THE FEASIBILITY STUDY
FOR THE PROJECT OF PRODUCTION OF THERMAL INSULATION MATERIALS MADE FROM SHEEP WOOL

Savjet za zelenu gradnju - Green Council
Sarajevo, 2016

ANNEX 2:
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Savjet za zelenu gradnju - Green Council
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Prilog 2: STUDIJA IZVODIVOSTI PROJEKTA PROIZVODNJE TERMOIZOLACIONIH MATERIJALA OD OVČJE VUNE

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LIST OF ABBREVIATIONS

BiH – Bosnia and Herzegovina
$CO_2$ – Carbon dioxide
$ENPV$ – Economic Net Present Value
EU – European Union
FAO – Food and Agriculture Organisation
FIRR – Financial Internal Return Rate
FNPV – Financial Net Present Value
KEA – Cumulative energy demand
MKA – Multicriteria analysis
NPV – Net Present Value
SDR – Social Discount Rate
THOR – Thorlan
TUW – Technische Universität Wien
UK – United Kingdom
UNDP – United Nations Development Programme
USA – United States of America
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SUMMARY

Sheep wool is traditional, natural, renewable and sustainable material close to people. At the same time, it is the material that reduces risks created by climate change and CO2 emissions that can result from its processing, installation and recycling. This material has no harmful effects on either the environment or people.

According to the results of the study focused on this material, thermal insulation products made from sheep wool have characteristics which are comparable to other conventional insulation materials. In certain situations, wool even demonstrated considerable comparative advantages in comparison with the conventional materials. “Hygroscopy, or the ability to absorb moisture, while preventing condensate to form, regulates humidity in the air, and creates very good and comfortable internal ambiance, represents a huge advantage of this material. This feature is very important for building materials in view of the optimal functioning of a building. ” In addition, durability of sheep wool is one of its advantages in comparison with the conventional insulation materials. Sheep wool can last for up to 50 years, which is considerably longer period of time in comparison with other thermal insulation materials.

The research has confirmed that sheep wool is an ideal material for insulation in buildings. The quality of wool in BiH is too low to be used in textile industry; however, its qualities by far surpass the standards required for production of

panels for the construction sector. The potential of wool use should be employed in building, which will take traditional processing of this material in textile industry a step further.

The price of sheep wool in BiH and the region is low. In BiH, there are facilities for wool washing and processing, such as the mechanical wool washing installation in Visoko with capacity of 100 tons per month. With some additional investments, the infrastructure for buying the wool from farmers through dedicated buying stations, which was well developed in the past, could be revitalised. Production of thermal insulation panels from sheep wool in BiH, with the current infrastructure and qualified work force available, could provide a product which is of good quality and competitive price in view of the demanding EU or US markets. In addition, the production could easily be tailored to fit the current facilities. Only the last part of the production process of the wool thermal insulation panels is different from the current one and requires specialised machines.

The feasibility study identified that investment into the project of production of thermal insulation panels made out of sheep wool would be cost-effective for the investors, since the earning would be sufficient to cover the future expenditures and that such project would be profitable. As was identified and elaborated in the Financial Analysis section, for the purpose of this study it is not necessary to present additional arguments in favour of the economic and financial cost-effectiveness of launching the project by expressing (monetising) significant non-financial social benefits of this project in terms of money. The indicators of Financial Net Present Value (cost-effectiveness of the investment) and Financial Internal Return Rate (FNPV and FIRR) show that net revenues can cover overall investment and obtain the planned profit.

Therefore, the Economic Analysis section focuses only on identifying certain social benefits that would result from implementation of the project of production of sheep wool thermal insulation panels, without monetising the identified social benefits or calculating their net present value by using social discount rate or social internal return rate. Among other things, the study identified several social benefits that would follow the launch of the project of production of sheep wool thermal insulation panels: (1) Sheep wool as building insulation material uses little primary energy and CO2 for production, installation, usage and recycling; (2) Sheep wool waste can be used as natural fertiliser; (3) Launching production of sheep wool insulation materials would revive infrastructure of sheep breeding, shearing and wool buying.

From the perspective of consumption of primary energy and CO2, the advantage of the natural sheep wool is great in comparison with other materials on the market. In his book “Environmental Design” Max Fordham says that if used locally this material consumes very little primary energy and CO2 for production, installation, usage and recycling.
The sheep wool is made out of biodegradable proteins and after being used in building construction the material can be turned into natural fertiliser. By taking care of animals, we achieve preservation of biodiversity and autochthonous species of animals on planet Earth, as well as establishment of equilibrium and diversity. Adequate support to sheep farming sector would bring about preservation of the autochthonous sheep breed Pramenka in BiH. It is important to stress that sheep wool can be easily recycled and reused.

Unfortunately, BiH and other countries in the region do not have strategies for usage of the material which represents self-sustainable natural capacity, and at the moment is ecological problem. It is necessary to ensure that this material in future is recognised as strategic building material and used in environmentally friendly way. BiH has a long tradition of sheep farming, processing and producing sheep wool, as well as qualified work force, but at the same time great quantities of this material are not used or adequately treated. The existing infrastructure could be adapted to the current EU standards with minor investments. BiH needs to harmonise its laws with the EU Acquis and adopt the most current legislation pertinent to this sector. It is necessary to raise awareness of all stakeholders (farmers, architects, civil servants, representatives of building industry, design companies, and universities) regarding sustainability and environmental requirements, and ensure their adequate training to support promotion of the use of this material and its placement on the market.

According to UNDP research from 2010, BiH has been importing some quantities of sheep wool from Croatia only to export it from BiH to Turkey, while local wool is being scattered around in the rivers and forests around the country. This issue needs to be approached strategically. In BiH and the region, new plans need to be set up for processing the wool insulation panels required in the EU and US markets, which due to local collection and processing use very little primary energy and CO2 emission.

Tackling the wool market issuing should be a part of wider strategy aimed at bringing improvement to the sheep farming sector. A strategic approach to organising the production of thermal insulation panels in BiH is required, since majority of wool from BiH could be used for this type of production. It is very important for different professional profiles, markets and end users to be linked together so to create a value chain and raise awareness on the advantages of this material. Furthermore, it is necessary to start promoting these products and their advantages, highlighting all benefits for nature and environment. Sheep wool, as an insulation material and energy saving material, responds to majority of requests in the current sustainable architecture sector. In addition, we need to focus future studies in BiH and the region to other possibilities in terms of wool production, advantages of combining wool with other natural materials such as wood, clay, lime, straw, and other advantages of clean technologies.
INTRODUCTION

Sheep wool is one of the unavoidable natural materials, when viewed in the context of new housing requirements, which due to its natural characteristics has been attracting the attention of a large palette of scientists and investors studying its features and the most economic and best quality models for use of this material in building industry.

This material has been used for a long time in the textile industry, primarily due to its thermal characteristics, for producing clothes, footwear, bedspreads and other items for everyday use. Occasionally, it was used in construction of buildings, which will be the focus of this study.

This is widely available material which continues to be an opportunity for economic development in BiH. The study will also look at how this potential is being utilised at the moment.

Since its collection in BiH is not well organised, wool is often thrown away and destroyed uncontrollably, reducing at the same time its exploitation. Thus sheep wool becomes waste which is difficult to adequately dispose of due to its features and long-life. This can become developmental opportunity for BiH, although its textile industry - which was very strong segment of its economy in the past - has disappeared over the past 20 years. This is particularly made difficult by the fact that BiH producers cannot compete with textile products from the Asian countries sold at the BiH market.
Current demands related to sustainable development and the building sector requirements, together with raising awareness among the general population regarding the need for healthy living space, have all contributed to having the healthy features of this material and advantages of its use recognised. Thus it has again been acquiring a prominent place in development of the building industry, as a strategic branch of sustainable development in EU and worldwide.

Over the past 50 years, artificial textile has been slowly pushing out this natural material from the market and thus forcing the biggest wool producers in the world, US, Australia, New Zealand and EU, to reduce their production. The traditional textile industry has been transformed into a new industry or it ceased production completely, with plants for this type of production disappearing. The decrease in demand for this type of natural material in the textile industry has lead to rapid drop in wool production over the past 20 years.

