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THE INNOVATIVE STRATEGY OF THE BUSINESS DEVELOPMENT BASED ON THE WASTE TIRE RECYCLING IN THE REPUBLIC OF LITHUANIA

Oleksandra Rozhenko, Maryna Iurchenko, Vytautas Juscius
Klaipeda University

Abstract:
This article explores the development of a new business strategy in the Republic of Lithuania that focuses on the processing of waste tires into fuel. An innovative approach has been adopted, which incorporates three interdependent components: managerial, legal, and financial/economic factors. This approach ensures the integration of different levels and functions of management for the inclusive development of this business in the Republic of Lithuania. A set of indicators has been proposed, which were used to conduct a comparative analysis of alternative types of energy used for heating, such as diesel fuel, pyrolysis, wood pellets, electricity, and natural gas. A mathematical model has been constructed to formalize the financial and economic results of the tire recycling business, and it can be used to determine the results with any number of recycled tires. The investment analysis of the tire recycling business in the Republic of Lithuania confirms the economic feasibility of the proposed strategy. The risk assessment of the proposed strategy was also conducted, taking into account the technical and possible initial volumes of processing. Based on these economic and mathematical tools, managerial decisions can be made regarding the strategic alternatives for implementation. Additionally, the implementation of this strategy can lead to multiple positive environmental and social outcomes such as reduction of waste tires in landfills and decrease in dependence on fossil fuels. The results of this research provide a valuable basis for decision-makers in the government and private sector to consider the implementation of this innovative strategy and contribute to the sustainable development of the country.

Key words: *eco-friendly energy, innovative strategy, legal support, pyrolysis fuel and oil, risk assessment*

INTRODUCTION

The problems of energy security in the European Union (including the Republic of Lithuania) are getting more acute and urgent each year. Moreover, depletion of energy resources, rising prices for energy products and their import dependence suggest that this trend will persist in the near future. All of the factors mentioned above indicate that regulatory policies concerning environment and energy have to be improved in accordance to the national interests and available capabilities. The issue of energy security became even more sophisticated under the latest refusal made by the Republic of Lithuania from the usage of the Russian energy resources since May 25, 2022, which is confirmed by Nord Pool's decision to stop the correspondent trade with Inter RAO Group Company [1].
An additional complication arises due to the fact that regular fossil fuels such as oil create an environmental problem and serve as main emitters of harmful particles into the surrounding environment. An alternative mechanism to increase the effectiveness of social and economic domestic policies within the business of fuel and oil production comes in the combination of renewable source processing and strategic management. The available processing technologies dealing with renewable energy in Europe (in particular, the Republic of Lithuania) are based on usage of "natural" sources (energy of sun, wind, water streams etc.) as well as on energy waste utilization [2, 3]. One of the available technologies to produce the alternative fuel for heating is *tire pyrolysis* [3, p. 36], a procedure of recycling waste tires that generates several valuable resources including the tire pyrolysis oil. Apart from fuel production, tire pyrolysis addresses another obvious problem: according to the GIA association data, tires have decomposition periods over 120-140 years and pollute the environment [4] and, according to the Tire Importer Organization, we are facing a considerable issue of the surrounding environment pollution caused by the tire stocks stored on the specialized sites as well as on the open landfills which are threatening the functioning of the ecosystem [5].

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Unfortunately, the tire pyrolysis technology has not been widely spread in the European Union, although there is sufficient potential to launch this innovative strategy effectively in the Republic of Lithuania. However, it should be admitted that avoiding the implementation of innovation in eco pure energy production, one cannot achieve the zero level of polluting emission under the program «Net Zero by 2050. A Roadmap for the Global Energy Sector» recognized by the Republic of Lithuania [6].

Thus, it is evident that the development of the innovative strategies for entrepreneurship in the Republic of Lithuania which are based on the technology of tire pyrolysis into fuel and oil under the increased demand for alternative sources of energy is up-to-date and very important and inspired the authors to conduct the correspondent research to meet its content and the targets.

LITTERATURE REVIEW

In order to run any enterprise in the segments of environment and energy, it is necessary to consider the current circumstances of dynamic environmental demands and geopolitical challenges as well as to employ such activities as development, improvement and implication of correspondent innovative mechanisms and strategies on a constant basis. Garry Kolafa underlines that [7, p. 73] «*The discussion hopes to bring some clarity in tackling our current and future energy problems in the light of mixing energy options and working towards a realistic energy transition that suits our future*». G. Kolafa studied the process of how the decisions are made by the management in the energy policy: including business relationship, understanding of the threats and opportunities of the further decision, evaluation and comparison of already available alternatives, namely everything that is important in the process of the development and implementation of the shown strategy.

