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# Evaluation of Effectiveness of Investment Projects of Agricultural Bio-gas Stations

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## Anotace

Příspěvek je zaměřen na problematiku hodnocení efektivnosti investičních projektů, výstavby a provozu zemědělských bioplynových stanic. Pojednává o významu výroby bioplynu v oblasti zemědělství. Biomasa, ze které se bioplyn vyrábí, je jedním z důležitých obnovitelných zdrojů energie.

V úvodu je část věnována vytvoření pojmotvorné základny z ekonomických a environmentálních literárních pramenů, definování pojmu „investice", souvisejícího „investičního rozhodování" a jednotlivých fází realizace investičního projektu. V metodické části jsou uvedeny dynamické techniky vyhodnocování efektivnosti investic.

Praktická část je zaměřena nejprve na základní charakteristiku hodnocených bioplynových stanic, na způsob jejích financování a dosažené nákladově výnosové relace. Těžištěm příspěvku je vyhodnocení provozu a hospodaření vybraných bioplynových stanic ve sledovaném období 2010 - 2013. Efektivnost investice je posuzována pomocí dynamických ukazatelů efektivnosti investic. Všechny čtyři použité ukazatele prokazují velmi příznivé hodnoty provozu stanice z hlediska efektivnosti.

Rovněž tak zjištěnými ukazateli rentability byl potvrzen také pozitivní vývoj hospodaření u všech hodnocených stanic. To plně platí při využití nevratné investiční dotace v rozmezí 25-37% vynaložených pořizovacích nákladů, kterou zemědělské podniky získaly z Programu rozvoje venkova. V případě budování stanic bez uvedené finanční dotace se parametry efektivnosti snižují.

## Klíčová slova

Investiční projekt, dynamické metody, ukazatele efektivnosti investic, míra rentability, životní prostředí, obnovitelný zdroj energie, bioplyn.

## Abstract

The paper is focused on problems of evaluation of effectiveness of investment projects, building and operation of an agricultural biogas stations. It deals with significance of biogas production in the area of agriculture. Biomass from which biogas is produced is one of important renewable energy sources.

A part of introduction is devoted to creation of term-creating base from economic and environmental literary resources, a definition of the term "investment", connected "investment decision making", and particular realization phases of the investment project. In the chapter Materials and methodology, dynamic technologies of investment effectiveness evaluation are introduced and used profitability indicators are delimited.

A practical part is focused at first on basic characteristics of the evaluated biogas stations, on a way of their financing and achieved cost-revenue relation. The mass centre of the paper is the evaluation of operation and management of the selected biogas stations in the monitored period 2010 - 2013. Effectiveness of the investment is evaluated by the help of dynamic indicators of investment effectiveness. All four used indicators show very favourable values of the station´s operation from the effectiveness point of view.

The found out profitability indicators also confirmed a positive development of economy in all evaluated stations. It holds fully in use of non-reversible investment subsidy in a range 25 – 37 % of expended costs which the agricultural enterprises obtained from the Rural Development Programme. In case of building of stations without the mentioned financial subsidy the parameters of effectiveness slightly decreased.

## Key words

Investment project, dynamic methods, investment effectiveness indicators, profitability rate, environment, renewable energy source, biogas.

## Introduction

According to economic theories, investment is understood as capital assets consisting of estates which are not determined for immediate consumption, but are determined for use in production of consumption goods or other capital goods.

Investment can be regarded from several directions. From the macroeconomical point of view, investments are understood as expenses for purchase of investment goods. Therefore financial investments connected with purchase of financial assets like for example shares or obligations are not ranked among them. Investment expenses of firms are autonomous, it means that they are not dependent on income, so, they can be consider non-elastic towards a product; however, only for short-time considerations. In a long period, investments are dependent on product increments (Brčák, Sekerka, 2010).

Investments in relation to an enterprise are considered also goods which do not serve for immediate consumption, but for production of other goods in the future. Also here a profit deferred in the future holds. From the financial view-point of business investment can be characterized as "one-shot expended sources which will bring financial incomes during longer future period" (Synek, 2007).

Investment decision making is characterized by several significant features, for example:

- long-term character of fixed assets
- time factor with a long-term horizon is taken into account
- it is demanding for exact knowledge of internal and external conditions
- coordination of various participants of the investment process
- capital-demanding operations
- work with really realizable financial income
- an influence of factor of entrepreneurial risk
- view-point of the environment, impact on ecology and infrastructure.

Within looking for solution of strategic considerations, main activities of investment decision making will result and the most important ones are generated. They include planning of capital expenses and financial incomes (to respect a time value of money), taking in account of risk and time, and also a choice of criteria of selection of projects from a view-point of yields and influence on liquidity of the enterprise (Kalouda, 2009).

At present for an enterprise is not possible to monitor only one main aim, but it depends on fulfilment of many aims which blend together. However, a big emphasis is put on financial aims. As the main business aims, effectiveness and financial balance of the enterprise, expressed by market values of the enterprise, investment profitability, and liquidity are considered. Other key aim of the enterprise is obtaining and keeping a share on the market and with this connected satisfying of demand. Also decision making about protection and renewal of the environment should be included into business aims. Within reaching of set aims it is suitable to find a compromise and stem from such a position, so that solution of particular aims would not become exclusive for other aims in other area. It is necessary to strive for a harmony and mutual respecting of every business aim. (Valach, 2010).