This study will demonstrate that minimal investment is required into renovation of the existing plants for sheep wool processing to make these into modern facilities for production of sheep wool insulation panels.

To produce the wool insulation panel, the wool among other things needs to be washed and protected, so that the wool washing facility is a very important segment of the processing process. In the past BiH had five plants for processing and production of wool, all of which had their own washing facilities. At the moment, there is only one machine washing facility with five washing tanks located in Visoko, which could with some minor investments reach the ecological and productions standards required by the EU.

Looking at all of the above from the perspective of future investment into clean technologies, which represent an opportunity for development in BiH, it can be concluded that infrastructure necessary for establishment of this production process in BiH is still present, along with trained work force. Furthermore, another important element in favour of investment is the fact that already established facilities for wool textile production would require additional investment in the last stage of the production process only, in order to be turned into facilities for production of insulation panels.

In particular because the required wool quality for production of insulation panels does not have to be very high, so that wool obtained from autochthonous sheep from the area of BiH fully meets the production requirements, and thus majority of wool collected in BiH is good for type of production\(^2\).

RESEARCH METHODOLOGY

This study was conducted in the period from April to July 2016. For the purpose of this study, quantitative and qualitative research methods were used. Interviews were conducted with representatives of producers and processors of sheep wool, as well as local and international experts for standardisation and certification of products. In addition, the research team attended the workshop titled “Insulation products made out of natural materials” as part of the project “Energy Efficiency in Buildings - Basis for Achieving Sustainable Socio-Economic Growth in Bosnia and Herzegovina”, held on 25 March 2016 at the International BURCH University, with support of the Royal Norwegian Embassy. It was aimed at collecting data necessary for establishment of this production process. Furthermore, the team consulted the practices from the countries in the region, in particular Croatia and Austria, to establish the appropriate institutional framework required for unhindered investments into this project. Preliminary results of the research were presented at the workshops “Creating regulatory framework for strengthening competitiveness of the BiH producers of building products at the EU and local markets” and “Promotion of natural local materials at the BiH market – raising awareness about the impact of materials on health and environment” held on 23 and 24 June 2016, in Sarajevo, at the International BURCH University.

The meetings and discussions which followed helped to test the research thesis, present preliminary results of the feasibility study and hear the opinions of a wider spectrum of stakeholders.

A feasibility study estimates chances for achieving objectives of a certain project. It encompasses analysis of the current condition, environment in which the project is to be implemented, technical and technological factors, business and organisational factors, costs and potential benefits. The objective of such study is to ascertain whether the project is good for investing. The feasibility studies use prescribed methodology to analyse all benefits and costs of a project to assess whether it is advisable to fund it. Such document, in brief, serves for the investors to decide whether it is purposeful to invest into a project.

For any serious investment, one need to do feasibility study, otherwise there is serious danger that decisions on investing into certain project will be made randomly, without adequate preparation, thus leading to wrong assessments with one’s resources wasted.

Feasibility study encompasses technical, financial and economic feasibility, as well as justification and rationality of the investment, as well as purposefulness of implementation of some investment idea.
ANALYSIS OVERVIEW

The feasibility study consists of eight sections. The first section sets forth initial considerations and introduces the methodology used. The second section is focused on contextual analysis, while the third section focuses on project identification. Feasibility analysis and analysis of options is presented in section four, with sections five and six focusing on financial and economic analyses. Section seven of the study focuses on risk assessment and the final section provides recommendations and conclusions.

CONTEXTUAL ANALYSIS

To produce a feasibility study for the project of production of thermal insulation materials from sheep wool, it is necessary, as step one, to adequately examine social, economic and institutional environment with the aim of identifying current situation in this sector in BiH. The assessment of the investment feasibility will of course depend on the gathered parameters.

At the onset, we need to examine characteristics of the wool which make it potential and very promising insulation material for the building sector.

Health qualities of the wool are extraordinary. It does not irritate respiratory organs or skin and due to such characteristics it is used as a natural material in the textile industry, which is not the case with artificial materials that have similar insulation characteristics (glass or mineral wool). On the other hand, glass and mineral wool have been classified by the National programme for research of toxic materials in the US as materials causing cancer.

Wool also absorbs negative substances emitted from other building materials, and thus enables healthier environment for humans. In addition, it absorbs the moisture in the amount up to 40% of its mass, without changing its insulation characteristics and returns the absorbed moisture into air once the conditions allow it.

It is also biodegradable, thus not harmful for the environment.

In fires, since wool fibres contain moisture, they do not promote fire but extinguishes it, so that use of wool protects individual elements of the construction.

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3 National Toxicology Program, Department of Health and Human Services; http://ntp.niehs.nih.gov
To remove impurities and grease, as well as to protect it from insects long term, the wool is washed and \textit{chemically protected} by natural Thorlan salts which cannot be washed out by washing, moisture or anything similar.

\textbf{Other significant benefits of sheep wool are the following:}

- Decreases danger from climate change
- Has thermal characteristics which are at the same level as conventional materials for thermal insulation
- Has acoustical qualities and protects from noise
- Uses primary energy and has CO2 emissions resulting from processing, installation and recycling at the lowest level, in comparison with other thermal materials
- With its local processing, it can achieve favourable price in building industry as thermal insulation element
- It does not require additional protective clothes for installation, since it is natural and healthy material for people, not harmful for respiratory organs
- It enables you to take part in preserving planet Earth by taking care of the animals, feeding them properly and shearing their wool
- It enables preservation of biodiversity and autochthonous animal breeds on planet Earth and much more.\footnote{Ibid}

\textbf{Physical and mechanical characteristics} of the wool fibres are determined by the following characteristics:

- Thickness (fineness), as one of the most important characteristics, ranges between 7 and 200 microns. The finer the wool the longer the yarn from one kilogram of wool;
- Length, the longer and finer the wool the bigger its price;
- Strength, the ability of fibre to resist tearing;
- Stretching, tolerates being stretched before the fibres tear;
- Elasticity, the ability to restore itself to the original position;
- The ability to twist, that is resisting tearing when twisting the fibre around its axis;
- Pliability is the ability to return to original position after the wind circulation ceases;
- Plasticity is the fibre ability to stay in the position in which they were placed during the processing;
- Curling, the ability to form narrower or dipper curls on the fibre;
- Softness, the bigger the finer the wool;
- Hygrosopy, the ability to absorb and store moisture;
- Specific mass of the fibre is the mass of 1 m² of wool fibres expressed in grams and at normal humidity it amounts to 1.3 g/cm³;
- Thermal conductivity, as a very important indicator for use of this material for production of insulation panels, since it is very low;
- The ability to get coloured;
- The layer of grease, the finer the wool the greater the percentage of wool grease.

Comparative values of thermal conductivity, thickness, thermal resistance and value of primary energy and CO2 emissions, for seven selected insulation materials demonstrated advantages of using this natural material, as presented in the table below:

Table 1: Comparison of characteristics of selected insulation materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Thermal conductivity (W/m K)</th>
<th>Thickness (kg/m³)</th>
<th>Thermal resistance (m K/W)</th>
<th>Primary energy (kWh/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  Polystyrene panel</td>
<td>0.035</td>
<td>25</td>
<td>28.6</td>
<td>1126</td>
</tr>
<tr>
<td>2  Mineralna vuna-rolna</td>
<td>0.040</td>
<td>12</td>
<td>25.0</td>
<td>231</td>
</tr>
<tr>
<td>3  Mineralna vuna-ploča</td>
<td>0.035</td>
<td>25</td>
<td>28.6</td>
<td>231</td>
</tr>
<tr>
<td>4  Fenolik pjenasta ploča</td>
<td>0.020</td>
<td>30</td>
<td>50.0</td>
<td>1126</td>
</tr>
<tr>
<td>5  Poliuretanska ploča</td>
<td>0.025</td>
<td>30</td>
<td>40.0</td>
<td>1126</td>
</tr>
<tr>
<td>6  Celulozna vlakna</td>
<td>0.035</td>
<td>25</td>
<td>28.6</td>
<td>133</td>
</tr>
<tr>
<td>7  Ovčja vuna</td>
<td>0.037</td>
<td>27.0</td>
<td>31</td>
<td></td>
</tr>
</tbody>
</table>

Source: Fordham M. (2006); „Environmental design”; Randall Thomas editorial

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5 Fordham M. (2006); “Environmental design”; Randall Thomas editorial
The use of wool for insulation panels in buildings is on the rise. Such method of insulation is most used in Europe, Australia and Canada, and is slowly expanding into the United States.