It is also important to utilize mathematical optimization techniques in strategic management of alternative energy sources, but every specific case of decision-making requires a proper integration of technical and economic indicators of the project into a specific mathematical model that is consistent with the real data. As an example, we mention the work [8] where the authors have conducted research in the sphere of joint application of renewable energy sources. They point out that «*indeterminate of resources such as solar panels, wind farm, diesel generator, and battery storage system paired with load profile result in random changes within the generation and the load phases, which create it is challenging to properly manage an MG (microgrid)*» and study a method to manage the energy consumption rate (including some load uncertainties of renewable energy sources and price optimization by linear programming methods).

One of the challenges of the current research is to overcome the issue of energy safety, especially for the Republic of Lithuania. This is confirmed by scholars Thomas Satticha, Rasa Morgana, Espen Moe [9] who admit that «*renewable energy policy was shaped by the perception of potential energy security threats, but in contrast to the theory of securitization we identify achieving a high degree of perceived energy security as the primary enabler of renewable energy*». The scholars consider energy safety as an integral part of the policy in the sphere of renewable sources of energy. Therefore, the implementation of the advised strategy depends on the available legal support responsible for this sphere.

Nives DellaValle, Veronika Czako [10] admit that the development of entrepreneurship in the energy sector takes place in the specific social and legal area and releases democracy tools in the society. They declare that citizens «*should partake through not only their energy investment and consumption decisions, but also as social and political actors who can shape the energy system*». The scholars emphasize that the energy sector requires decisions (including the management ones) based on multi-element and alternative background.

Madeleine Wahlund, Jenny Palm [11] studied the alternative energy sources within their civil and legal aspects: «*Calls for 'energy democracy' and active forms of 'energy citizenship' are tightly connected to the debate on energy transition, and the need for a decentralized energy system, based on renewable energy and increased local energy ownership*». The results achieved by the scholars confirm the necessity of constant development and improvement of innovation on the managerial and operational levels of this segment.

Lori Snyder Bennear [12] studies vectors of enterprise development in the areas of clean energy and energy decarbonization. The author «*summarizes the state of knowledge on the energy justice implications of the clean energy transformation along four dimensions – production of energy, energy insecurity/energy poverty, access to clean energy technologies, and impacts of policy instrument choices for achieving decarbonization*». This research is important in the context of our work as it reveals that eco-friendly entrepreneurship implies social and economic development of the society.

Giorgio Graditi, Marialaura Di Somma [13] also consider the issues of green energy. They declare that «*Addressing climate change is one of the most important drivers for national energy policies worldwide by defining the urgent need to decarbonize energy systems through mitigating their environmental impacts*». However, the mentioned work does not discuss general concepts of synchronizing the environmental/energetic social safety modeling with the strategic management of the microeconomic systems.

Zheng Xu [14] discusses basic technical issues in energy systems in the period of fast transformation to low carbon and carbon free sources, «*which makes the non-synchronous generator sources become the main part of the newly added power sources*».

Thus, the synchronizing of already available and alternative sources of energy into society activities is a complex and multifactorial issue of development of the green power sector.

METHODOLOGY

To achieve the aims of this study, we apply the following methods:

- *theoretical generalization* (formulation of the innovative strategy of entrepreneurship development): to study the issue of innovations in strategic management;
- *logical generalization* (analysis of the Regulations of the economic activity within the target business segment under this research): to characterize the legal support;
- *graphical method* (visualizing sensitivity of the NPV to changes in technical and economic indicators): to study sensitivity of the offered strategy;
- *normative study* (classification of expenses and pinpointing the total cost amount): to define the technical and economic indicators;
- *computational analysis* (calculation of the sales price, profitability indicators as well as quantification of investment effectiveness): to define the resulting indicators;
- *direct costing* (calculation of the production costs to determine the financial stability tolerance): to manage the direct costs;
- *mathematical models and simulations* (mathematical study of dependence of the factors from the exact technical and economic characteristics in the offered strategy): to formalize the economic and financial indicators;
- *rating analysis* (analysis of the competitors to apply the integral indicator): to perform an integral assessment.