An investment project is a special name of project whose subjects are investments, and it is primarily focused on purchase or improvement of the enterprise´s property with the aim to gain economic profit. The investment project is a collection of technical and economical studies used for preparation, realization, financing and efficient operation of proposed investment. In building investments it includes usually also architectonic and ecological studies.

A life cycle of project can be expressed as a series of steps which logically mutually follows. The starting stage is a conception, than practicability, a preliminary planning, a detailed planning, a pilot conception, a subsequent implementation, a test, and a handover into operation follow. A project management in particular stages will enable control over the whole course of the project whereas the division into phases brings easier focus on the main project indicators and the financial expression of a risk. The phases subsequently follow and each of them has a well-founded importance of occurrence. A successful termination of one phase is a necessity for starting of the next phase.

The own preparation and realization of project can be expressed as a sequence of consecutive four phases:

- Preparation of investment
- Realization of investment
- Introduction of the investment into operation
- Evaluation of effectiveness of the investment operation

The law No. 406/2000 Col., on energy management defines renewable energy sources as usable energy sources whose energy potential is renewed by natural processes; it is dealt e.g. for natural element (sun, wind, water), geothermal energy, and biomass (of plant and animal origin). It is possible to state that a renewable energy source is a source which is in fact unexpended and renewing. A common energy source in the CR is fossil fuels, concretely coal and natural gas. These fuels are ranked among natural sources; however, surely they cannot be considered inexhaustible sources.

Biomass is an organic mass which arises by means of photosynthesis, or a mass of animal origin. In such way marked biomass is usable for energy purposes as a renewable energy source. A substance is of biological origin. For easier imagination it is possible to compare biomass to some “energy can” in which a part of sun energy is deposit (Murtinger, Beranovský, 2006).

Preferences of biomass use are several. It is an energy source which has a renewable character and is connected with smaller negative impacts on the environment. Biomass is inland energy source, therefore it is not possible to import energy from abroad, thereby it contributes to reduction of consumption of imported energy resources. There is no local limitation and managed biomass production contributes to creation of landscape and care of it (Pastorek, Kára, Jevič, 2004).

In an agricultural station, organic materials from agricultural production are processed by fermentation for production of electric and heat energy. The residual product is co called digestate which is used without a rest as an organic fertilizer. This technology enables to use energy aggregated in plants and to return spent mineral substances back into soil. Thereby they create a closed substance circulation. With is activity it also considerably reduce a rise of green-house gases, mainly methane which oxidizes to less harmful $CO^2$. In such way arisen carbon dioxide is absorbed again by plants.

The aim of paper is to evaluate the adopted and realized investment projects of agricultural biogas stations (further BGS) in an agricultural enterprise.

## Materials and methods

The project documentation contains presumed energetic, financial, and environmental contributions and impacts. The stations have been in operation minimally for three years, therefore it is possible to analyse its activity in time series. To evaluate how BGS effectiveness developed, an amount of produced energy, its supply in a public network, and use of heat which as a product of cooling of gas-engine contributes to improvement of energetic balance of the enterprise. The partial aim is, by means of ratio indicators of profitability, to analyse economic contribution for the enterprises..

From the methodological view point, the paper is divided into two parts. Theoretical starting points are realized by creation of term-creating base by study of appropriate professional literature. Data resources were provided by the agricultural enterprises which operates the biogas stations. The groundwork for an analysis of the operation of biogas stations are monthly protocols about gas production in the monitored period, project documentation to realized investments, and other internal resources. Daily and monthly records about gas production are converted on yearly shown values and are monitored in a time series from 2010 when the BGSs were already fully in operation, to December 2013. All data are processed with use of Microsoft Office Excel 2007. Tables and appropriate graphical illustrations of the course of management are created in this programme.

Accounting statements of profit and loss of the BGSs from 2010 to 2013 are the main output resource for the evaluation of effectiveness of the investment. The enterprise files in the accounting particular centres which provide the production mutually for intra-plant prices. One of the single centres is the BGS.

Within evaluation of the given project, dynamic models of evaluation of investment effectiveness are used. The reason is the fact that they take into account a risk and the time factor which cannot be omitted in gaining the investment by building. By decision about investment in the given project of the enterprises implicit cost arise which increase costs for the investment. Also explicit costs connected with a partial financing by foreign capital arise, as well as inflation affects the investment amount. Dynamical methods have higher explanatory power from a viewpoint of processing of mathematical calculations of basic indicators. In the chapter on processing and results, particular indicators of investment effectiveness indicators are calculated.

$$\text{Net present value (NPV)} = \sum_{0}^{t}\left(\frac{\text{CF}}{(1+\text{i})\text{t}}\right) - \text{IN} \qquad (1)$$

$$\text{Internal rate of return} = \text{il} + \frac{\text{NPVl}}{(\text{NPVl}-\text{NPVh})} * (\text{ih} - \text{il}) \qquad (2)$$

$$\text{Payback period (PP)} = \frac{\text{IN}}{\text{DCF}} \qquad (3)$$

According to availability of data from the statement of profits and losses of the BGS, only selected profitability indicators are quantified in per cents.

