition to observations and mutual comparisons also offer evaluation of alternatives, namely with the Kepner-Tregoe method, intended for moderately demanding decision-making issues and the DEX methods for the most demanding decision-making processes, with greater emphasis on the subjective judgement with the use of symbolic parameters and efficiency functions. The constructed model under the DEX method was realised with a computer programme for the multi-parametric DEX modelling in three steps: creating parameters and structure, stocks of parameter values and efficiency functions – possible also with weightings expresses by percentages.

The results of the research indicate advantages and disadvantages of each of the four analysed biogas plants, which have been analysed in detail. Finally, they have been ranged giving in-depth evidence for each of the four biogas plants businesses with policy implications for green agribusiness and supply of energy for heating and electricity in Slovenian villages. This can be supported by the policy measures in the framework of the European strategies for multifunctional rural development and in the framework of the set objectives on renewable sources of energy, which provide opportunities for production of heat and electrical energy in agriculture for the needs in agriculture and for other consumers in rural areas [11].

Among measures to increase biogas production are also some other measures such as regulatory measures to simplify administrative procedures for permissions for biogas plants, greater role of information and education, economic and financial measures, and a favourable public opinion that technical, organisation, economic, and ecological aspects are acceptable for local citizens and general public opinion. These are issues for future research.

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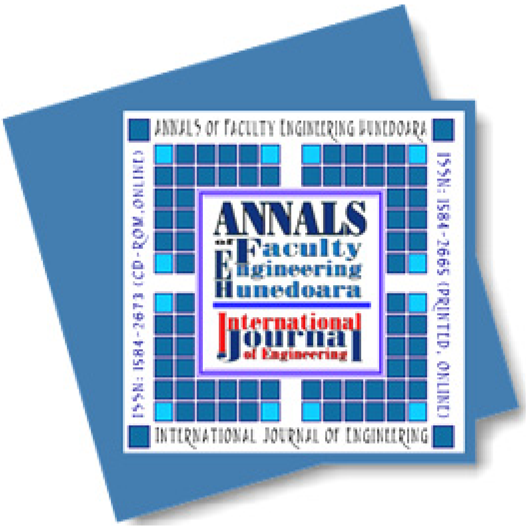

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