RESULTS

According to the WIPO (World Intellectual Property Organization) data [15], the Republic of Lithuania is ranked 39th among 132 economies studied by the Global Innovation Index (GII) in 2021. Compared to the previous year, the GII ranking of the Republic of Lithuania is higher than in 2020 and lower than in 2019. Those results got impacted by the corresponding values of *Input Sub-Index* that is computed on the basis of the following variables: *Institutions*, *Human capital & research*, *Infrastructure*, *Market sophistication*, *Business sophistication*, more valuable than Output Sub-Index captured such pillars as Knowledge & technology outputs and Creative outputs values (Fig.1).

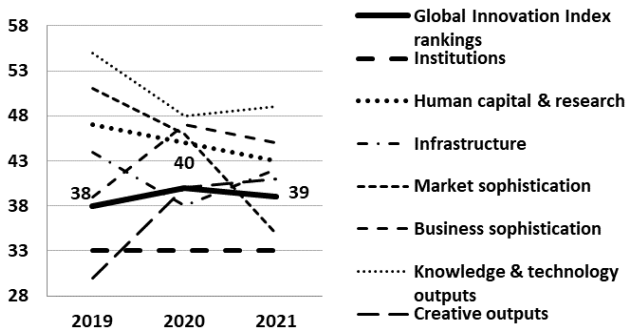


Fig. 1 Rating of Lithuania in the Global Innovation Index

The study of the data indicates that the Lithuanian GII index is characterized by unstable dynamics and, as a result, efforts to increase the index are required. One of the ways to do that lies in the development of innovations, innovative activities, and innovative products in the Republic of Lithuania. According to Article 2 (5-7) of the Law on Technology and Innovation of the Republic of Lithuania [16], innovations can be accomplished through the implementation, development, and launch of improved products or processes, or a combination of both. These improvements should be significant and distinct from previous versions, and should be introduced into the market, public administration, social, and cultural sectors. The strategy proposed in the present paper can also be considered from this point of view: it can be considered as innovative; all activities related to its implementation can be considered as innovative activities, and the output products, pyrolysis fuel and oil, should be regarded as innovative products.

In compliance with [17], the implementation of the considered innovation strategy in the Republic of Lithuania is proposed on the basis of an inclusive approach, which is presented in Fig. 2.

The legal framework for the circulation of used tires in the Republic of Lithuania has specific characteristics, which are regulated by the Waste Management Law of the Republic of Lithuania [18]. Article 2 of this Law defines the fundamental concepts on which the proposed project is based:

- paragraph 6, which refers to waste as "a substance or object that the owner discards, intends to discard, or is required to discard";
- paragraph 7, which defines waste processing as "recovery or disposal, including preparation for recovery or disposal";
- paragraph 66, which defines the disassembly of a vehicle as "the dismantling of individual parts, assemblies, mechanisms, systems, cutting, grinding, or other processing of a vehicle for reuse, recycling, or disposal."
- Thus, the implementation of tire-to-fuel recycling technology in the Republic of Lithuania aligns with the objectives of this Law (Article 1) which includes "waste management to prevent the adverse effects of waste on public health and the environment."

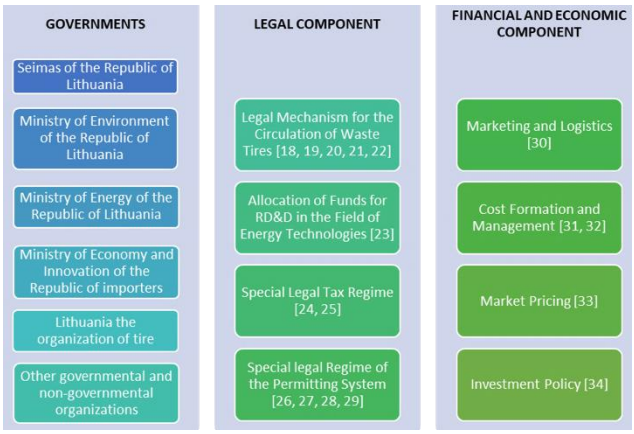


Fig. 2 An inclusive approach to the proposed innovative strategies implementation for the business structures development in the Republic of Lithuania

The legal mechanism for the circulation of waste tires, in compliance with Article 3 of the Law [18], also includes an

order of priorities for their management, which is based on the principles of environmental protection.

According to Article 34.4 of the Law [18], a special characteristic of the legal mechanism for the circulation of waste tires is the regulation of the rights and obligations of the relevant subjects: participants in the management system of decommissioned vehicles. These include manufacturers and importers of vehicles, as well as government agencies, waste owners, organizations for individual and collective decommissioning of vehicles, companies providing maintenance and repair services, and waste management entities. These parties interact with each other and must construct internal business processes, such as waste management in each district, in order to fulfill their obligations. This system of legal relations is complex and multilevel, ensuring versatility and clarity in achieving the goals set in the above Law. However, its functionality is only fully realized when combined with other legal components of an inclusive approach to the implementation of the proposed innovative strategy for the development of entrepreneurial structures in the Republic of Lithuania.