$$\text{Return on sales (RS)} = \frac{\text{profit (EAT)}}{\text{returns on sales}} \qquad (4)$$

$$\text{Cost on sales (CS)} = \frac{\text{costs}}{\text{returns on sales}} \qquad (5)$$

$$\text{Return on costs (RC)} = \frac{\text{profit (EAT)}}{\text{costs}} \qquad (6)$$

where: CF – cashflow, i – interest rate, il – Lower interest rate, ih- higher interest rate, NPVl – NPV at a lower interest rate, NPVh - NPV at a higher interest rate, EAT – profit after taxation, DCF – discounted cashflow, IN - investment

After evaluation and mutual assessment of the above mentioned indicators it is possible to pronounce a qualified conclusion about effectiveness of the investment project.

For the evaluation cost growth is simulated on base of determination of average growth rate of particular variables which enter in revenues and costs of operation of the biogas station. It is dealt with following variables:

- Price of input substrates
- Price of fuels
- Price of purchased electricity
- Price of heat
- Wage costs
- Price of other operational cost

The drop-out of co-generation unit by reason of execution of basic servicing (exchange of filters, oil, setting of the unit) is projected in calculations by decreased revenue for sale of electric energy. The services are carried out approximately after 30 thous. motohours. The particular calculations of the average growth are following. In saved heat the average yearly growth is set by 2.5 % (the average growth of analysed time series of heat price). The purchased electric energy increased on the average by 0.4 % (the calculation on base of time series of prices of electric energy). Wage costs increase yearly by 0.5 % (this growth is calculated from average wages in the selected enterprises. Costs for transport increases in dependence on growth of diesel fuel price which increases on the average by 0.7 % (the calculation is set on base of time series of petrol price from MPO statistics. The last cost is a price of output substrate. In this case, data of UZEI – cost plant survey were used for the calculation. The calculation is based on a share of particular inputs with a view to project increasing costs for growing into the calculation of net current value. In this cost the growth coefficient 2 % yearly was used for the enterprises.

## Results and discussion

The Czech Republic in approval of new biogas station follows a methodical direction of the Ministry of Environment. The main purpose of this methodical direction is to bind the appropriate authorities of the state administration in the area of environment to unified procedure in permitting and approval of biogas stations before putting in operation, and to optimize conditions of their operation from the environment point of view. The methodical direction is determined above all for official of the state administration and operators of stations for security of qualified approval process and for elimination of problems with placement of biogas stations (Švec, 2010).

At present, biogas stations processed mainly slurry and other agricultural products. Some operators of these stations grow purposefully crops suitable for processing into biogas, e.g. maize. Production of electricity generation is majority and a by-product is arising heat. In total 487 biogas stations was in operation on the territory of the Czech Republic to the 31st July 2013. The Agrarian Chamber of the CR states that the biggest number of BPSs is agricultural, 317, further BGSs within sewerage plant, their number is since 2008 the same 97, 55 BGSs on dumps, 11 industrial BPSs, and 7 communal. Building of new agricultural BPSs has growing trend in the monitored period.

From resources of the Czech Biogas Association it is possible to find out that the total electricity generation from biogas reaches 1 089 GWh for the year 2013. Agricultural biogas stations are classified in the Czech Republic into three groups according to installed power: up to 250 kW, up to 550 kW and more than 550 kW.

Biogas stations do not product only electricity and heat, but just also digestate which has a significant value as fertilizer for agricultural land. Use of digestate as an organic fertilizer has important role because thanks to this agricultural enterprises avoid use of mineral fertilizers (Lijo and at al., 2014).

Some authors point out a fact that big concentration of biogas stations together with a big amount of used digestate can lead to pollution of surface and underground water (Hermann, 2013).

### Characteristics of investment projects

Chosen agricultural enterprises realized a BGSs project on own parcels where the businesses operate their agricultural activity (plant and production). The production and subsequent sale of electric energy (eventually use of waste heat) can be understood as a new resource of incomes for a guaranteed purchase price for a lifetime of the project (20 years) from the start of operation. At the same time, realization of BGSs increases a share of renewable sources in the CR and also decreases consumption of primary (non-renewable) energy source, and thereby it also decrease exhalations connected with production of electric energy and heat. BGSs building invokes diversifications of activities within agricultural enterprises with a possibility of significant strengthening of economic potential of the agricultural enterprises.

**Enterprise A**

The enterprise A is situated in 435 m above sea level in Plzeň region. A BGS fermenter has a volume 3816 m3, uses units with the installed electric power 716 kW (heat power 823 kW) of mark TEDOM. The enterprise deals with both the plant and animal production with acreage of managed area 1987 ha.

**Enterprise B**

The Enterprise B is placed in 460 m above sea level in the South-Moravian region. It uses two fermenters with capacity 2500 m3 and defermenter with capacity 1400 m3. Further it uses co-generation unit (combined production of heat and power) with the installed electric power kW (heat power 789 kW) of mark JENBACHER. The enterprise deals with both the plant and animal production with acreage of managed area 2876 ha.