“Thomas’s Son and Grandsons” is a company established in 1943, as a producer of wool textiles and accessories. The company is in process of shifting its production from traditional wool products to production of insulation panels, which started in 2002. The company has set itself up as a leader in supplying insulation materials in Ireland, UK, US and Canada. Their products are 100% sheep wool and are great, healthy and environmentally friendly products.

In Austria, there are several producers of sheep wool insulation materials (Deamwool, Hauser in Wolle). It is interesting to note that the number of sheep in Austria is four times smaller than in BiH, however this country developed investment plans for this sector because it recognised the advantages of this material in the building industry. The particular advantage is that these products were included in the catalogues of building materials, and that they enjoy great support from the Universities, research centres and institutes through various papers which promotes these products and confirms their quality. One of the papers by a group of authors J. Zach, A. Korjenic, V. Petranek, J. Hroudova, T. Bednar, publicised in 2012 in the journal “Energy and Buildings”, titled “Assessing and researching performances of the sheep wool as an alternative thermal insulation material” presented results from testing this material for sound absorption, thermal conductivity, and correlation of thickness, temperature, relative humidity and hygroscopy of this material.

In addition, for the purpose of PhD thesis by Sanela Klaric, in cooperation with TUW [Technische Universität Wien], i.e. Professors Korjenic and Bednar, a research was conducted focusing on practical application of the wool insulation panel placed on the internal side of the wall, for the purpose of tackling the thermal insulation issue in case of facilities where interventions on the outside façade were not possible. A simulation of the building wall physics was done for three different types of materials in the construction of the outside wall. It was established that sheep wool, as insulation installed on the inside of the wall with a steam lock, proved as a good option in terms of building physics due to its positive moisture absorption characteristics. The moisture absorbed by this material can be returned back into the room once the conditions for that are created. The absorbed moisture is accumulated on the cold side of the insulation, but less so than in the case of mineral wool.

Benefits for planet Earth achieved through sustainable use of sheep wool in all forms of human activity are multiple. Its use as a building element will reduce CO2 emissions produced through processing, installation and recycling. Sheep wool waste can be used as an element aimed at improving the quality of agricultural land. Taking care of the material which at this moment represents ecological
waste and is disposed of inadequately in nature can help heal planet Earth. Thermal characteristics of wool, well known since the ancient times, influenced the most decision to afford this material more attention even in the building sector.

“After all identified benefits, one cannot escape thinking that nature took care of everything, while the men only have to act in line with it. Nature gave humanity material that comes in threads, so to save huge amounts of energy that would be needed to cut out of rock or glass threads needed for thermal insulation. It is up to modern designers to get to know it as much as possible and use it in more sustainable ways. Different breeds of sheep give wool of different characteristics. Some should continue to be used in textile industry for warm and soft clothes, while other wool was given by nature characteristics and quality which can and should be used to respond to requests for providing thermal insulation for buildings. The nature again intervened so that each type of sheep wool could be used to provide separate response to separate needs in the lives of men, while protecting planet Earth in the process.”

WOOL IN BIH

Production and collection of wool were well organised in BiH prior to war. The collection was done by big cooperatives which placed on the market all excess wool bought from private farmers and state resource centres. The wool collected in this way was used in textile industry and mostly to produce carpets and rough wool fabrics for army, which made some 40% of the overall orders, due to the quality of the wool from local sheep breeds which was not very high. Thus local production of wool met only 15% of the needs of the textile industry. The rest of the wool was imported from Australia and New Zealand. Local wool had to be mixed with merino wool or the wool by sheep breeds crossbred with merino sheep. The wool of the crossbreeds was also good for carpet industry.

The UNDP BiH “Wool Market Feasibility Study” conducted in 2010, noted that sheep population in BiH prior to war was circa 1.3 million. Over 80% of this population was the local breed Pramenka which provided between 0.75 to 3 kg per fleece. The average quantity of the sheared wool is 1.7 kg.

The sheep farming sector is slowly being renewed. According to the latest data by Food and Agriculture Organisation (FAO), as part of the sector analyses in the sectors of agriculture, nutrition and rural development in BiH, in 2012, in BiH there were 1.515.0007 sheep heads⁷.

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⁷ FAO, Sector Analysis, Meat and milk sector in BiH, 2012
Table 2: Sheep population in Bosnia and Herzegovina 1990 – 2012

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheep Population</td>
<td>1 318 673</td>
<td>787 759</td>
<td>1 030 654</td>
<td>1 515 000</td>
</tr>
</tbody>
</table>


Unfortunately, in the period after the war, the same as in many other sectors, in this sector we saw disappearance or fragmentation of the production, so that sheep shearing is organised individually or disconnectedly at the farms. Some estimates indicate that annually some 1,400 tons of wool are sheared, mostly by hand. After the shearing, the wool should be collected however this segment is very weak, disorganised, in some regions there is no wool collection organised at all. This is why considerable amounts of wool are left outside the market channels.

Overall quantity of wool which could be collected in BiH is up to 2,500 tons per year (1,515,000 sheep x 1.7 kg/per head). It is estimated that 80% of sheep population in BiH is Pramenka breed (fibre classified between D and E, i.e. Fibres with an average thickness in micrometers between 37 and 60), thus 80% of wool, i.e. some 2,000 tons is coarse wool and the remaining 20%, i.e. 500 tons, is fine wool. This raises the issue of price, i.e. whether it is profitable to collect all the sheared wool, so that one can presume that some of the wool would still remain outside of the scope of organised collection and unused. In an interview with Bahrudin Bojčić, general manager of the "Wool-line" company for production and sale of wool products, it was noted that in the current framework some 1,200 tons of wool could be collected for the effort to be profitable. This claim implies using all the collected wool, both fine and coarse, for production of insulation panels.

As noted in the book by Professor PhD Sanela Klaric “ Sustainable housing—wood, sheep wool, straw – challenges and potentials of traditional natural materials “, the useable wool is represented by the quantity of clean (washed) wool expressed in percentages obtained from 100 kg of unwashed wool. Such quantity is increased by the normal moisture content expressed in percentages, which is 17% in fine, 15% in coarse and 16% in semi-fine wool, measured at temperature of 16°C and air humidity of 65%. The usable wool varies from 30% in case of the finest merino wool to 80% in case of sheep with coarse wool. It is estimated that usable wool obtained by washing the wool of the autochthonous sheep breeds in BiH is around 40%. All of the above indicates that in BiH it is possible to collect a total of 2,500 tons of wool and that the quantity of washed wool that can be obtained amounts to 1,500 tons (2,500-40%). On the other hand, due the fact that collection process is not profitable, currently it is possible to collect in a profitable way only up to 1,200 tons of wool, i.e. 720 tons (1,200-40%) of washed wool.
PROJECT IDENTIFICATION

Based on the lessons learned we know that the best preparation for any type of project is identification of the issue. Of course, behind each capital investment there stands certain need of the citizens, i.e. their claim. Also, this can be manifested as a problem or group of problems.

It often happens that one first sets activities which need to be implemented prior to identifying the issue that needs to be resolved, i.e. prior to setting the objectives which need to be achieved. This is what constitutes the difference between oversized capital investment projects and systematic, planned development. If one is to launch into problem solving in such a way, it is very easy to be faced with situation in which planned activities are not fully, or to great extent, harmonised with the problem, which again leads to bad decisions and unnecessary costs.

Such approach, which starts from the solution and not the problem, can also result in developing a project which is too big and will not be able to secure funding.

In line with the above, here we will present the biggest issues we faced in the process of implementing this project.

**The issue of profitability of investment and financial sustainability of the project of launching production of wool insulation panels** was the primary issue this study focused on. In particular, in view of the issues such as collection, production, certification and placement of finished product at the domestic and international market.