In cases where the turnover of used tires is ensured by manufacturers and importers of taxable products (tires) collectively fulfilling their obligations, the legal mechanism provides for the activities of the Tire Importers Association [19] established in the Republic of Lithuania. The association brings together existing manufacturers and importers in the Lithuanian market and performs organizational and managerial functions in the tire recycling industry.

However, some manufacturers and importers of taxable products (tires) are able to individually fulfill their obligations in the management system for this type of waste. This complicates the implementation of certain administrative and management procedures in this area [20]. According to of the Business Plan for 2022 of the Tire Importers Association, under the section 2 "Plans for the Development of the Organization's Activities", it is planned to handle 1,250,000,000 (80% of the planned amount to be placed on the market) tons of used tires in 2022 [21]. These sources indicate that there are environmental problems related to the whole volume utilization and recycling of the used tire waste.

At the same time, legislation of the Republic of Lithuania [22] allows for alternative organizational and legal forms for establishing an entrepreneurial structure that could implement this innovative strategy. According to Energy Technology RD&D [23], in many cases, research and development funds in the Republic of Lithuania are not allocated specifically to energy-related technologies, but are assigned to different projects through tenders. In the context of this study, this method of project financing is appropriate, as the technology in question is not consistent and is non-standard and original in the geographical region being considered. Additionally, there are no advisory business entities or corresponding economic ties in this area.

The legal regime for taxing entrepreneurial activities that involve recycling tires into fuel also has specific features in the Republic of Lithuania. In addition to mandatory taxes, a pollution tax [24] and an excise tax [25] must also be paid. The pollution tax is paid by the relevant business entities, as emissions are produced during this process, in accordance with paragraph 1 of Article 4 of the Law on Environmental Pollution [24]. The management of this type of waste in the Republic of Lithuania is also affected by taxes paid by manufacturers and importers of tires, as they are considered a taxable product. According to paragraph 2 of Article 4 of the Law [24], tires that weigh more than 3 kg, "which were supplied to the domestic market of the Republic of Lithuania as separate goods that are not part of another product," are subject to taxation, as they will become waste after use. According to paragraph 4 of Article 6 of the Law [24], this tax can be avoided for the amount of waste that is submitted for processing, if there are documents confirming this. Therefore, the transportation, collection, and storage of used tires is either at the expense of the pollution tax paid by tire manufacturers and distributors, or done by the manufacturers and distributors themselves. This mechanism for managing waste is rational and serves to protect the interests of various entities, including public administration, entrepreneurship, and various segments of the population.

The result of tire recycling using the proposed technology is an energy product, which is considered a taxable product according to subparagraph 6 of paragraph 1 of Article 2 of the Law on Excise Duties of the Republic of Lithuania [25]. However, the law [25] specifies that excise rates for energy products are applied to specific groups of goods and that certain authorities separately identify excisable energy products that can be applied to project pyrolysis fuel.

According to [26], the specifics of the legal regime of the licensing system for entrepreneurial activity in this area is the formation of a package of permits in two areas: environmental and energy.

Regulation of the environmental aspect is provided by "The assessment of the effects of certain public and private projects on the environment", as stipulated by EU legislation [27], and "Environmental impact assessment of the proposed economic activity" in the Republic of Lithuania [28]. This legal framework allows for the use of thermal treatment, specifically pyrolysis, in economic activities for the recovery or disposal of non-hazardous waste. This type of economic activity is subject to an assessment of its impact on the environment and requires the completion of appropriate procedures and the obtaining of necessary permits.

The implementation of the proposed innovative strategy for entrepreneurial activity in the energy sector, as outlined in [29], includes the organization of certification for energy audit specialists and the administration of the process of training specialists for the installation of production facilities for certification by the Lithuanian Energy Agency. This is part of the permitting system for the proposed project.

Implementing this innovative strategy, which is based on the technology of processing tires into fuel, leads to an

increase in the socio-economic efficiency of management. The sector of recycling used tires in the Republic of Lithuania is a component of the development of the country's energy and ecological systems and contributes to improving the quality of life of the population by implementing the principles of an inclusive economy.

The financial and economic aspect of an inclusive approach to implementing the innovation strategy primarily involves studying the market environment and logistical patterns in this area.