**Enterprise C**

The enterprise C is located in 605 meters above sea level in the South-Bohemian region. For fermentation process it uses a fermenter with capacity 4325 m3. A co-generation unit has an installed electric power 535 kW (heat power 568 kW) of mark DEUTZ AG. The enterprise in its activity deals with both the plant and animal production with acreage of managed area 2416 ha.

**Enterprise D**

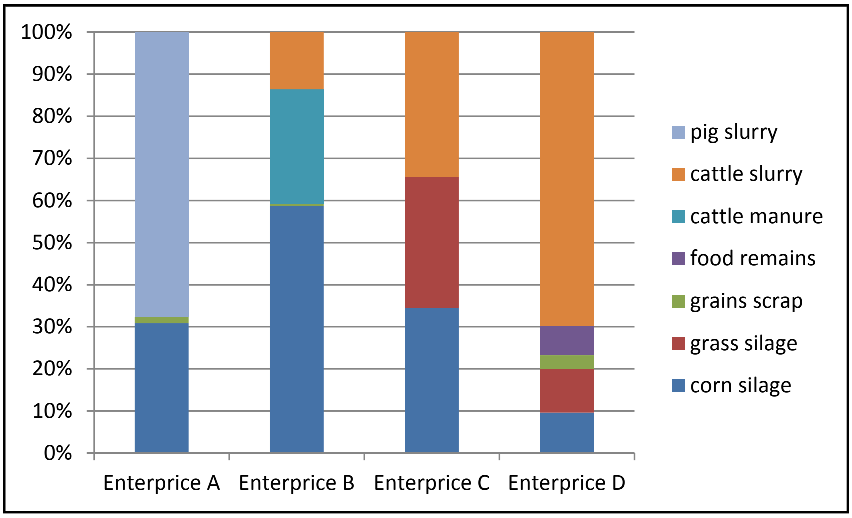
The enterprise D is situated in 465 meters above sea level in the region Hradec Králové. For the fermentation process it uses fermenters with capacity 2025 and 2285 m3. A co-generation unit has an installed electric power 549 kW (heat power 566 kW) of mark MAN Nutzfahrzeuge AG. The enterprise in its activity deals with both the plant and animal production with acreage of managed area 2219 ha.

### Security of input substrates

As already mentioned, all inputs in particular PGSs comes from their own production. Also the entire fermentation process and with that connected production of electric energy depend on composition of particular input substrates. Because BGS is a long-term investment, it is necessary to secure suitable input raw materials for all lifetime of the BGS. The following Graph 1 introduces for particular BGSs a proportion of input raw materials which are used within the fermentation process (values for 2012).

From the graph 1, differentness of used inputs in particular agricultural enterprises is obvious. From a view-point of division into animal and plant inputs in the enterprise A animal inputs prevails – the main input substrate is pig slurry (it creates more than 70 %) which is completed with silage maize. In the enterprise B the situation is opposite – the main input substrates are silage maize with a share exceeding 60 %. The enterprise C uses 2 plants and 1 animal input. Maize silage creates 34 %, grass haylage 32 %, and remaining 34 % is cattle slurry. The enterprise D uses in large quantity animal inputs – a dominant input is cattle slurry which represents 70 % of annual inputs, and further it is completed with silage maize, grass haylage, deeding remains and cereal meal.

Results of the research are in harmony




Source: Enterprises´ data processed by author

Graph 1: Structure of input substrates for particular enterprises (2012).

with conclusions of authors Mužík, Abrham (2013) who state that it shows that use of biomass is energetically effective just in those cases when biomass is energetically used where it rises (the best when a producer and user of biomass is one entrepreneurial person). In the papers evaluated agricultural biogas stations meet this requirement because all input raw materials come from the own production of enterprises.

Walla and Schneeberger (2006) state that use of green electric power from energy plants. Lucerne is on ecological farms the most efficient energy crop-plant. In the evaluated stations in the enterprises B and C raw materials of plant origin and in enterprises A and D the basic raw material are wastes from animal production and not purposefully grown energy plants.

## Financing of investments in particular enterprises

Particular evaluated enterprises used for financing of BGS investment subsidies from the Rural Development Programme of the CR. The maximal permissible amount of subsidy amounts to 40 % for purposefully expended costs connected with BGS building. The particular enterprises achieved following subsidies:

In the enterprise A subsidies for BGS create 25 % of investment cost value. The total investment in BGS in this enterprise was 86 600 thous. CZK. The amount of subsidy amounted to 21 992 thous. CZK. The enterprise used for financing own sources in amount 13 226 thous. CZK, the remaining financial part vas covered by a loan.

In the enterprise B the subsidies for BGS create 27 % of investment costs. The total investment in BGS was in amount 94 800 thous. CZK. The amount of subsidy was 25 500 thous. CZK. At the same time the enterprise used for financing its own sources in amount 4 300 thous. CZK, a remaining part of investment was covered by a loan.

