Feasibility basis for use of new solid household waste processing equipment

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Abstract. Economic efficiency assessment of innovative organizational project of solid household waste processing enterprise (SHW) is given. A distinctive feature of this project is new mining and chemical technology use of waste depolymerization. The proved feature is fuel-resource production in portion modules of tubular type. They are patented and approved under laboratory conditions. The main ways of SHW processing in the world including Russia are described. Advantages and disadvantages are revealed. Comparative analysis is carried out. Technology prioritization is a result of this analysis. During organization of such enterprise, it was proved that not only SHW processing is a result of its functioning. The other result is environmentally friendly production using secondary raw materials. These products can be sold and can have bring income. Main investment and current expenses necessary for the offered project implementation are defined. This allows making economic assessment of innovative enterprise efficiency.

1. Introduction

Problem statement. Nowadays solid household waste utilization is an up-to-date problem on a global scale. This problem is especially up-to-date for cities and towns. According to the UN, more than a half of world population is city dwellers: in the middle of 2016, their number was 4 billion people (54,5% of the total number of population). In Russia this indicator exceeds 72%. Both in the Central Federal District and in Northwest this indicator is 90%. In European countries this indicator is about 70% respectively and by 2030 can reach 80% [1]. According to the UN SHW, the amount on average per one inhabitant is: in megalopolis – up to 500 kg per year, in towns – from 150 to 200 kg per year. In Europe the situation is the same. In the USA, it is by 200 kilograms higher. In Russia, according to the Federal Service for Surveillance on Consumer Rights Protection and Human Wellbeing SHW, the average volume is up to 70 million tons (both for population and for enterprises). That is about 500 kilograms of garbage per person.

Sweden, Germany, Belgium, Switzerland have great success in waste processing by using the legislative base and active educational work. But it should be noted that in these countries not all SHW can be processed. In the largest industrialized countries waste products are still buried on dumps and disposal sites. Only an insignificant share of waste is processed. On average it is no more than 25%, although in these countries there is an access to modern ecotechnologies. In general in the world, garbage is taken out on disposal sites and dumps.

In spite of the fact that human economic activity cannot be realized without waste products, it is necessary to use modern knowledge and technologies to eliminate them. And also it is necessary to use advanced achievements of science and technology to minimize harm from waste by reusing

waste products. It should be noted that searches of measures for fight against anthropogenous pollution of the environment were started in the middle of the last century. And a search for new approaches to solid household waste utilization is an up-to-date problem. Disposal sites content is also valuable secondary raw material for demanded production. It is an alternative source of heat and electric power.

One of SHW processing ways is described in this article. Efficiency assessment of innovative project about organization of solid household waste processing enterprise is carried out. This waste processing is carried out in portion modules of tubular type in Kursk region.

Studies and publications analysis. It should be noted what there are a lot of studies about an effective SHW management. Studies by C. Schulz and C. Bailey [1], Hornsby C., Ripa M., Vassillo C., Ulgiati S. [2], by Pan S.-Y., Chiang A., Chang E.-E., Lin Y.-P., Kim H., Chiang P.-C. [3]; monographies by P.R. O'Leary, P.W. Walsh, «Decision Maker's Guide to Solid Waste Management» [4], by G.A. Davis, C.A. Wilt, «Extended Product Responsibility: A New Principle for Product-Oriented Pollution Prevention» [5] etc. In modern Russia there are studies about this problem. They are undertaken by I. Androsova [6], E. Leontyev [7], Y. Polozhentseva [8], V. Plotnikov [9], Y. Vertakova [10], S. Emelianov [11] etc. However, despite scientific importance, their attention is paid generally to technical and technological aspects. At the same time, questions of economic efficiency of innovative projects about organization of solid household waste processing enterprises (SHW) are not studied a lot.

The purpose of this article is to describe ways of economic efficiency assessment of an innovative project of SHW processing with the use of new mining and chemical technology use of waste depolymerization.

2. Materials and methods

Theoretical and empirical methods are used in the research, in particular: literature review, retrospective, logical and system analysis, graph-analytical methods of visualizing the results of system analysis. Economic efficiency calculations is performed by the methodology for UNIDO (United Nations Industrial Development Organization) [13].

The considered innovative method of resource reproduction of hydrocarbons through processes of depolymerization of solid waste has patented protection (patent ru 2496587, patent ru 2613507).