According to [30], existing examples of tire recycling technologies in the Republic of Lithuania are conceptually different from the proposed production outcome. Alternative boiler fuels derived from tire recycling have a stronger demand than building materials or other downstream products.

An analysis of the strategic competitive environment for alternative energy sources for heating is provided in Table 1.

The main competitors of pyrolysis fuel in the Republic of Lithuania as an alternative type of energy production for heating are diesel fuel, wood pellets, electricity, and natural gas. Based on an integrated assessment of the rating of these fuels using the indicators of cost of obtaining 1 MJ, approximate life-cycle CO_2 emissions, part of imports in consumption volume, and renewability of used resources, pyrolysis fuel took 3rd place in the rating out of five, after wood pellets and natural gas. The advantages of pyrolysis fuel include its relatively low cost, independence from imports, and renewability, which are key factors in the current geopolitical conditions.

The functioning of the transportation services market in the Republic of Lithuania, which generates a large quantity of waste (used tires in particular), shows the greatest economic activity of business entities in this area in the central part of the country. Therefore, it is advisable to locate the activities for the implementation of the proposed innovation strategy in this region, taking into account the possibilities of using these wastes from nearby countries.

The formation of the total costs of entrepreneurial activities for the implementation of this investment strategy was carried out according to the classification in the Accounting Standard "Costs" [31]. This will align them with the relevant reporting data, regulatory and calculation and analytical methods, taking into account the experience of implementing this technology in Ukraine [40]. For economic elements, the amounts of activity costs are formed in accordance with the current legislative acts, prices, and tariffs in the Republic of Lithuania. Cost management in this area of business activity is proposed to be carried out using the “direct costs” method, which allows managing the cost of a unit of production depending on the volume of its production, sales prices, and net profit [32]. The specificity of the formation and management of costs for the implementation and execution of the proposed innovation strategy lies in the availability of free raw materials (used tires) that must be delivered to the place of processing and the high level of labor costs in the cost structure. It necessitates, in the long term, studying and developing a special personnel policy.

The pricing for products in this type of entrepreneurial activity takes into account both external factors, such as competitive prices and market tariffs and rates, and internal factors, such as qualitative and quantitative indicators. To determine the price per unit of production for alternative volumes of waste tire recycling, factors such as the generated cost per unit of production, prices for alternative types of products, and the minimum level of profitability in the Republic of Lithuania (as represented by deposit rates of commercial banks) are considered. It is proposed to include a specific profit margin of 30-40% return on costs, in direct proportion to the volume of processing. This pricing strategy ensures a stable demand for manufactured products and promotes inclusive development of entrepreneurial activity in this area.

Table 1

An analysis of the alternatives energy for heating strategic competitive environment

No	Energy source	Production costs of 1 MJ, eu		Approx. life cycle CO_2 emissions, kg/GJ		Import share in the consumption volume, %		Renewability of the resources		Rating on the competitors strategic map	
		Importance of the indicator 0.5		Importance of the indicator 0.2		Importance of the indicator 0.1		Importance of the indicator 0.2			
		Value	Rating	Value	Rating	Value	Rating	Value	Rating	Mean Value	Rating
1	Diesel fuel	0.046	4	72	4	100	4	0	3	3.8	5
2	Pyrolysis	0.029	3	72*	4	0	1	1	1	2.6	3
3	Wood pellet	0.005	1	45	2	11.12	2	0	3	1.7	1
4	Electro energy	0.067	5	0	1	84.32	3	0.5	2	3.4	4
5	Natural gas	0.023	2	63	3	100	4	0	3	2.6	2

** not available, assumed to be equivalent to diesel fuel due to physical-chemical affinity [35, 36, 37, 38, 39]*

The investment policy for the proposed innovation strategy in the Republic of Lithuania is based on the compliance of investment analysis indicators with normative standards, as outlined in [34]. The choice of indicators depends on the legal form and capital structure of the business entity.

MODEL FORMULATION

The costs of the innovation strategy under consideration can be represented as follows:

Capital Expenses = [initial cost of major equipment]+[initial cost of vehicles and other equipment]+[tools and fixtures]+[office equipment].

Operating Expenses = [cost of fuels and lubricants]+[fuel cost to run equipment]+[cost of electricity]+[water supply costs]+ [cost of packaging + the cost of workwear]+ [other material costs]+ [accountant salary]+ [salary of service personnel]+ [specialist salary]+ [director's salary]+[engineer salaries]+[social payments]+[lease of production areas]+[depreciation of fixed assets]+[environmental pollution tax]+[lab costs]+[equipment maintenance costs].