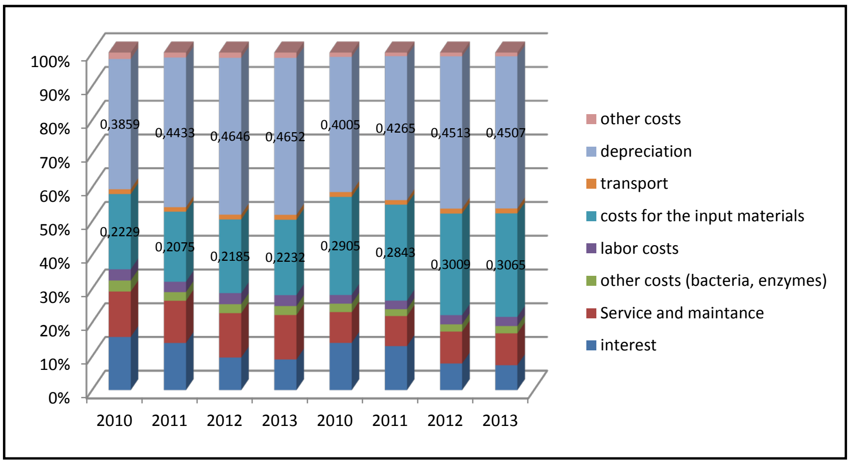
In the enterprise C, subsidies for BGS represented 28% of investment cost value. The total investment in BGS in this enterprise was in amount 59 970 thous. CZK. The allotted amount of subsidy for this enterprise was 17 000 thous. CZK. This investment was partly financed by own sources in amount 3500 thous. CZK and the remaining means were obtained by the enterprise in form of loan.

In the enterprise D the subsidies for BGS create 37 % of investment cost value. The total investment was in amount 76 993 thous. CZK. The amount of subsidy for this BGS amounted to 28 252 thous. CZK.

All costs and revenues connected with the operation of biogas station the plant register separately from management of the whole enterprise, therefore in calculations authors started above all from profit and loss statement of BGS. The monitored period is from 2010 to December 2013.

## Structure of project operating costs

In particular enterprises the structure of cost items does not differ significantly which is obvious in the following Graph 2.




Source: Enterprises´ data processed by author

Graph 2: Structure of operating costs in enterprises B, C (2010-2013).

A significant part of BGS financing is creating by a bank loan for which interests have to be paid. The interest item moves in the total cost structure in particular enterprises in a range 13 – 9 % in the first year of operation and gradually the share of this cost item decreases. The most significant part of costs is created by the own depreciations of BGS. Particular technological parts are, according to accounting, ranked in other depreciation groups. The building part of BGS is included in a depreciation group 4 with a depreciation time 20 years while technological system belong in a depreciation group 2 with a depreciation time 5 years (Mužík, Abrham, 2006).

From a view-point of biogas station, costs for the input material (substrate) in BGS are very important. Here in particular enterprises, there is a relatively wide range of share in the total costs. It very depends on a kind of input material (slurry x maize) and their representation in feeding rations in BGS. Shares of the cost item for input material moves in range 22 – 35 % of the total costs arisen in BGS.

A service creates 9 – 15 percents of total costs, particular service acts run approximately after 30 thous. hours of operation (change of oil, seal) and after 60 thous. hours of operation it is necessary to carry out a general engine repair (setting, change of basic components).

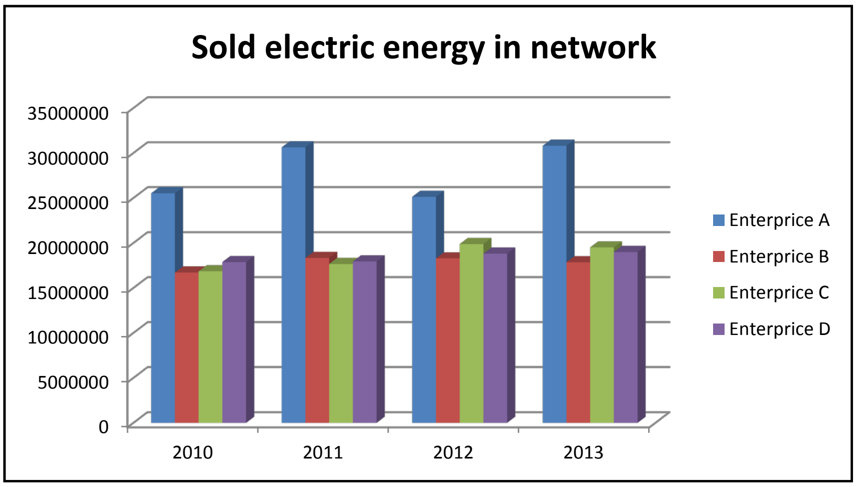
Remaining items of type of other costs, transport, labour costs create only a minimal part of the total costs.

### Revenues structure in project realization

The main part of revenues from BGS operation is represented by annual invoice payments for supplies of electric energy in a distributional electric system. The revenues can have a form of savings in its purchase from an external supplier (a form of green bonuses), or are realized by direct sale of these energies in the network (purchase price). A standardized operation of co-generation unit is 8100 h/year (Kazda, 2009). All analyzed enterprises use the green bonuses regime. Other possibility is a use of waste heat for use in neighbouring municipality, or own use within the enterprise. From BGS operation view-point, waste components arise in the fermentation process – digestate or fugate (in this case it depends on state) which can be further used as a fertilizer according to the Law No. 156/1998 Col., on fertilizers. Also the digestate has to be used according to the ordinance No.474/2000 Col., on fertilizers. And last but not least the Government Regulation No. 262/2012 Col., on determination of vulnerable areas and action programme. This regulation sets particular vulnerable areas according to cadastral territories, use of fertilizers in this area, storage of nitrogen substances in the vulnerable areas, change of grown crop-plants, farming on steep agricultural land and so on.

