International Scientific Conference *People, Buildings and Environment 2014* (PBE2014)
15-17 October, 2014, Kroměříž, Czech Republic, www.fce.vutbr.cz/ekr/PBE

ECONOMIC ANALYSIS OF THE GREYWATER TREATMENT PROJECT

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Abstract

The goal of this paper and the purpose of the research is the proposal of an approach for the economic evaluation of projects of realization and operation of technologies for treatment of greywater. The paper follows the scientific problem solving possibility of using greywater as possible alternative to the use of drinking water. In the frame of the scientific problem the assessment and demonstration of the economic efficiency of the installation and operation of wastewater treatment technologies for the greywater re-usability is solved. The paper includes an analysis of the present state of the greywater issue and economic evaluation of investment projects. Methodology for assessing of the economic efficiency of the project of the greywater treatment based on the analysis of the present state is proposed. It has been tested on a case study and subsequently used for the determination of the prices of water, whether the project of realization of the greywater treatment technology is efficient from the economic point of view. The paper also provides an indicative list of areas in the Czech Republic where this kind of project would be efficient to be carried out. The effectiveness of the project is based on the theory of the time value of money and is determined using the discounted payback period and net present value. The discussion consists in determination of the critical price of water from public water supply system as a critical variable for the greywater treatment technology assessment.

Key words

Economic efficiency; greywater treatment; greywater re-usability; price of water

To cite this paper: *Vítková, E., Hromádka, V., Raclavský, J. (2014). Economic analysis of the greywater treatment project, In conference proceedings of People, Buildings and Environment 2014, an international scientific conference, Kroměříž, Czech Republic, pp. 478-484, ISSN: 1805-6784.*

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1 INTRODUCTION

The need of water is still increasing not only in developed countries and the requirements for the possibility of its recycling and its reuse are still more frequent. One of possible approaches is the use of greywater. This paper solves mainly an economic part of the greywater treatment. Basic indexes of the economic efficiency assessment are primarily monitored. In the first part of the paper the present state analysis in the area of technical part of greywater treatment is introduced and theoretical background for economic analysis of project including greywater treatment projects is defined. Next part is focused on the assessment of the methodological approach to the economic valuation of the greywater treatment project, which is consequently verified on the case study. In the end of the paper discussion and conclusion are carried out.

2 LITERATURE REVIEW

The subject of the paper is the proposal of the approach for the economic evaluation of projects of realization of technologies for the greywater treatment. Within the analysis of the present state the technical part of solved issue has been evaluated and suitable methods for the economic evaluation have been summarized.

2.1 Greywater treatment technology

The use of greywater in buildings is not a new concept, but a means for environmental water management. A greywater system collects greywater even before it flows into a sewer, septic tank or wastewater treatment plant. Greywater, i.e. water from showers, washing machines and washbasins is not usually extremely polluted. It requires a basic purification processes, such as degreasing, filtration, sedimentation, sanitation and disinfection. Water thus treated may be used as service water for toilet flushing and the irrigation of gardens or green areas. Greywater from households accounts for up to 35% of total water consumption. Relatively clean greywater is produced in large volumes in buildings such as hotels, schools, restaurants, hostels and other public facilities [1], [2].

Rainwater may also be reused, and can be collected from impervious surfaces, especially roofs. The treatment of rain water consists of basic purification processes such as sedimentation, filtration and sanitation. Rainwater usually contains fewer pollutants than greywater. However, a rainwater system is strongly dependent on rainfall, climatic conditions and storage tank size. For the above reasons, rainwater and greywater should be used in a combined system [3].

Greywater is slightly polluted wastewater as described above. Under certain conditions, it may be used again as service water. The treatment technology and the equipment configuration selected for its processing are fundamentally different depending on the amount of water to be dealt with, which is affected by the size of the population using the greywater treatment unit.

Greywater treatment is processed using the following technologies: coarse filtration, micro-filtration, activation (biological-mechanical purification), sedimentation, and UV radiation.

Aerobic greywater treatment technology is suitable for water from showers, hand washing and the washing of clothes [4].

The finalization of water treatment may be carried out using UV radiation; this is an alternative greywater treatment. Purified water is accumulated in a tank. Greywater must be stored in such a way so as to prevent the growth of microorganisms. The best placement option for a greywater tank is in the ground, as the temperature is low and there is little light, or in a basement location.