The models mathematical formulation, taking into account the notation presented below, has the following form:

$$\sum_{n=1}^{T}(C_n^* - q \cdot X_n) \cdot \frac{1}{(1+r)^n} + C_0^* = NPV, \;\; n = 1, \dots T, \qquad (1)$$

where:

r – Discount Rate;

P_0^1 – Initial cost of major equipment;

P_0^2 – Initial cost of vehicles and other equipment;

P_0^3 – Tools and fixtures;

P_0^4 – Office equipment.

$$C_0 = \sum_{n=1}^{4} P_n^i - \text{Total Capital expenses}$$

P_n^1 – Cost of fuels and lubricants;

$$P_n^1 = 10^{-3} \cdot W_n \cdot \beta^{(1)} \cdot \beta^{(2)} \qquad (2)$$

P_n^2 – Fuel cost run equipment;

$$P_n^2 = 6{,}5 \cdot 10^{-5} \cdot W_n \cdot \beta^{(3)} \qquad (3)$$

P_n^3 – Cost of electricity;

$$P_n^3 = 3{,}75 \cdot 10^{-2} \cdot W_n \cdot \theta^{(1)} \qquad (4)$$

P_n^4 – Water supply costs;

$$P_n^4 = 2 \cdot k^{(1)} \cdot \theta^{(2)} \qquad (5)$$

P_n^5 – Cost of packaging;

$$P_n^5 = 2{,}5 \cdot 10^{-3} \cdot W_n \qquad (6)$$

P_n^6 – Cost of workwear;

$$P_n^6 = k^{(1)} \cdot \theta^{(3)} \qquad (7)$$

P_n^7 – Other material costs (10% of the total cost of fuel to run equipment and the cost of fuels and lubricants are determined);

$$P_n^7 = 10^{-4} \cdot W_n\left(\beta^{(1)} \cdot \beta^{(2)} + 6{,}5 \cdot 10^{-2} \cdot \beta^{(3)}\right) \qquad (8)$$

P_n^8 – Accountants salary;

P_n^9 – Service personnel salary;

P_n^{10} – Specialists salary;

P_n^{11} – Directors salary;

P_n^{12} – Engineers salaries;

P_n^{13} – Employees social insurance costs;

$$P_n^{13} = \delta \cdot \sum_{j=8}^{12} P_n^j \qquad (9)$$

P_n^{14} – Lease of production areas;

$$P_n^{14} = \gamma \cdot \theta^{(4)} \qquad (10)$$

P_n^{15} – Depreciation of assets;

$$P_n^{15} = \frac{0{,}9 \cdot C_0}{12 \cdot T}, \text{where T} - \text{project life time} \qquad (11)$$

P_n^{16} – Environmental pollution tax;

P_n^{17} – Lab costs;

P_n^{18} – Equipment main tenance costs;

$$P_n^{18} = 1{,}071 \cdot W_n \qquad (12)$$

$\beta^{(1)}$ – Fuels and lubricants price;

$\beta^{(2)}$ – Fuels and lubricants volume of use on the 100 km;

$\beta^{(3)}$ – Fuels price to run equipment;

$\theta^{(1)}$ – Current price of 1 kW/h of electricity;

$\theta^{(2)}$ – Current price of 1 m^3 of water;

$\theta^{(3)}$ – Current work wears price;

$\theta^{(4)}$ – Current of 1 m^2 rent price;

γ – Area of leased territories;

$k^{(1)}$ – Number of production employees;

$k^{(2)}$ – Number of service employees;

W_n – Amount of recycled tires (kg);

δ – Employee social security interest rate;

q – Price of 1 ton of finished products;

X_n – Volume of products received, ton;

qX_n – Income from the product sale for year *n*, $n = \overline{1, T}$.

Thus, the total operating expenses are:

$$C_n = \sum_{i=1}^{18} P_n^i, \qquad (13)$$

where:

$C_0^* = C_0$;

$C_1^* = \sum_{j=1}^{12} C_j$ – Cost for the frist of project implementation;

$C_2^* = \sum_{j=1}^{24} C_j$ – Cost for the second year of project implementation;

$C_n^* = \sum_{j=12(n-1)+1}^{12n} C_j$ – Cost for the n-yar of project implementation.

In the present paper we assume for simplicity that $X_n = X$, $C_n^* = k$,

where:

k – unit costs,

$T = 8$.