3. Research Methodology

Main waste processing ways and methods are [10]:

- Dump or disposal sites (the most widespread way). At the same time waste sorting (valuable components and fraction extraction for recycling) and earth filling can also be done. Main advantages are general waste features for utilization; low expenses; possibility of further recultivation. Disadvantages are environmental pollution; big land area; lack of free sites for new dumps formation; garbage transportation costs; disposal sites cannot be used for other purposes; further recultivation; this way does not comply with the "State policy bases in the field of ecological development of the Russian Federation till 2030".
- Natural methods of SHW decomposition: composting (biothermal aerobic fermentation (with fertilizers, biofuel, fuel receiving, etc.); anaerobic fermentation (with biogas receiving). Advantages are SHW sorting and processing; new product production, return to natural biogeochemical organic circulation; restoration and support of earth balance; dumps resetting; reduction of environmental pollution; improvement of economic indices in housing. Disadvantages are implementation and service investment and current costs; waste sorting and preparation; smell from fermentation; regular airing and waste shoveling; a possibility of harmful substances distribution in case of inadequate SHW preparation and sorting (for example, existence of heavy metals (batteries and power cells).
- Thermal SHW processing: 1) burning. Advantages are its popularity and practical approval; quite widespread equipment with a high level of automation is used; waste remains production or their further processing, which do not have negative influence on ecology; energy production, which can be

used further for economic purposes and can replace other natural energy suppliers. This advantage promotes preservation of limited natural resources (oil, gas, etc.); 2) low-temperature pyrolysis (SHW process "liquefaction" and gasification under which drying and dry distillation take place (pyrolysis), gasification and burning of carbon residue with gaseous products allocation. Disadvantages are considerable preparatory work; used equipment is subjected to frequent breakages and failure; technology is not economically and energetically effective now in comparison with other thermal processing methods; 3) high-temperature pyrolysis (plasma processing) at which temperature is higher than the slag melting temperature that allows one to make harmless vitrified products and useful energy. As well as burning, this technique is economically effective for different SHW without their preliminary preparation, i.e. drying, sorting and etc. The other advantage is rather a small size which allows creating mobile technological modules. The main disadvantage is considerable electric power expense.

It should be noted that in 2003, the waste disposal method on dumps or on disposal sites was widespread in the world, except Sweden and Switzerland (where the 2nd and 3rd waste processing ways were popular). In recent years the world situation changes: countries try to avoid waste disposal in favor of thermal processing and composting.

In Russia, according to statistical data, SHW processing market can be characterized as follows [9]: annually 15-20 million t of organic waste products are put on deposit sites and dumps. This is 30-40% of the total amount of organic fertilizers used by agriculture in Russia (53 million t.). In Russia, the annual volume of paper and cardboard waste (about 15 million t) three times exceeds produced cellulose (6 million t). And during burial, about 11,3 million t are lost forever that is equal to paper and a cardboard production in Finland. It is the main exporter of this type of goods in the EU; the annual volume of glass waste (3,1 million t) is almost equal to glassware produced in Germany; according to the latest data, required investment into secondary processing development in Russia is 44 billion euros. Therefore it is possible to reach processing of 38-40% of the total amount; in 2015 investment obligations of concessionaires has grown ten times; the growth is predicted in 2016.

In Russia in 2017, SHW processing has been estimated by experts and it is 14 million tons. There is no more than 10% of SHW from which 3% are burned and other 7% are industrially processed. It would be theoretically possible to use 77% of the SHW total amount as raw materials for industry (37%) or for composting (40%). But it could be carried out under separate waste collecting. But as in Russia collecting is carried out without sorting, it is impossible to take this volume. Sorting of transported SHW in the mixed container allows one to receive no more than 11-15% of secondary resources. In this case, biodegradable (organic) waste cannot be used.

In general, it is necessary to note that in Russia not enough attention is paid to this problem. And waste processing industry is still extremely poorly demanded by Russian business. However, it is potentially successful. Calculations for creation of innovative project are done by the example of Kursk region, where, as well as in the world, the first way is mainly used. This can have negative impact on an ecological situation. The comparative analysis of SHW processing options (tab. 1) is carried out. According to this table, the option, offered by the authors is more favorable in comparison with other ways of SHW processing.

4. Results and Discussion

It is offered to use new equipment. The equipment can carry out new mining and chemical processes of waste depolymerization and fuel production (SWSU patents RU 2478169, RU 2496587) [11, 12]. The thermocatalytic depolymerization method is the basic method. SHW organic and polymeric components should be separated, dried up and crushed in advance. Rubber and dry organic dissolution takes place. Then the received mass is divided into two components (synthetic oil and solid residue). All the process takes place in a tubular reactor under high temperatures and pressure at the presence of hydrogenous solvent which is close to pseudo-critical.

It is possible to have environmentally friendly products from secondary raw materials. These products are components of an offered method. And then these products are used as commercial products. Figure 1 shows the production scheme. Necessary equipment is described in table 2.