2.2 Economic evaluation

Basic objective of the economic evaluation is the assessment of the efficiency of resources inserted into the realization of the investment project. But economic evaluation is not connected only with the realization alone. Impacts of operational or liquidation phase is very important as well and should be included in the economic evaluation. For this reason indexes respecting the whole life time of the project including economic impacts connected to particular years are used for the economic evaluation of investment projects. Basic criterion for the economic efficiency of investment projects evaluation is the Net Present Value (NPV). This index is based on the principle of comparison of positive and negative cash-flows of the project arising from investment, operational and liquidation phase (investment costs, operational incomes and operational expenditures). In the comparison of cash flows their time value by discounting with usage of correctly selected discount rates is taken into account. The result of the analysis is the net present value expressing the total benefit of the project for the whole life time of the project. Next suitable criterion is the Internal Rate of Return (IRR). Index IRR is based on the principle of NPV, in fact it is defined as a discount rate, while the Net Present Value of the project is zero. In practice it is possible to characterize it as an average annual profitability of the project. In addition the payback period (or discounted payback period) can be used as a very popular and illustrative criterion. This criterion provides information about the number of years, during which the net cash-flows (or discounted net cash-flows) will cover investment costs. Net cash flows are assessed as a difference between positive and negative cash-flows. In detail the issue of the economic efficiency of investment projects is solved by [5] Czech authors e. g. Fotr and Souček [6] or Máče [7]. Issue of the greywater projects and their economic efficiency is discussed also in publications of Memon [8] and Chen [9].

3 ECONOMIC EVALUATION

Evaluation of the economic efficiency is carried out on the case study of delivery of technology for the greywater treatment in the hospital in Jihlava. In the first part of the chapter the methodology of the economic analysis elaboration is identified, in the second one the economic evaluation and discussed results are carried out.

3.1 Analysis methodology

The methodology of the project of the greywater treatment analysis is based on the cash-flow analysis. For the needs of the analysis of the cash-flows it is necessary to define necessary input data. Basic input information is the duration of the evaluated time period. In this case the duration of the evaluated period is based on the expected technical lifetime of the fixed property. Next input information is the investment cost. The investment cost arises in the frame of the realization phase of the project in relation to the acquisition of the fixed property. Within the solved projects it concerns mainly with the acquisition of the sewer and water mains and the technology specified in chapter 2.1. Necessary inputs for the economic analysis are next cash-flows in the operational phase of the projects in the form of incomes and expenditures. Expenditures are connected mainly to the operational costs of the technology and repayments of the annuity connected with the bank credit, if it is needed. Operational costs of the technology include mainly electrical power for the operation of the technology, the replacement of the UV lamp and purchase of chemicals and activated sludge. The repayment of the annuity includes partial repayment of the credit and appropriate interest based on the interest rate agreed with the bank. Incomes of the project are in the solved case understood as savings of water from the water mains and tax savings. Water savings are set according to the information about the daily capacity of evaluated technology and the price of water, which can be different according to the supplier. The tax saving is based on the assumption that costs connected to operational phase of the project are tax acceptable and they decrease the tax base of the investor. The saving, the benefit and positive cash-flow are decreasing the income tax of the investor. Mentioned costs are mainly operational costs of technology, depreciation of fixed property and interest on the bank credit.

In the next step the calculation of net cash flows and the difference between positive and negative cash-flows are carried out. Those cash-flows are next discounted with usage of appropriate discount rate. The discount rate expresses the minimal required profitability of the investment from the point of view of the investor, when the lower limit is defined as a profitability of the "risk-free" investment. The upper border is not limited and depends on expectations and requirements of the investor from the evaluation of invested capital. The sum of discounted cash-flows then defines the final net present value of the project. Using assessed cash-flows it is possible to calculate also next criteria for the economic efficiency evaluation: the internal rate of return, the profitability index and the simple or discounted payback period.

3.2 Economic analysis – case study

In accordance with the methodology presented in the previous chapter the economic evaluation of the monitored project is carried out in several steps. The first step is the assessment of investment costs. Investment costs are in this case calculated as costs for the acquisition of the fixed property in the form of the technology for the greywater treatment and distribution of water supply and sewerage for the connection of the technology. Overview of expected investment costs is displayed in Table 1.

Tab. 1: Investment costs (Source: own elaboration)

Item	**IC in CZK**
Distribution	744,167
Technology	975,625
Total	**1,719,792**

For the processing of the economic analysis it is necessary to assess costs connected with the operational phase of the project. Costs for the operational phase are determined in chapter 3.1. Their values are displayed in the Table 2.

Tab. 2: Costs of the operational phase, the tax saving (values in CZK) (Source: own elaboration)

Year	**1**	**2**	**3 ... 8**	**9**	**10**
Operational costs of technology	196,017	201,224		241,761	248,183
Depreciation - tubing	40,929	78,138		78,138	78,138
Depreciation - technology	20,976	50,245		50,245	50,245
Interest	51,594	47,679		12,852	6,613
Total Costs	309,516	377,286		382,995	383,179
Tax saving	**58,808**	**71,684**		**72,769**	**72,804**

The key input for the economic analysis is the price of drinking water in the region and its expected future development within the evaluated period of the project. From Table 3 the development of prices of drinking water in the Brno region for last 12 years can bee seen.