According to the assumptions (2) - (13), can be represented in the form:

$$(q - k) \cdot X \cdot \sum_{i=1}^{8} \frac{1}{(1+r)^n} - C_0 = NPV \qquad (14)$$

The released financial and economics results of the business activities at the implementation of the innovative strategy of the tire recycling into fuel and oil over 8 years (T = 8) for alternative volumes of recycled waste (tires) are presented in Table 2.

The financial and economic results presented for the implementation of an innovative strategy based on the technology of processing tires into fuel demonstrate its feasibility and overall positive dynamics.

However, when comparing projects for different volumes of recycled waste, it was found that the financial and economic results have varied dynamics. The growth rate of return on costs and equity capital for the 4 tons of tires per day is lower than that of the 2 tons of tires per day recycling project.

Table 2

Financial and economics results of the business activities at the implementation of the innovative strategy of the tire recycling into fuel and oil

Indicator for the year	Recycling of waste tires per day, tons				
	1 ton	2 tons		4 tons	
	Indicator	Indicator	Pace of change (2 t/1t), %	Indicator	Pace of change (4 t/2t), %
Proceeds from the products sale without indirect taxes, euro/hour	117133	168247	143.64	299381	177.94
Operating Expenses, euro/hour	79528	107510	135.19	187040	173.97
Profit before tax, euro/hour	37605	60737	161.51	112341	184.96
Return on costs, %	47.29	56.49	119.47	60.06	106.32
Return on equity, %	85.75	91.04	106.18	67.33	73.95
Unit cost 1 ton pyrolysis, euro/ton	1154.00	776.14	67.26	622.08	80.15
Price of 1 ton pyrolysis without indirect taxes, euro/ton	1500.20	1008.98	67.26	870.91	86.32
Break-even point, tons pyrolysis	3.90	7.51	192.75	12.59	167.70
Financial safety margin, %	30.44	32.97	108.29	43.79	132.83

Table 3

Investment analysis of the business activities at the implementation of the innovative strategy of the tire recycling into fuel and oil

Indicator for the year	Recycling of waste tires per day, tons				
	1 ton	2 tons		4 tons	
	Indicator	Indicator	Pace of change (2 t/1t), %	Indicator	Pace of change (4 t/2t), %
Cash flow, euro/hour	37605	60737	161.51	112341	184.96
Capital Expenses, euro/hour	43857	66714	152.12	166857	250.11
Discount Rate (r), coefficient	0.05	0.05	-	0.05	-
Net Present Value (NPV), euro/hour	199194	325843	163.58	559227	171.62
Profitability Index (PI), coefficient	5.82	6.18	106.18	4.57	73.95
Pay-back period (PP), hours	1.761	1.638	92.99	2.387	145.73
Internal Rate of Return (IRR), %	0.763	0.814	106.73	0.574	70.55
Cross-price elasticity coefficient (Eq),%	3.801	3.337	87.81	3.460	103.68
Coefficient of cross-elasticity (Ex),%	1.219	1.205	98.81	1.300	107.94

However, the growth rate of the financial stability margin increases with an increase in the volume of processing.

The results of the investment analysis for the implementation of the proposed innovation strategy over an 8-year period for different volumes of recycled waste are presented in Table 3.

The obtained financial and economic characteristics of the proposed innovation strategy are in compliance with the norms set by the Order of the Minister of Finance of the Republic of Lithuania "*On the approval of the description of the temporary procedure for the implementation of projects financed or partially financed with the funds of the European Union funds and measures for economic recovery and resilience enhancement for the years 2021-2027*" [41]. This expands the possibility of finding sources of investment.

The sensitivity of the Net Present Value (NPV) indicator is considered to compare with the analytically settled price for n = 1, 2, 4 MT within its operational limits equal δ = 0±15% in order to provide the risk assessment of the innovative strategy.

The visual description quick response of the resulting Net Present Value indicator to any changes in this factor is shown in Fig. 3.

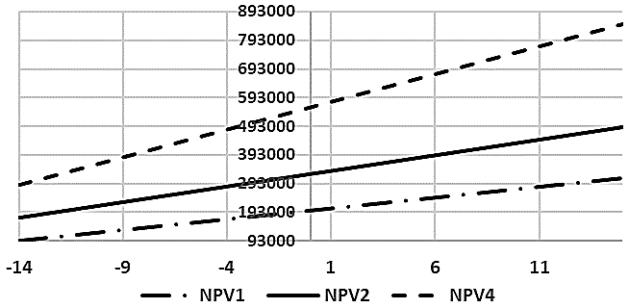


Fig. 3 Plot of NPV w.r.t. q

These plots show that the recycling project for n = 4 MT reveals the highest risk probability which is confirmed by the angle of inclination of a graph to the x-axis.