Secondary issues the study focused on were the following:

**The issue of energy efficiency and CO2 emissions.** Energy efficiency in production of insulation panels made from artificial materials is very low. A lot of primary energy is used for their production, distribution and installation, and significant quantities of CO2 are emitted. Natural materials such as wool, in particular if used locally use very little primary energy and have low CO2 emission in the process of production, installation, use and recycling.

**The health issues** resulting from continues use of dominant building materials as insulation panels. We already said that glass and mineral wool were declared cancerous materials by the National programme for research of toxic materials in the US. They are referring to irritation of the airways caused by these two materials. In addition, according to studies done by Doroudiani S. and Omidian H. the use of styrofoam, as one of the most represented materials for thermal insulation on buildings, is linked to serious safety, environmental and health issues because it is extremely flammable and produces toxic fumes when set on fire. Furthermore, styrofoam is responsible for creating the green house gases, because it does not let air through, in facilities which do not have ventilation system set up, i.e. recupera-
tion, although in line with the regulation it should be there. On the other hand, wool is natural material and good for health of human beings, which does not require workers to wear additional protective clothes when installing it, does not irritate the airways.

The issue of flammability of buildings which should be reduced. This refers primarily to buildings with insulation panels made out of styrofoam. It is known that firemen in Vienna are not obliged to come to the site if the building on fire has styrofoam insulation around it. This is primarily due to very harmful materials that are emitted when this material is burning.

The issue of insufficient collection and use of wool, due to lack of interest among the wool producers to deliver sheared wool to remote areas, and due to badly organised wool collection as well as lack of interest among processors due to its bad quality for use in textile industry.

The issue of economic development. This in particular, because preconditions for production of insulation panels are fully in place in BiH. Unfortunately, these potentials are not adequately used. Development of this segment contributes to strategic development of BiH in the area of clean technologies.

In line with the issues identified as above, it is possible to identify objectives we want to achieve, i.e. we can identify the project.

Project objectives are the following:

- Identify if the investment is profitable and financially sustainable, for the project of launching production of the wool insulation panels
- Increase energy efficiency and reduce CO2 emission
- Reduce health problems for population caused by inadequate housing conditions
- Decrease number of facilities insulated by styrofoam and thus reduce their flammability
- Increase collection and usage of wool to maximum profitability
- Contribute to economic development of BiH
### Table 3.: Correlation of the identified issues and objectives

<table>
<thead>
<tr>
<th>Problem</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>The issue of profitability of investment and financial sustainability of the project of launching production of wool insulation panels</td>
<td>Identify if the investment is profitable and financially sustainable, for the project of launching production of the wool insulation panels</td>
</tr>
<tr>
<td>The issue of energy efficiency and CO2 emissions</td>
<td>Increase energy efficiency and reduce CO2 emission</td>
</tr>
<tr>
<td>The health issues</td>
<td>Reduce health problems for population caused by inadequate housing conditions</td>
</tr>
<tr>
<td>The issue of flammability</td>
<td>Decrease number of facilities insulated by styrofoam and thus reduce their flammability</td>
</tr>
<tr>
<td>The issue of insufficient collection and use of wool</td>
<td>Increase collection and usage of wool to maximum profitability</td>
</tr>
<tr>
<td>The issue of economic development</td>
<td>Contribute to economic development of BiH</td>
</tr>
</tbody>
</table>

*Source: The authors*

With objectives set as above, we have identified the project. This study seeks to establish whether the objectives are realistic and possible to accomplish.

## ANALYSIS OF FEASIBILITY AND OPTIONS

On the basis of executed research by the Green Council organisation, three policy options were identified and reviewed as potential option of production of insulation materials made of sheep wool.

Reviews options are:

1. **Ambitious option of production of insulation panels with maximum buying of unwashed sheep wool in quantities of 2,500 tons per year,**

2. **Realistic option of production of insulation panels with available buying of unwashed sheep wool in quantities of 1,200 tons per year, using existing facilities for washing and protection of wool (machine washing in Visoko – with needed investments),**

3. **Realistic option of production of insulation panels with available buying of unwashed sheep wool in quantities of 1,200 tons per year, with option of installation of new washing and wool protection machines (investment in new facilities and equipment).**
Policy Option 1 - Ambitious option of production of insulation panels with maximum buying of unwashed sheep wool in quantities of 2,500 tons per year

As stated earlier, according to World Food and Agriculture Organisation research, it is estimated that there were 1,515,000 sheep in BiH in 2012. Special problem is the fact that sheep shearing is not networked. Estimate is that circa 1,400 tons of wool a year is sheared.

Due to unorganised system of collection, significant quantities of wool remain unavailable for the market. Quantity of wool that could be gathered in BiH comes up to 2,500 tons a year (1,515,000 sheep x 1.7 kg/per head), however, due to undeveloped wool buying infrastructure and low buying price, it is completely unrealistic to, in the following period, calculate with buying of total quantities of produced wool.

Policy Option 2 – Realistic option of production of insulation panels with available buying of unwashed sheep wool in quantities of 1,200 tons per year, using existing facilities for washing and protection of wool (machine washing in Visoko – with needed investments),

Based on estimates of existing and potential producers of processed wool, it is realistic, due to undeveloped infrastructure, to expect collection of circa 1,200 tons of raw unwashed wool.

Only several companies survived in the former developed BiH textile sector that used to employ thousands of workers, along with the fact that their price is not competitive with prices of textile products produced in China and India, which are present in the market of BiH.

It is very important for future investors who would direct resources towards clean technologies, and which are a strategic opportunity for development in BiH, to know that the infrastructure for this production still exists in BiH. With small investment, wool washing facility in Visoko can reach the needed environmental and production standards. Furthermore, machines that differ from those used in textile industry are needed only in the final production stage for the wool-based insulation panes, so the first part of the production matches entirely with the current one. There is also educated work force in this sector.

Wool quality for insulation elements doesn’t have to be high, so semi-rough wool that comes from autochthonous sheep - Pramenka breed in BiH meets the requirements of this production.

The estimate that BiH market can supply 1,200 tons of raw wool is very realistic, as is that the existing washing and wool processing facilities can organise, with additional investments and adaptation, production of circa 600 tons of insulation panels of this natural material.
Policy Option 3 – Realistic option of production of insulation panels with available buying of unwashed sheep wool in quantities of 1,200 tons per year, with option of installation of new washing and wool protection machines (investment in new facilities and equipment).

In comparison to Policy Option 2, this option has a disadvantage of shutting down the existing facility in Visoko, as well as the additional investments in procurement of machines for wool washing and protection.

SELECTION OF POLICY OPTIONS

After reviewing the presented options, their advantages and disadvantages, the conclusion comes that the only realistic and sustainable realistic option for functional establishment of production of sheep wool insulation materials is the Policy Option 2 that includes buying of circa 1,200 tons of raw unwashed wool and keeping the wool washing facility facility in Visoko.

Financial and economic analysis will identify and analyse expenses this option causes in comparison with quantified but also non-quantified social benefits of realisation of this project.

FINANCIAL ANALYSIS

The aim of the financial analysis is to estimate financial viability of the project through calculation of financial revenue. Purpose of the financial analysis is to use the prognoses of project financial flow for calculation of investment profitability, namely, to determine how much the project financially profitable is for the investors. Analysis should also show if all future incomes will be sufficient to cover future expenses.

There are two significant financial indicators that can be determined, having in mind the invested capital, namely public financial sources:

1. Financial Net Present Value – (FNPR)
2. Financial Internal Return Rate – (FIRR)

We get to these financial indicators by discounting financial flows for each year of the project duration, taking into consideration only cash incomes and expenses, and not the amortisation, reserves or similar, as well as the financial flows created if the projects really starts and not those that already exist, which need to be discounted for comparison in different years.
Net Present Value (NPV) is current value of all future annual net savings during the economic duration (from year 1 to year n) reduced by investment (year zero). Depending on the result, one can decide if the project is ready for investment or if it will be rejected.