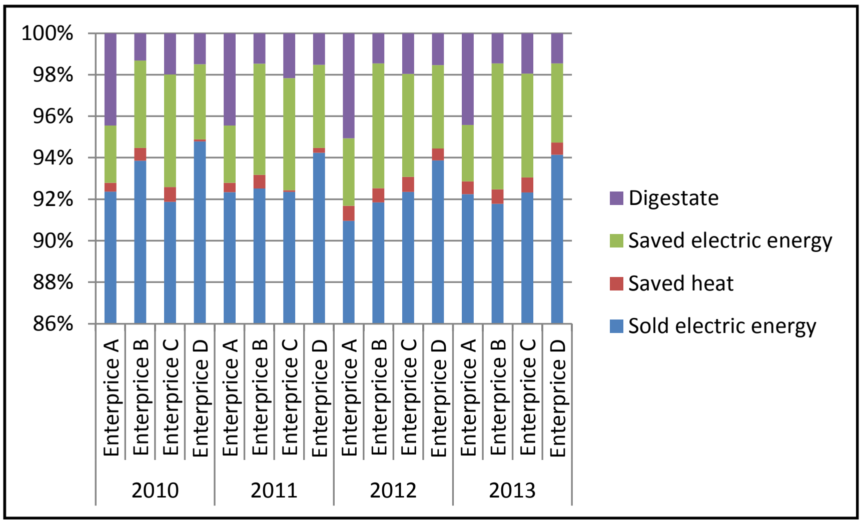
The following Graph 3 shows amount of revenues only for sold electric energy in the network in particular enterprises in the period 2010 – 2013 on base of underlying data from BGSs.

As already mentioned, the sale of electric energy is the main of BGS incomes. Other possibility is in case of the green bonus saving for purchase of electric energy, use of waste heat, eventually use of sale of digestate as a fertilizer. In the following Graph 4, a structure of all BGS revenues is introduced.




Source: Enterprises´ data processed by author

Graph 3: Sold electric energy in network (CZK, 2010 – 2013).




Source: Enterprises´ data processed by author

Graph 4: Revenues structure of BGSs (2010-2013).

From the revenue structure view-point, in all enterprises it is obvious that revenues for sale of electric energy in the network create 91 – 85 % of BGS revenues. In the enterprise A a significant part is represented by revenues from digestate (use as a fertilizer) in a range 4 – 4.5 % of BGS revenues. The saved electric energy (by use of electric energy from the own BGS) creates 3 – 6 % of revenues of the enterprises. The use of heat in these enterprises shares in the total BGS revenues only in 0.3 – 0.4 %. Just the use of waste heat from BGS is a very significant attribute for efficient use of the total BGS potential.

### Evaluation of effectiveness of biogas stations (NVP, IRR)

In calculation of NVP, two variants are introduced; the first counts on receiving of subsidy after one year of operation on base of real values (Table 1), and the second variant shows NVP in case of failure of subsidy (Table 2). This paper counts on a discount rate 5.6 %.

A prediction of financial flows is compiled on base of presumptions mentioned in the chapter Materials and methods.

| Variant 1 | NVP | IRR |
|---|---|---|
| Enterprise A | 57 179 052 | 14.094% |
| Enterprise B | 27 045 787 | 11.392% |
| Enterprise C | 53 471 239 | 16.650% |
| Enterprise D | 33 235 266 | 11.554% |

Source: author

Table 1: NVP and IRR for selected BGSs with receiving of investment subsidy.

| Variant 1 | NVP | IRR |
|---|---|---|
| Enterprise A | 36 754 811 | 10.473% |
| Enterprise B | 4 743 073 | 6.438% |
| Enterprise C | 38 759 601 | 12.616% |
| Enterprise D | 4 983 568 | 6.749% |

Source: author

Table 2: NVP and IRR for selected BGSs without receiving of investment subsidy

The net present value (NPV) for the selected BGSs in all cases resulted positive, even i case of failure of subsidy. In the lifetime 20 years the internal rate of return (IRR) moves for the first variant in a range 11 – 16 % (it is dealt with a variant when the subsidy for BGS of the enterprise is paid off after one year of operation). The second variant is failure of subsidy for BGS; in this case results of NVP and IRR considerably decreased (NPV is in range 6 – 12 %). The payback period (PP) is in the first variant for the particular enterprises following:

The enterprise A has the payback period 7.2 years in the variant 1 (with subsidy), the enterprise B 9.8 years, the enterprise C 6.5 years and the last enterprise D 9.6 years. According to Mužík and Abrham (2006) the payback period in these investments up to 10 years with recognized subsidy acceptable. The PP up to 5 years is than very good. Gebrezgabher et al. (2010) deals with economic analysis of biogas stations in the Netherlands. By the help of linear programming they simulated scenarios influencing the amount of net present value and the internal rate of return in dependence on chosen input substrates, amount of electric energy, digestate, and waste heat. In this case the internal rate of return reached a value approximating 20 %.