Tab. 3: Development of prices of drinking water in the Brno region (values in CZK/m3) (Source: The portal dedicated to water Czech Republic (2014) [10])

Year	Total including VAT	Total without VAT	Water including VAT	Water without VAT	Sewage including VAT	Sewage without VAT
2003	44.68	42.55	20.90	19.90	23.78	22.65
2004	46.91	44.68	21.88	20.84	25.03	23.84
2005	48.79	46,47	22.77	21.69	26.02	24.78
2006	49.98	47.60	23.32	22.21	26.66	25.39
2007	49.98	47.60	23.32	22.21	26.66	25.39
2008	53.97	49.51	25.18	23.10	28.79	26.41
2009	56.68	52.00	26.45	24.27	30.23	27.73
2010	57.20	52.00	26.70	24.27	30.50	27.73
2011	60.17	54.70	28.06	25.51	32.11	29.19
2012	64.30	56.40	29.99	26.31	34.31	30.10
2013	67.61	59.31	31.40	27.54	36.21	31.76
2014	70.94	62.23	33.73	29.59	37.21	32.64

Based on average increase in prices, which has been 3.2% annually since 2003, the prediction of the prices of water development for the evaluation period of the project was assessed using the linear regression. The price of water is the basic input for the saving assessment for saved water, which is calculated as a multiplication of the water unit price and amount of greywater used instead of water from water supply. The saving for saved water together with tax savings create total benefits of the project. The principle of the tax saving calculation is dealt with in chapter 3.1 and amount of the tax saving is presented in Table 2. Total expected benefits of the project including addition of savings of water and tax savings during valuated period are presented in Table 4.

Tab. 4: Benefits of the project (values in CZK) (Source: own elaboration)

Year	1	2	3 ... 8	9	10
Savings for water	281,228	290,173		361,279	372,770
Tax savings	58,808	71,684		72,769	72,804
Total benefits	340,037	361,859		434,057	445,584

Regarding the fact that in financing of the project it is calculated with the usage of the bank credit in amount of 50% of investment costs, Table 5 contains the simplified overview of payments and interest. The duration of the payback period is considered the whole evaluated period.

Tab. 5: Financing with the bank credit (values in CZK) (Source: own elaboration)

	1	2	3 ... 8	9	10
Balance at the beginning of the year	859,896	794,657		214,200	110,219
Annuity	116,832	116,832		116,832	116,832
Interest	51,594	47,679		12,852	6,613
Repayment of credit	65,239	69,153		103,980	110,219

All values from previous table serve as inputs in the economic analysis of the project. Economic analysis of the project includes the cash-flow analysis respecting the time value of money. The overview of discounted cash-flows is displayed in Table 6.

Tab. 6: Discounted cash-flows of the project (values in CZK) (Source: own elaboration)

	0	1	2 ... 8	9	10
Investment costs (-)	1,719,792				
Bank credit (+)	859,896				
Benefits (+)					
- savings for saved water (+)		281,228		361,279	372,770
- tax saving (+)		58,808		72,769	72,804
Operational costs (-)					
- operational costs for tech. (-)		196,017		241,761	248,183
- annuity (in the case of credit) (-)		116,832		116,832	116,832
Net cash-flows (NCF)	-859,896	27,187		75,455	80,558
Discount factor	1.0000	0.9524		0.6446	0.6139
Discounted NCF (DNCF)	-859,896	25,892		48,639	49,456
Cumulated DNCF	-859,896	-834,004		-477,082	-427,627

Basic indexes for the economic efficiency of the specific project evaluation are the Net Present Value and Internal Rate of Return. Their values were calculated based on data from Table 6 and are displayed bellow.

Net Present Value NPV = - 427,627 CZK

Internal Rate of Return IRR = - 6%

It is evident that when taking into account the prices of water in Brno region and their prediction for the evaluated period the project is not efficient. The project becomes efficient from the economic aspect in case, when prices of water exceed the border 73 CZK/m3 without VAT for the whole evaluated period.

4 CONCLUSION AND DISCUSSION

Up to now there has not been any economic pressure to use water other than that from public distribution systems or wells in the Czech Republic. In recent years the abundance of resources has, in fact, been sufficient. It is possible to expect that water and sewage rates will continue to increase to facilitate the smooth replacement and reconstruction of largely outdated utilities. This increase will create conditions for a return on investments into grey and rainwater use. For these reasons, TAČR project No. TA01020311, titled "The Use of Grey and Rain Water in Buildings", which deals comprehensively with the above-mentioned issues, has been submitted and accepted.

This paper deals with the economic efficiency of the greywater treatment projects and provides the proposal of the methodological approach to its assessment. The main indexes of economic efficiency assessment are net present value, internal rate of return and payback period. Their calculation depends on different variables, such as investment and operation costs, expected benefits and conditions connected with financing. But the key variable is the price of water from public distribution system. In the case study the price of water in Brno region, which is quite low, was considered. In this case the project is not efficient enough. Anyway from the logic of the economic efficiency assessment it is evident that the higher the price of water, the higher efficiency it is possible to expect. So the economic efficiency depends on the region, where the project is carried out. In fact in the Czech Republic the prices differ according to the region and even nowadays there are regions, where this project could be efficient.

ACKNOWLEDGEMENT

This paper has been written with the support of The Ministry of Education, Youth and Sports Programme COST CZ project LD14113 Effectiveness of Megaproject in the Czech Republic.

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