For project to be accepted as financially cost-effective, following two conditions need to be met:

- Project FNPV needs to be positive or at least equal to zero (FNPV ≥ 0). Current value of incomes needs to be higher or at least equal to current value of project expenses.
- FNPV of the selected option needs to be higher or at least equal to FNPV of other project options that were subject to review.

Negative result is common with infrastructure projects since infrastructure investments are demanding, and direct financial effects are insufficient to cover the expenses. However, for infrastructure projects relevant is the economic analysis that also takes into consideration the effects on society as a whole. Negative financial NPV to total investment (FNPV/C) confirms that the project requires additional co-financing by the EU or from budget grants.

Financial Internal Rate of Return (FIRR) is the indicator of project profitability on annual level. FIRR shows the ability of the project to sustain (incomes higher than expenses) after taking into consideration the discount rate. FIRR tells which rate is the rate that keeps the project positive. Based on FIRR decision is made among several options for investments, since higher FIRR means that project has higher financial quality. Profit is defined by difference between FIRR in relation to the discount rate.

If the FIRR is negative, which means that this project would have no interest in banking sector since the bank cannot receive revenue of the invested with expected profit, the project is looking for co-financing from other sources, such as EU finances.

Financial analysis needs to determine if the project of production of sheep wool insulation materials is financially profitable for investor, if the future incomes are sufficient for covering future expenses, and if the project FIRR is higher than the discount rate, which means that the project is profitable. If the given indicators are negative, the project will ask for co-financing from other sources, such as governmental grants or EU funding. In that case, it is needed to monetise benefits of the project for society in general, which is subject to economic and not financial analysis.
During the development of the Feasibility study of the project of production of insulation materials from sheep wool, we have done all the calculations for the time period of six years.

**TOTAL INVESTMENT**

These investments are related to investments in fixed assets and start-up costs of the project. Start-up costs occur in the first observed years of the analysis, or after the commencement of the project with the main objective of creating adequate conditions of implementation of the project. In this project, calculated start-up costs are costs related to the employment of staff, their training, and the cost of product certification in order to provide their placement on the EU market, as well as consulting, notarial, administrative and other services. Since it is only about investments and cash outflows, all the items have a negative sign.

Investments in fixed assets were calculated on the basis of consideration of existing infrastructure, interviews and assessments of necessary facilities and equipment for the project. Investments into properties are not calculated on a large scale following the information from the already established practice that the accommodation of production and storage facilities can be provided in existing facilities (wool washing facility in Visoko) and the leasing of certain facilities which are funded from the operating costs (lease of office space) which are calculated in part of the analysis which treats revenues and expenses. Due to the necessary precautions in the calculation of cash flows, estimated was property investment in the amount of 300,000 KM allocated to the first two years of the project.

Equipment investment was calculated based on research and interviews with potential investors who already examined both market of suppliers and market of buyers as well as available wool processing facilities and sheep wool insulation panels production facilities. For the existing option of processing of 1,200 tons of available raw wool, namely 720 tons of washed and protected wool per year, it is necessary to procure three specialised machines with capacity of 250 tons of final product with planned work in two shifts, five days a week, for 12 months. Framework price of these machines is, after review of available offers, circa 55,000 KM per one machine (all expenses of fixed asset procurement included), so for total of three machines it is necessary to invest 1,650,000 KM. Investments are carefully allocated—procurement of two machines in the first year, and third machine in the second year.

There is only one machine wool washing facility in BiH with capacity of 5 boilers and it is located in Visoko. It could, with smaller investment (50,000 KM) reach the EU standards. Remaining washing facilities that are in function are of smaller capacities and function as manual washing facility in makeshift cauldrons.
Investments in other equipment are related to procurement of transportation vehicles, storage equipment and office devices (200,000 KM allocated throughout first two years).

Start-up costs are also calculated on the basis of research, interviews, attendance in workshops and exchange of information and calculations. Total calculation is in the amount of 170,000 KM in the first year and 40,000 KM in the second year, and they include the expenses of certification, employment and training of staff, consulting, notarials, administrative services and other start-up costs.

All start-up costs are allocated in the first two years of the project, with estimated investments dynamics. Start-up costs are not calculated for personnel already employed at the Visoko wool washing facility, nor for the establishment of infrastructure of breeding, shearing, or sheep wool buying. Establishment, namely, the revival of this infrastructure that was well developed 30 years ago, represents the additional social benefit of this project that could, in some further studies and through economic analysis, be monetised, which would significantly increase the revenues at this project.

**Table 4 – Review of total project investments (KM)**

<table>
<thead>
<tr>
<th>INVESTMENT ITEMS</th>
<th>YEARS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
</tr>
<tr>
<td>1. Real-estate</td>
<td>-200.000</td>
</tr>
<tr>
<td>2. Equipment</td>
<td>-1,250.000</td>
</tr>
<tr>
<td><strong>A TOTAL FIXED ASSETS (1+2)</strong></td>
<td>-1,450.000</td>
</tr>
<tr>
<td>1. Product certification</td>
<td>-50.000</td>
</tr>
<tr>
<td>2. Employees’ training</td>
<td>-20.000</td>
</tr>
<tr>
<td>3. Consulting, court, notarial, administrative and other services</td>
<td>-20.000</td>
</tr>
<tr>
<td>4. Other start-up costs</td>
<td>-80.000</td>
</tr>
<tr>
<td><strong>B TOTAL START-UP COSTS (1+2+3+4)</strong></td>
<td>-170.000</td>
</tr>
<tr>
<td><strong>TOTAL INVESTMENTS (A+B)</strong></td>
<td>-1,620.000</td>
</tr>
</tbody>
</table>

*Source: The authors*
BUSINESS COSTS AND REVENUES

Business costs of the project presented in the financial analysis cover all business costs that have character of cash outflow. So, these costs do not include costs that don’t cause cash outflow, such as amortisation costs, which actually are budgetary costs and most often don’t cause cash outflow. Interest rates and taxes costs, even though being cash outflow, are not included in the business costs (interest rates are included in the financial analysis as an integral part of the discount rate, while tax costs are included only in the project financial sustainability costs).

Business incomes do not include incomes based on state grants, or the value added tax.

Primary cost and outflow of this project are costs for raw materials, which are, for the purpose of this study, defined as the costs for washed wool protected with natural Thorlan salts (Thorlan IW).

Price of unwashed wool in BiH is very low and it varies between 0.50-0.75 KM per 1 kg of greased fleece or rough unwashed wool (35 µm to 40 µm) and 0.80-1.00 KM per 1 kg of lam wool of higher fineness (28 µm to 32 µm). Price of 1 kg of washed wool varies from 2.5 to 3.5 KM, depending on class. Price of carded wool varies from 6.00 to 9.00 KM (depending on class) per 1 kg. For the sake of comparison, price of merino wool in international market is circa 8 $ per 1 kg. Today, processes can vary in relation to the final product. If the subject is insulation panels, carding processes is replaced by wool fibre stacking process in vertical position, just like on the animal, with assistance of natural nets and glue or other patented manners that differ between producers. Sanela Klaric, "Sustainable housing-wood, sheep wool, straw - challenges and potentials of traditional natural materials", International Burch University Publications, Sarajevo 2015

Washed and Thorlan protected wool was calculated in this study as raw material with price of 3.5 KM per 1 kg of washed wool.

As we calculated before, the quantity of wool that could be gathered in BiH amounts to 2,500 tons a year (1515 sheep x 1.7 kg/per head). Out of that, 80% is rough wool, namely, 2,000 tons of wool from autochthonous breed Pramenka, and the remaining 20%, 500 tons, is wool of higher fineness Sanela Klaric, "Sustainable housing-wood, sheep wool, straw - challenges and potentials of traditional natural materials", International Burch University Publications, Sarajevo 2015

According to UNDP BiH 2010 study, out of total collected wool, 31% is wool of higher quality, which found its place in production. Remaining wool is exported Sljepcevic S.; "Wool Feasibility Study" UNDP BiH, 2010; full study available at: www.undp.ba
as raw materials, whereas large quantity of wool is either dumped or collected at farms, since collection is not appropriately organised.

BiH textile industry sector, which used to employ thousands of workers, collapsed during and after the war. Only several companies survived, followed by the fact that their price is not competitive to prices of textile producers from China and India.