### Profitability indicators of BGS

The rate of cost profitability was calculated according to methodology of cost and return calculation of biogas stations in agricultural enterprises (Poláčková, 2013).

Manganelli (2013) in its study draws attention to economic advantages from use of biogas co-generation power station fuelled by biogas from wastes in cattle breeding and other waste materials arising from the same production chain in the area of Campania (Italy) with an intensive animal production. Economic results analyzed in the paper in biogas stations in the enterprises A and D confirmed in accord with the author suitability of biogas production from wastes

| Enterprise A | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|
| Rate of cost profitability | 32.45% | 23.57% | 9.12% | 28.06% |
| Return on sales | 23.17% | 18.26% | 8.20% | 20.84% |
| Cost on sales | 71.40% | 77.46% | 89.88% | 74.27% |
| Return on costs | 40.06% | 29.10% | 11.26% | 34.64% |
| Enterprise B | 2010 | 2011 | 2012 | 2013 |
| Rate of cost profitability | 30.72% | 20.42% | 26.78% | 24.37% |
| Return on sales | 22.27% | 16.31% | 20.13% | 18.74% |
| Cost on sales | 72.50% | 79.87% | 75.15% | 76.87% |
| Return on costs | 37.93% | 25.21% | 33.07% | 30.09% |
| Enterprise C | 2010 | 2011 | 2012 | 2013 |
| Rate of cost profitability | 47.12% | 22.70% | 41.30% | 39.37% |
| Return on sales | 29.79% | 17.73% | 27.35% | 26.49% |
| Cost on sales | 63.22% | 78.11% | 66.23% | 67.29% |
| Return on costs | 58.17% | 28.03% | 50.98% | 48.60% |
| Enterprise D | 2010 | 2011 | 2012 | 2013 |
| Rate of cost profitability | 45.41% | 33.07% | 33.75% | 65.05% |
| Return on sales | 28.97% | 23.67% | 25.14% | 36.33% |
| Cost on sales | 71.03% | 77.14% | 80.38% | 64.36% |
| Return on costs | 40.78% | 30.69% | 31.27% | 56.44% |

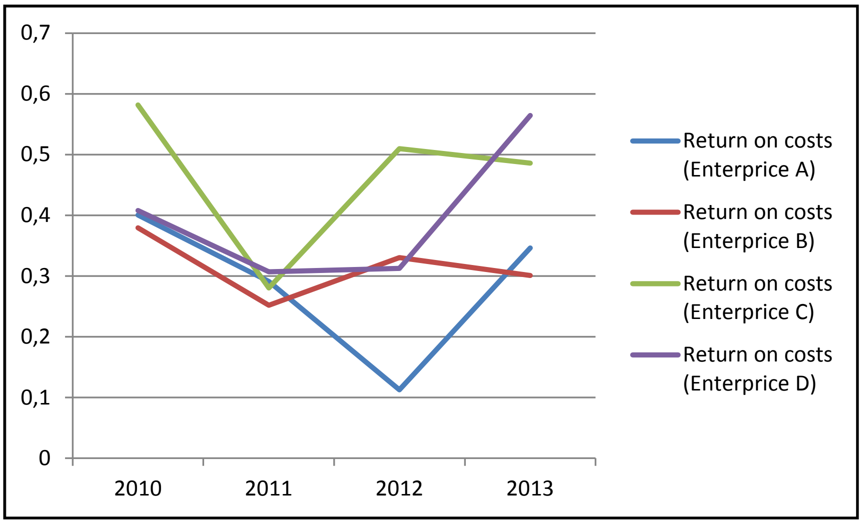
Source: Enterprises´ data processed by author

Table 3: Results of evaluated indicators (2010-2013).

in animal production. The first evaluated indicator is the return on costs (see the Graph 5). These indicators express how many hellers of profit falls on 1 CZK of costs. From the graph swings are obvious in particular enterprises. The steadiest BGS from this indicator viewpoint is BGS of the enterprise B where the return on costs moves in a range 28 – 39 %).

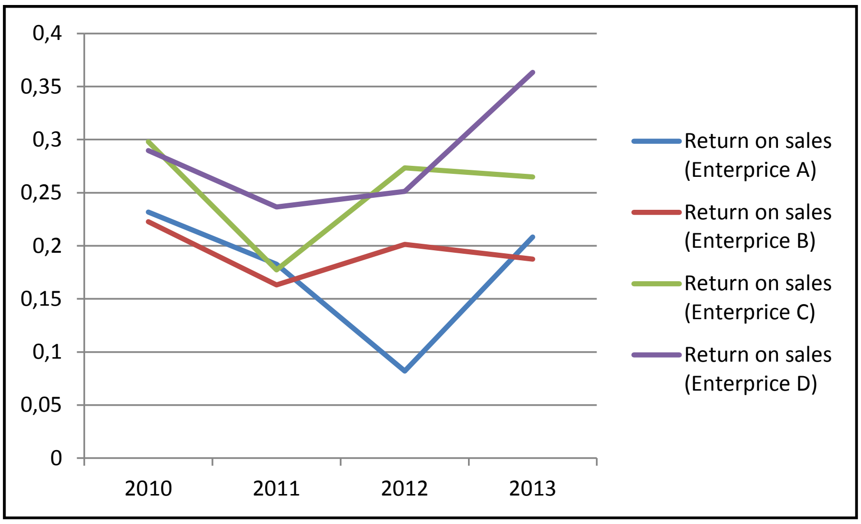
Other significant indicator of business effectiveness is return on sales (see the graph 6) which can be marked also as profit margin. For calculation of return on sales, the net profit of BGS is given in relation with the value of revenues for associated production (electric energy, heat, digestate). In the monitored period, this indicator moves in a range 8 – 35 %. A fall in 2012 in the enterprise A was caused by a drop out of a co-generation unit by reason of repairing which projected in the amount of revenues for sold electric energy. In the enterprise B and C, the development of revenues on sale is relatively steady moving in a range 20 – 28 % (20 – 28 hellers fall on 1 CZK of revenues).