Fig. 4 shows the relation of the NPV to changes of r, a discount rate, while the other settled factors remain unchangeable.

Analyzing the relation shown in Fig. 4 we can say that the above projects aren't very sensible to the discount rate changes, despite the recycling project, where n = 4, which is the most vulnerable to the discount rate changes. If r = 0.67 this project shows NPV < 0 and became less appealing for its implementation.

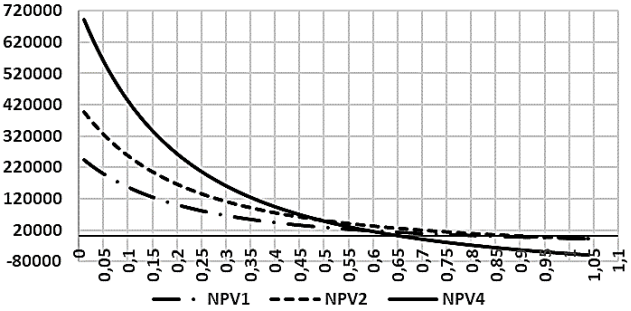


Fig. 4 Plot of NPV w.r.t. γ

The set of the outcoming results formed in this study comes with considerable versatility, enabling the flexibility of the implementation regarding the type of the waste to be recycled. The managerial decision concerns the alternative how to implement the project is offered to be conducted with regulatory matrix of integral indicators, the comparative results of the piece of work you can find in Fig. 5.

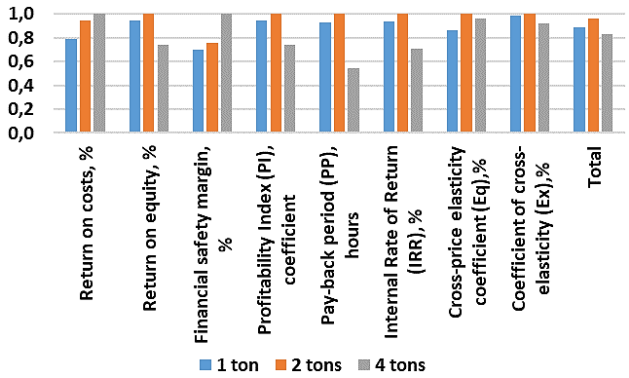


Fig. 5 Integral assessment of the resulting indicators

The gained results show the advantages of the alternative way of the above innovative strategy implementation if the volume makes 2 MT, n = 2 MT.

CONCLUSIONS AND SUGGESTIONS

An innovative business development strategy based on the technology of processing tires into fuel in the Republic of Lithuania has been developed in line with the principles of an inclusive economy. The development of entrepreneurial activity in this field addresses the problem of environmental pollution caused by used tires, and the processing of tires into pyrolysis fuel provides a competitive alternative in the energy market. The existing legal framework in the Republic of Lithuania provides the necessary prerequisites for the implementation of this strategy. A set of indicators was used to conduct a comparative assessment of the competitive environment of alternative types of energy used for heating, which include the cost of obtaining 1 MJ, approximate life-cycle CO_2 emissions, the share of imports in the volume of consumption, and the use of renewable resources. Pyrolysis fuel took 3rd place in the ranking of the five options considered as a result of the analysis of the strategic competitive environment of alternative types of energy for heating. The obtained financial and economic indicators show the effectiveness and sustainability of the proposed strategy and provide a low risk. A mathematical model was created to formalize the dependence of the price of the products on the specific technical and economic characteristics of the proposed strategy. Integral assessment of the indicators such as return on costs, return on equity, financial stability margin, profitability ratio, payback period and internal rate of return, and elasticity coefficients for price and sales volume show the alternatives for implementing the proposed strategy are preferred.

Future research in this field should explore ways to introduce functional technologies of the "circular economy", and examine legal regulation, economic and logistics support for these technologies.

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Oleksandra Rozhenko
ORCID ID: 0000-0002-9358-5436
Klaipeda University
H. Manto g. 84, 92294 Klaipeda, Lithuania
e-mail: oleksandra.rozhenko@ku.lt

Maryna Iurchenko (corresponding author)
ORCID ID: 0000-0001-8992-6093
Klaipeda University
H. Manto g. 84, 92294 Klaipeda, Lithuania
e-mail: maarinaiurchenko@gmail.com

Vytautas Juscius
ORCID ID: 0000-0001-9507-9484
Klaipeda University
H. Manto g. 84, 92294 Klaipeda, Lithuania
e-mail: ek.shmt@ku.lt