All of this, if observed from the position of investing into clean technologies, which is a strategic opportunity for development in BiH, can be used as an important input for future investors, because the infrastructure still exists in BiH. Washing facility in Visoko can meet the needed environmental and production standards with small investments. Production facilities for wool textile require special parts and machines for insulation elements production just in the final phase, the rest of the process is satisfactory and doesn’t require changes. There is also educated work force in this sector.

Based on the research and interviews with existing and potential sheep wool processors, it is realistic to calculate for the near future of several years, under conditions of inappropriate and undeveloped infrastructure of breeding, shearing and wool buying, with quantity of 1,200 tons of unwashed wool per year. Given the 40% utilization coefficient in the process of washing, protection and drying, it is realistic to expect circa 720 tons of washed protected wool. Machine washing facility in Visoko can, with its capacities, provide this quantity of raw materials for production of thermal insulation panels made of this natural material. Total annual production of final product is realistically, in existing conditions, calculated to the amount of 612 tons of thermal insulation panels made of sheep wool. Production would gradually increase from 200 tons of final product in start year to 612 in fourth and later years of the project realisation. Price of the final product is calculated in the amount of average 15 KM per kilogram of thermal insulation panel, depending on its thickness and density. Complete placement of the product is planned to go via wholesalers so marketing and product sales costs are not projected. The price is very carefully projected since the price in the EU market can be more profitable (even up to 30 KM per kilogram).

The project anticipates employment of 50 workers in the processes of processing of washed and protected wool and production, storing and distribution of thermal insulation panels made of sheep wool. So, the estimate and calculation are related only to the newly-employed in the segment of direct production of thermal insulation panels. Those employed in the segment of breeding, shearing and wool buying, as well as those engaged in washing, drying and wool protection with Thorlan are not calculated in the costs or cash flows in this study. Their expenses are calculated in the price of washed wool of 3.5 KM per kilogram. Additional employment boosted by revival of sheep breeding, buying stations and, eventually new machine washing facilities, is an additional benefit that could be monetised
in the economic analyses for the needs of other studies. Costs of employees are calculated on the basis of average gross salary and compensation per employed person in BiH.

Energy sources are calculated on the basis of installed power of machines and equipment, and other business costs are calculated on the basis of previous experience data of producers, as well as projections and analyses for this industry.

Table 5 – Overview of business costs and revenues (KM)

<table>
<thead>
<tr>
<th>BUSINESS INFLOW AND EXPENSES ITEMS</th>
<th>YEARS</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sales incomes</td>
<td></td>
<td>3.000.000</td>
<td>6.000.000</td>
<td>7.500.000</td>
<td>9.180.000</td>
<td>9.180.000</td>
<td>9.180.000</td>
</tr>
<tr>
<td>A TOTAL BUSINESS INFLOW (1+2+3)</td>
<td></td>
<td>3.000.000</td>
<td>6.000.000</td>
<td>7.500.000</td>
<td>9.180.000</td>
<td>9.180.000</td>
<td>9.180.000</td>
</tr>
<tr>
<td>1. Raw material costs</td>
<td></td>
<td>-822.500</td>
<td>-1.645.000</td>
<td>-2.065.000</td>
<td>-2.520.000</td>
<td>-2.520.000</td>
<td>-2.520.000</td>
</tr>
<tr>
<td>2. Employees’ expenses</td>
<td></td>
<td>-600.000</td>
<td>-720.000</td>
<td>-960.000</td>
<td>-1.200.000</td>
<td>-1.200.000</td>
<td>-1.200.000</td>
</tr>
<tr>
<td>3. Energy sources and material costs</td>
<td></td>
<td>-18.000</td>
<td>-60.000</td>
<td>-75.000</td>
<td>-91.800</td>
<td>-91.800</td>
<td>-91.800</td>
</tr>
<tr>
<td>4. Production services costs, current maintenance</td>
<td></td>
<td>-36.000</td>
<td>-120.000</td>
<td>-150.000</td>
<td>-183.600</td>
<td>-183.600</td>
<td>-183.600</td>
</tr>
<tr>
<td>B TOTAL BUSINESS EXPENSES [1+2+3]</td>
<td></td>
<td>-1.527.500</td>
<td>-2.575.000</td>
<td>-3.287.500</td>
<td>-4.041.300</td>
<td>-4.041.300</td>
<td>-4.041.300</td>
</tr>
</tbody>
</table>

Source: The authors

Obviously, the project makes profit at the end of the each business year only on the basis of final product sales revenue. Through cash flows, discount annual yield, current net value and internal revenue rate, we will determine the assessment of investment profitability into this project.

Costs of salaries, operative material expenses and capital expenses gradually grow in proportion to the growth of production and employment to the optimum level of employment.
CASH FLOWS AND NET CURRENT CASH VALUE

In the rest of the financial analysis, the data from previous two tables will be presented within the table that provides unique overview of cash incomes and expenses related to the investment in this project (project cash flows).

Table 6 – Overview of cash inflow and outflow (KM)

<table>
<thead>
<tr>
<th>CASH FLOWS</th>
<th>YEARS</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VI</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Total business inflow 3.000.000 6.000.000 7.500.000 9.180.000 9.180.000 9.180.000 44.040.000

A TOTAL CASH INFLOW (1) 3.000.000 6.000.000 7.500.000 9.180.000 9.180.000 9.180.000 44.040.000

2.1. Raw material costs -822.500 -1.645.000 -2.065.000 -2.520.000 -2.520.000 -2.520.000 -12.092.500

2.2. Salaries and compensations -600.000 -720.000 -960.000 -1.200.000 -1.200.000 -1.200.000 -5.880.000

2.3. Other costs -105.000 -210.000 -262.500 -321.300 -321.300 -321.300 -1.541.400


3. Total investment -1.620.000 -790.000 0 0 0 0 -2.410.000

B TOTAL VAS OUTFLOW (2+3) -3.147.500 -3.365.000 -3.287.500 -4.041.300 -4.041.300 -4.041.300 -21.923.900

NET CASH FLOW (A+B) -147.500 2.635.000 4.212.500 5.138.700 5.138.700 5.138.700 22.116.100

DISCOUNT FACTOR 1.0000 1.05000 1.10250 1.15763 1.21551 1.27628


DISCOUNT RATE 5%

FNPV(C) 18.875.788

FRR(C) 18.43

Source: The authors

Based on the value of financial indicators, we determine if the project of production of thermal insulation panels made of sheep wool project is profitable for the investors, if the future incomes are sufficient for covering future expenses, and if the FIRR of the project is larger than the discount rate, which means that the pro-
ject will yield profit. If the given indicators are negative, the project requires additional co-financing from budget grants or from the EU. In that case, it is necessary to monetise the benefits the project brings to society in general, which is subject to economic and not financial analysis.

Using the financial parameters of net cash flow in the previous table, we determined the Financial Net Present Value (FNPV). It was determined by using the recommended discount rate of 5% (recommended rate by the European Commission for the needs of investment financial analysis). Net present value is the value of invested money in the future period reduced to the present day.

Table 7 – Discount net cash flow (KM)

<table>
<thead>
<tr>
<th>YEAR</th>
<th>NET CASH FLOW</th>
<th>CASH FLOW PRESENT VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>-147500</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>2635000</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>4212500</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>5138700</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>5138700</td>
<td></td>
</tr>
<tr>
<td>VI</td>
<td>5138700</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>22,116,100</td>
<td>18,875,788</td>
</tr>
</tbody>
</table>

Source: The authors

Discounting enables expression of cash flows that occurred in different time periods in present moment.

So, after reducing to present value, the total cash inflow is 18,875,788 KM. So, FNPV is higher than zero, which means that the project can be accepted as financially profitable by the investor.

**Financial internal revenue rate (FIRR)**, which is defined as discount rate that reduces financial net present value (FNPV) to zero\(^{11}\), was calculated, for the project of production of thermal insulation panels made of sheep wool, using the excel function. It was determined in the amount of 6.51 and it is higher than discount rate of 5%, which means that the project expressed ability to sustain itself financially, namely, that one can expect revenue from the invested with reaching the planned profit.