Table 1. Average characteristics of main SHW processing options in Russia

Parameters name	Unit of measure	Offered option (+,-) in comparison with SHW processing options		
		Deposit sites	Plasma arc gasification	Composting
Indirect capital expenditures	Thous. rub./1t of SHW a year	6-9	-6 and -4	-1.5 and 2
Land lease cost	Thous. rub./1t of SHW a year	-0.027	0	0,004
Indirect operating costs	rub./1t of SHW	1340-1750	-500	300-600
Indirect income	rub./1t of SHW	730-860	490-620	520-650

Remarks. Calculations are done by the authors

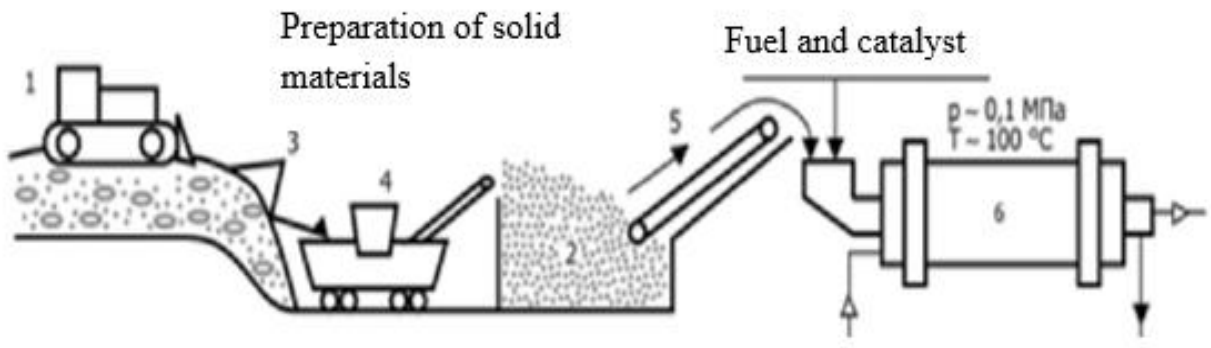

Figure 1. Production scheme of described innovative project

Table 2. Capital investments into technical equipment for raw preparation

№	Name	Quantity	Approximate price, rub.
1	Bulldozer (Chinese bulldozer costs 3500000, premium class bulldozer costs 6500000)	1	7000000
2	Throw screen (from 350000)	1	500000
3	Screw	1	300000
4	Packaging machine	1	200000
5	Scissors for waste rubber cutting	1	300000
6	Drying mill	1	1000 000
7	Toothed-roll crusher	1	1750 000
Total			11000000

It is stated that main SHW processing products, which can be marketed, are metals, petrol fraction, fuel oil and cement clinker. It is necessary to note that there is such production demand on Kursk region market and on other region markets of the Russian Federation. According to necessary calculations, the authors have found out that power of 10 t of garbage production a day and the use of one high pressure reactor leads to the following production volumes of goods (table 3).

Table 3. Income from realization of project

Production name	Production capacity, t/m.	Sale, rub.	
		month	year
Metal	24	300000	3000000
Synoil	86.5	-	-
Petrol fraction	56.2	1700 000	17000 000
Fuel oil	30.3	450000	4500 000
Cement clinker	42.6	150000	1500 000
Total		2500000	25000000

Main risks (see [10]) can be grouped as follows:

- technological (for example: special equipment failure, excess of SHW actual accumulation volumes),
- organizational and administrative (non-compliance with work schedule at an investment stage, shortage of qualified administrative and managerial staff, illegal actions against an enterprise),
- financial (investment budget excess, increase in expenses on SHW removal, liquidity risk),
- economic and market risks (lack of garbage for transportation, tariffs change for SHW removal),
- environmental risks (toughening ecological safety requirements, ecological law violation).

According to necessary calculations, investment expenses (IE) are 59552100 rub. These are expenses on equipment for raw material preparation and expenses for technological equipment purchasing.

Knowing expenses, the economic efficiency of offered actions is defined. Main efficiency indicators of this innovative project are calculated (table 4).

Table 4. Calculation of innovative project efficiency

Efficiency indicators	1 year (for 7 m. term)	2 year	3 year	for 3 years term
Financial efficiency				
1. Net income (or net sales – profit and loss review). thous. rub.	70219.33	133135.85	143520.45	346875.6
2. Profit due to innovation realization (or total profit). thous. rub.	28439.18	54287.82	58815.72	141542.7
3. Net profit due to innovation realization. thous. rub.	22751.34	43430.26	47052.58	113234.2
4. Sales profitability. calculated according to net profit. %	32.40	32.62	32.78	32.64
Investment efficiency				
1. Net discounted pay-back period (or NPV). rub.	58833616.7			
2. Profitability index	1.99			
3. Discounted pay-back period. years	2.3			

According to calculations, the innovational project should be admitted to examination.

5. Conclusion

The carried-out technical and financial calculations prove economic efficiency of an offered SHW processing method. This project has financial and investment efficiency: the profitability index is 1,99, the discounted payback period is 2,3 year and the net discounted income is 58833616,7 rub.

This project novelty and relevance allow finding consumers after research and development study and after production development. At the same time, it is necessary to consider that innovative mining and chemical technology of waste depolymerization is effective. It is effective with not only the considered design capacity, but also when installation power on ten-twenty reactors of high pressure will be 10 times more than that in an offered case. The use of such technology will contribute to the reduction of anthropogenic load and is one of directions of development of "green economy".

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