The rate cost profitability moves in particular BGS moves in range 10 – 65 % in the monitored period. In 2010 – 2011, the values are relatively steady without significant swings in particular BGSs. After 2012, these indicators significantly increased




Source: Enterprises´ data processed by author

Graph 5: Development of return on costs indicators for particular enterprises (2010-2013, in %).




Source: Enterprises´ data processed by author

Graph 6: Development of cost on sales indicators for particular (2010-2013, in %).

in the enterprises A and D. This jump increment can be explained by that consumption of input raw materials slightly decreased (enterprises started to use enzymes for better fermentation and they also started to use more waste heat).

Authors Hrůza and Stober (2009) state that agricultural biogas station can bring many effects in the economic system of agricultural enterprise, however, it depends mainly on good communication between the investor and the designing firm.

In the paper analyzed results of evaluated biogas stations in a longer time period confirm the mention presumption on base of wider and longer-range investigation than in one investment project which most authors evaluates in their studies.

## Conclusion

A result of the realized investment project is a building and operation of biogas stations in agricultural enterprises where input raw materials are above all maize silage, grass silage, and cattle slurry. The necessary components come from own production of the enterprise. The operation of biogas station contributes to the agricultural enterprise to a stabilization of economic situation by securing a regular and at the same time guaranteed source of incomes.

Revenues on BGS operation in the analyzed enterprises shares in the total revenues on operation activity in a range 27 – 17 % and creates a significant part of operating revenues the enterprise. At the same time a biogas station represents a financial pillow in case of a more significant volatility of product prices of animal and plant production on the market, or in case of bad revenues. Purchase prices of electric energy are guaranteed for the whole lifetime of the project and create an income certainty for agricultural enterprises. The annual operating characteristic is from a view-point of supplied power steady. In a trouble-free operation it is affected only by regular short-term service shut-downs of the co-generation unit (a change of filters, oil, spark plugs and so on). A more significant fluctuation of power or long-term shut-downs are than often caused by breach of operation regulations, especially dosage, composition and quality of input substrate.

Investment into biogas stations supports diversification of activities towards non-agricultural activities – a sale of electric energy, use of waste heat, increase in hygiene of animal bedding, and remains-less processing of feeds. At the same time the BGS operation satisfies also tight conditions regarding the environment.

The realization of biogas stations in the area of agriculture has large preferences for enterprises from both the viewpoint of use of own input raw materials of plant production, and the processing of wastes from the animal production. Also such waste raw materials from biogas stations as digestate can be used in agricultural operation. The enterprise separates the arisen waste to fugate, which is further used for reutilization in the plant production, and a separate which serves for bedding of dairy cows. The fugate is a resource of nutrients of organic origin for the plant production.

The revenues structure in particular BGSs shows that over 92 % of revenues create sale of electric energy in the network. Other revenues on BGS operation arise by use of waste heat (in this case the analyzed enterprises have considerable reserves in use possibilities), or digestate as a fertilizer.

For investment evaluation, dynamic indicators of investment evaluation were used – the net present value and the internal rate of return. On base of results in particular enterprises with BPS we can state that investments are acceptable for the enterprises (ceteris paribus). In all evaluated BGSs the net present value was positive, even in case without receiving subsidy for BGS building. The internal rate of return moves in the first variant (variant with subsidy) in a range 11 – 16 %. According to the payback period indicator, all evaluated BGSs got below 10 years (according to Mužík and Abrham (2006) it is dealt with acceptable values).

At present, biogas stations are already an integral part of entrepreneurial activity of a large number of agricultural enterprises. The input substrate can be products both of the animal and the plant production (ideally a combination). Considering that it is necessary to think about the future permission of these operations regarding the character of activity – to permit for processing of complementary activities (processing of manure, slurry and so on.). Regarding the animal production a biogas station represents a certain rate of competition (decision-making whether to use crop-plants as an input substrate in the biogas station or as feeding for animals).

On base of the analysis of operation and results in the paper evaluated biogas stations it is unambiguously proved that agricultural biogas stations represent permanent and certain source of financial means for agricultural enterprises, which operate them, and contribute in this way to the financial stability of these enterprises. This results is confirmed also by other studies from other countries, e.g. Gregersen (2002), Mittal (1997) when a positive influence of biogas stations in light of characteristics of decentralized energy source, a better use of wastes, redistribution of nutrients was proved and they significantly partake in solution of problem in the environment area.

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