Financial inflow indicators (financial profitability of investment) and financial sustainability indicators show us that net incomes can cover total investment. It is obvious that this project can use the financial net revenue to cover total investment.

\(^{11}\text{Milan Cupic, ”Cost-benefit analysis”, Business Start-up centre Kragujevac, 2009}\)
Numerous economic and social benefits produced by this project need not to be monetised or financially put down in order to prove profitability of launching production of thermal insulation panels made of sheep wool.

However, we will identify social benefits of this project in the next chapter, explain them, and in some future study these benefits could be monetised, thus confirming the profitability of launching production of thermal insulation panels made of sheep wool.

ECONOMIC ANALYSIS

The purpose of the financial analysis is to determine financial inflow the project produces. In the economic analysis, we determine what are the advantages and disadvantages of the project for the society in general.

Unlike the financial analysis that relies on market prices in its calculation, economic analysis uses the valuation prices (accounting or shadow prices). Valuation prices respect the Social Discount Rate – SDR, which present the inflow which is, from the point of the society in general, minimum acceptable. SDR can differentiate from the financial discount rate due to market imperfections, however, traditional approach, which recommends having the discount rate equal to financial discount rate, can also be accepted.

Three steps are implemented in the process of development of economic analysis within the cost – benefit analysis:

1. Conversion of market to valuation prices
2. Inclusion and monetisation of non-market (non-financial) benefits of the project
3. Discounting assessed costs and benefits and calculating project economic inflow indicators

As we determined and explained in the financial analysis, and for the needs of this study, it is not needed to additionally argue the profitability of launching this project in a manner of monetising social benefits of this project. Financial inflow and financial sustainability (FNPV and FIRR) show us that net incomes can cover total investment with making planned profit.

So, the economic analysis we’re doing here will focus only on identification of several social benefits that would come out of realisation of the project of production of thermal insulation materials made of sheep wool, and in this phase we will not monetise identified social benefits nor will we calculate their net present value by using social discount rate or social internal revenue rate – ERR.
IDENTIFICATION OF NON-MARKET (NON-FINANCIAL) PROJECT BENEFITS

In the contextual analysis of this study, we have quoted conclusions from the research made by Professor PhD Sanela Klaric who stated that “modern requirements of sustainable development recognised the characteristics of this natural material and advantages of its usage, so it, once again, gains a significant position in the modern development of building industry as a strategic branch of sustainable development in the EU and worldwide. Minimum adaptation and investment is needed for the existing traditional processing facilities for sheep wool so those facilities would become modern production facilities for insulation panels made of sheep wool.”

A series of advantages of sheep wool as natural material were identified: it reduces climate change danger, it has thermal characteristics that are on same level as conventional materials for thermal insulation, it is acoustic, provides noise protection, during processing, installation and recycling it emits the lowest level of CO2 in comparison to other thermal materials, it can absorb up to 40% of moist without changing its thermal characteristics, namely it keeps the moist till the moment of surrounding air being dry, then releasing the moist back naturally, with its local processing it can meet the affordable price in construction as thermal insulation element, through care for animals, their nurture, proper feeding and shearing actively participates in preservation of planet Earth, enables maintenance of biodiversity and autochthonous animal breeds on planet Earth, and so much more.

Launching project of production of thermal insulation materials made of sheep wool would produce, among others, the following social benefits that could be monetised, should further research demand it:

1. Sheep wool, as construction insulation material, uses a little primary energy and CO2 during production, installation, usage and recycling.
2. Sheep wool residue can be used as a natural fertilizer.
3. Launching production of insulation materials made of sheep wool revives infrastructure for sheep breeding, shearing and wool buying.

Benefit 1 – Sheep wool, as construction insulation material, uses a little primary energy and CO2 during production, installation, usage and recycling.

Carried out research on environmental impact of some traditional natural and artificial insulation materials, including sheep wool, determined that coconut fibres, cellulose, flax and sheep wool have the least environmental impact.\(^{13}\)

![Diagram showing Global Warming Potential for certain materials](image)

**Picture 1:** Global Warming Potential for certain materials; Source: Asdrubali F. (2006); Survey on the Acoustical Properties of New Sustainable Materials for Noise Control, Euronoise, Tampere, Finland

Advantage of natural sheep wool is huge in comparison to other materials on the market. In his book “Environmental Design”, Max Fordham stated that, if used locally, this material spends very little primary energy and CO2 during production, installation, usage and recycling.

According to already mentioned researches that were, in cooperation with researchers from Technical University in Vienna (prof. Korjenic and prof. Bednar), carried out by Professor PhD Sanela Klaric, one of the key parameters for establishment of environmental balance is cumulative energy demand – KEA. KEA is the amount of energy certain material uses for construction or certain construction for its duration, in direct or indirect sense. Some construction materials mark KEA with MJ/m³. For the needs of this research and for the purpose of comparison, KEA value is recalculated in MJ/m².

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\(^{13}\) Asdrubali F. (2006); Survey on the Acoustical Properties of New Sustainable Materials for Noise Control, Euronoise, Tampere, Finland
Research results show that construction with calcium-silicate plate consumes the least energy. However, if one observes only insulation materials, then sheep wool shows the biggest energy savings.

Research speaks for the benefit of the fact that sheep wool, if used as construction insulation material, consumes a little primary energy and CO2 during production, installation, usage and recycling. This social benefit can be, for the purpose of some further research, monetised.

**Benefit 2 – Sheep wool residue can be used as a natural fertilizer**

Due to collapse of textile industry in BiH, lack of support to development of sheep breeding and destruction of formerly developed infrastructure of buying stations, and low buying prices, the breeders are totally unmotivated to sell sheared wool in the market. Sheep wool becomes waste in time, waste that is hard to take care of due to its characteristics and longevity thus becoming an environmental problem.

Launching production of insulation materials made of sheep wool would re-stimulate production and market placement of this material, thus significantly reducing the costs of taking care of dumped wool and ecological waste that we have today.

Sheep wool is made of biodegradable protein so even after usage in constru-
ction it can be turned into and used as natural fertilizer and be used as an element for improvement of quality of agricultural land.

"By taking care of the material which is currently ecological waste and which is stored in an inappropriate manner in the nature, we are helping to heal planet Earth."

**Benefit 3 – Launching production of insulation materials made of sheep wool revives infrastructure for sheep breeding, shearing and wool buying.**

Launching production of insulation materials made of sheep wool with stimulation of sheep breeding in BiH creates conditions for revival of formerly well developed infrastructure of buying stations for sheep wool. Direct consequence of this revival is increase of employment in rural areas. We have described this social benefit in both contextual and financial analysis in this study.

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MULTICRITERIA ANALYSIS OF OPTIONS

Series of identified goals, effects and advantages of sheep wool, i.e. potential social benefits and costs, are not easy to monetise without a solid statistical database and further analysis. With the purpose of valorisation of impact of other effects of this project, we have carried out the multi-criteria analysis (MKA) that should show us which of the three defined options gives the best effects in comparison to the goals and benefits that we identified and formulated earlier.

First step in the MKA is formulation of option that will be scored (in section 4 - Analysis of feasibility and options) as well as the criteria for grading the given options. Identified and formulated criteria are given a score of their significance in relation to the total result of the multi-criteria analysis.

Table 8: MKA Criteria and their significance

<table>
<thead>
<tr>
<th>CRITERION</th>
<th>SIGNIFICANCE</th>
<th>PONDER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usage of primary energy and CO2</td>
<td>100</td>
<td>0.21</td>
</tr>
<tr>
<td>Wool as waste-pollutant (elimination of environmental problem)</td>
<td>80</td>
<td>0.17</td>
</tr>
<tr>
<td>Biodegradation (wool as a natural fertilizer)</td>
<td>60</td>
<td>0.13</td>
</tr>
<tr>
<td>Possibilities for support to this project by existing infrastructure for wool production and buying</td>
<td>100</td>
<td>0.21</td>
</tr>
<tr>
<td>Increased employment in this sector</td>
<td>80</td>
<td>0.17</td>
</tr>
<tr>
<td>Financing and financial sustainability of the project</td>
<td>60</td>
<td>0.13</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>480</strong></td>
<td><strong>1.00</strong></td>
</tr>
</tbody>
</table>

Source: The authors

As one can see in the table, the biggest significance was given to effects of usage of primary energy and CO2, as well as to possibilities of support to the project by the existing wool production and buying infrastructure, and then to increased employment in this sector, since establishment of production and increase in production and export directly impact the economy rate growth. We score all options per individual criterion in the next step.
Table 9- Scores for options per each MKA criterion

<table>
<thead>
<tr>
<th>CRITERION</th>
<th>OPTION I</th>
<th>OPTION II</th>
<th>OPTION III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Wool buying (2400 t)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Realistic buying (1200 t) and washing in Visoko</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Usage of primary energy and CO2</td>
<td>100</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>Wool as waste-pollutant (elimination of environmental problem)</td>
<td>100</td>
<td>60</td>
<td>80</td>
</tr>
<tr>
<td>Biodegradation (wool as a natural fertilizer)</td>
<td>100</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>Possibilities for support to this project by existing infrastructure for wool production and buying</td>
<td>10</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Increased employment in this sector</td>
<td>100</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Financing and financial sustainability of the project</td>
<td>60</td>
<td>100</td>
<td>80</td>
</tr>
</tbody>
</table>

Source: The authors

In order to mathematically make a decision on which option is the most beneficial, we have multiplied the scores per each criterion with pre-calculated criterion’s ponder value.
Table 10 – MKA: Pondered score of provided options

<table>
<thead>
<tr>
<th>CRITERION</th>
<th>OPTION I</th>
<th>OPTION II</th>
<th>OPTION III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Wool buying (2400 t)</td>
<td>21</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Realistic buying (1200 t) and washing in Visoko</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Realistic buying and procurement of washing machines</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Usage of primary energy and CO2</td>
<td>21</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Wool as waste-pollutant (elimination of environmental problem)</td>
<td>17</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>Biodegradation (wool as a natural fertilizer)</td>
<td>13</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Possibilities for support to this project by existing infrastructure for wool production and buying</td>
<td>2</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Increased employment in this sector</td>
<td>17</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>Financing and financial sustainability of the project</td>
<td>8</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>76</strong></td>
<td><strong>83</strong></td>
<td><strong>78</strong></td>
</tr>
</tbody>
</table>

Source: The authors

On the basis of the research and conclusion that we reached in this project feasibility study, we have tried to objectively score each of the options per each formulated criterion.

Realistic option of production of insulation panels with available buying of unwashed sheep wool in quantities of 1,200 tons per year, using existing facilities for washing and protection of wool (machine washing in Visoko), was scored per defined criteria as the most efficient one, which was already confirmed in the earlier analysis (contextual analysis, analysis of feasibility and options, financial and economic analysis).
RISK ASSESSMENT

In terms of financial and economic analysis of the project, there is always the danger that proponent of the project did not do a good job assessing all project parameters. For that reason, analysis always includes the risk assessment.

Risk consists of insecurities related to future effects of the project and can be measured and analysed. In the section focused on risk assessment we will examine the sensitivities of the project [identify key project factors and quantitative analysis of the impact of key factors on the project].

SENSITIVITY ANALYSIS

The sensitivity analysis is focused on identifying key factors of the project. These are factors whose positive or negative changes have the biggest impact on financial and economic profitability of the project.

As a general rule, key are those factors whose change in the estimated value for 1% causes changes in net present value of the project by more than 1%.

Below is the list of the identified project factors.

Table 11 – Identification of key factors

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>POSSIBLE FACTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL INVESTMENT</td>
<td>Inflation rate, change in price of products and services, decreased levels of financing, failing to meet deadlines...</td>
</tr>
<tr>
<td>BUSINESS EXPENDITURES</td>
<td>Inflation rate, change in price of products and services, change in price of work force, changes in prices of energy generating products...</td>
</tr>
<tr>
<td>BUSINESS REVENUES</td>
<td>Political instability, insufficiently researched and instable market, inadequate projects, reduction in funds...</td>
</tr>
</tbody>
</table>

Source: The authors
QUANTITATIVE ANALYSIS OF THE IMPACT OF KEY FACTORS ON PROJECT

After identifying factors, we produced quantitative analysis of the impact of key factors on economic net present value (ENPV) of the project, based on the criteria that key are those factors whose channel in value of 1% will cause the change in net present value of the project for more than 1%:

Table 12 - Quantitative analysis of the impact of key factors on ENPV

<table>
<thead>
<tr>
<th>CRITICAL FACTOR</th>
<th>VALUE OF THE FACTOR</th>
<th>% CHANGES OF FACTOR</th>
<th>NEW FACTOR VALUE</th>
<th>ENPV</th>
<th>NEW VALUE OF ENPV</th>
<th>% CHANGE OF ENPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL INVESTMENT</td>
<td>2.410.000</td>
<td>1%</td>
<td>2.434.100</td>
<td>18.875.788</td>
<td>18.899.888</td>
<td>0,13%</td>
</tr>
<tr>
<td></td>
<td>2.410.000</td>
<td>-1%</td>
<td>2.385.900</td>
<td>18.875.788</td>
<td>18.851.688</td>
<td>-0,13%</td>
</tr>
<tr>
<td>AMOUNT OF BUSINESS EXPENDITURES</td>
<td>19.139.400</td>
<td>1%</td>
<td>19.330.794</td>
<td>18.875.788</td>
<td>19.067.182</td>
<td>1,01%</td>
</tr>
<tr>
<td></td>
<td>19.139.400</td>
<td>-1%</td>
<td>18.948.006</td>
<td>18.875.788</td>
<td>18.684.394</td>
<td>-1,01%</td>
</tr>
<tr>
<td>AMOUNT OF BUSINESS EXPENDITURES</td>
<td>42.840.000</td>
<td>1%</td>
<td>43.268.400</td>
<td>18.875.788</td>
<td>19.289.194</td>
<td>2,19%</td>
</tr>
<tr>
<td></td>
<td>42.840.000</td>
<td>-1%</td>
<td>42.411.600</td>
<td>18.875.788</td>
<td>18.462.382</td>
<td>-2,19%</td>
</tr>
</tbody>
</table>

Source: The authors

As the table indicates, overall investment are not key factors of the project. Overall business revenues are key factor of the project because they impact significantly the project effects, i.e. change of value of this factor for 1% will change net present value of the project for over 1% ( +/- 2.03%). Business expenditures are very close to key project factors.
CONCLUSION

The research confirmed that sheep wool is an ideal material for insulation in buildings. Our local wool is of low quality in terms of fine textile industry, however its characteristics do meet the standards required for production of insulation panels for buildings. BiH has a tradition of sheep breeding, processing and producing sheep wool, as well as qualified work force, while at the same time great quantities of this material are not used or adequately treated.

Very developed infrastructure of wool buying through collection stations from the past, could be revitalised with some additional investment. The production of sheep wool thermal insulation panels in BiH, with its current infrastructure and qualified work force, could produce good and competitive products for the demanding EU or US markets. In addition, production can be easily adapted in the current facilities. Only the last stage of the production process for wool thermal insulation panels is different and requires specialised machines.

Its usage for production of building insulation elements reduces CO2 emissions resulting from processing, installation and recycling. Waste from sheep wool may be used as an element for improving the quality of agriculture land. By taking care of the material which is currently ecological waste and is disposed of inadequately in nature, we help heal planet Earth. Thermal qualities of wool, well known from ancient times, have been the greatest influence on the building sector to become interested in this material.
This feasibility study established that investments into production of thermal insulation materials out of sheep wool would be profitable for the investors. The indicators of Financial Net Present Value (cost-effectiveness of the investment) and Financial Internal Return Rate (FNPV and FIRR) show that net revenues can cover overall investment and get to the planned profit.

At the end of this study, in view of indisputable advantages and benefits of this traditional, natural, biodegradable and long lasting material with extraordinary hygroscopy, low CO2 emissions and small consumption of primary energy, we deem it necessary to recommend future research in BiH and the region to focus on other options in terms of wool production, advantages of combining wool with other natural materials such as wood, clay, lime, straw, and other advantages of clean technologies.