Environmental and Climate Technologies
doi: 10.2478/rtuect-2013-0005
2013 /11

Sustainable Development in Estonian Mining

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***Abstract* – Importance and demand of high qualified mining material (carbonate rocks, oil shale) are growing nowadays. Deposits are widespread around the world. Is it possible to create the sustainability paradigm, that helps to manage quarries adequately to improve overall effectiveness of the company in total? This study focuses especially on the mining industry. This paper will introduce modern systems and a new one, that allows to make an indexation of the company by mining sustainability index and gradation of the company by its wellness; also brings several benefits for future sustainable development.**

***Keywords* – Sustainability Assessment, carbonate aggregates, oil shale mining**

I. Introduction

Estonia has an increasing demand for carbonate rock aggregates of very high quality. The investigation in this research paper was carried out in the conditions of the Estonian company Väo Paas LTD (Germany and Finland subsidiary company), Eesti Põlevkivi LTD company ash sales department in OSAMAT LIFE+ 09/ENV/EE/227 project frame, road building company Matthaei Ehitus LTD and in cooperation with the Tallinn Technical University Department of Mining. The research is based on different deposits and geological conditions in different parts of the country, as well as central Estonia Kareda dolostone (77,6 ha) quarry and north Estonia Tondi Väo limestone quarry (48 ha). Quarries are located in high populated areas. In Väo quarry drilling blasting excavates limestone deposit rock. Selective excavation is not currently applied. Derived from limestone by rotor crusher and then sieved to obtain different fractions of the aggregates. The same excavation processes were followed at the Kareda dolostone quarry. Output aggregates go to road, railway and building construction, concrete aggregates and concrete mixtures stuffing, also for unbound mixtures composition. Each area of usage is followed by EN (European Normative) standards which are valid throughout the European Union. The results of the current thesis topic test may also be used for research in other EU countries. The basis of this research is to find solutions to improve the situation in the mining industry today.

The most important locations for mining in Estonia are the Ida-Virumaa County with its oil shale mining for electric power stations (about 15 million tons annually), and the Harjumaa County, which holds second place in total mining and the first in raw building material mining. In Harjumaa County in 2008,1746 000m^3 carbonate raw materials 1746 000m^3 and 49 800m^3 of pure limestone were extracted for technological use [1].

The Estonian oil shale deposit is located in the north-eastern part of the country. The oil shale bed has a form of a flat bed slightly inclined (2 – 3 m per km) southward. The commercial oil shale bed and its immediate roof consist of oil shale and limestone seams. The main roof consists of carbonate rocks of varying thickness. Characteristics of the individual oil shale and limestone seams are rather different. The strength of the rocks increases southward. The underground mining works are conducted at a depth 35-65 m, but at the southern border of deposit mining the depth will increase up to 120-130 m, notable increases overburden and its pressure to pillars [21]. The thickness of the commercial oil shale seam is about 2.8 m. The waste rock separated from run of mine, the proportion of which is approximately 40%, is suitable for production of construction and backfill material [22].

In Estonia, oil shale has been used for over 90 years mainly for production of electricity and oil, with the generated ash, which has been used for light brick production and cement. Oil shale usage has always been related on available mining and processing technologies on the one hand and world oil and petroleum prices on the other. This also holds true today when new technologies are being applied at power or oil processing plant [2].

Limestone companies in Estonia are mostly located in Harjumaa County which is located in northwestern Estonia, on the southern shore of the Gulf of Finland, about 80 km south of Helsinki. Geologically this area belongs to the southern slope of the Fennoscandian shield, where the Precambrian Early Proterozoic crystalline rocks of age 2.0-1.3 Ga are covered by sequence of the Ediacaran and Paleozoic sedimentary rocks with age between 600 Ma and 359 Ma in Estonia. In the Harjumaa County there are being registered 16 carbonate stone deposits, four of them: Vasalemma, Harku, Nabala, and Väo are listed as deposits of country-wide importance [10].

To develop advanced mining technologies and to evaluate the practical output of mining companies' competitiveness in Estonia on the basis of the consumer's wishes and needs, sustainable development should consist of obtained data modernization with the unique system, which can be useful also in the country's development plans, mining designs and in teaching and scientific work.

Sustainability Assessment helps to identify the weakest or the strongest company aspects, which determine sustainability: economics, environment, technical feasibility, socio-cultural aspects. Sustainability Assessment can be used with large-scale matrix methodology in carbonate stone quarries and with small-scale for oil shale mining. Sustainability Assessment is useful for company owners, administration, staff and potential purchaser.

II. Previous Study

In the frame of this research a review was made of the sustainability field of existing researches in different countries. They confirm the necessity of the new sustainable assessment for mining in module system.

The Estonian National Strategy on Sustainable Development, Sustainable Estonia 21, was approved by the Parliament of Estonia in 1995 and, accordingly, long-term plans of sustainable development are to be elaborated in the energy, transport, agriculture, forestry, tourism, chemical industry, building materials industry and food industry sectors. These plans consist of theoretical assumptions and are estimated by theoretical estimations and not focusing on the mining as well only stratifying the next years of country wellbeing [3].

The analytical publication of Indicators of Sustainable Development presents over 60 social, environmental, economic and institutional indicators in the following fields: equality, health, education, living conditions, security, welfare, atmosphere, land use, coastal areas, freshwater, biological diversity, structure of economy, pattern of consumption and production, environmental economy, institutional capacity. The data of other countries and the European Union data have been presented for comparison. The indicators are presented in accordance with the list of the United Nation Commission of Sustainable Development and the Statistical Office of the European Communities. Most recent data is for the years 2003 or 2004. The regional dimension is also presented where possible. Indicators are supplemented with definitions and comments on data. Information has been provided in overviews, tables, diagrams and thematic maps. Materials are addressed to the users more interested in the subject history. The important precondition for achieving success in carrying out the sustainable development strategy is the sustaining of the self-renewal capacity of renewable resources and using non-renewable resources according to clear rules and at as low rate as possible, foreseeing the possibilities for replacements in the future [4].

Enno Reinsalu's research for oil shale mining can be useful as a good example of economic analysis in conditions of mining in Estonia and to help in determination of the company wellbeing, because it allows to measure such a parameter like a company's possible lifetime and also to make an outlay analysis, its calculation and price calculations. Results are shown in the table and graphically also for quick illustrative purposes. The data used in the economic analysis has some similar aspects. Oil shale quality analyses are too specific and cannot be applied for carbonate stone mining, only for the energy materials. Sustainability is not measurable and understandable immediately; it depends on the resources of the universality, scope of application, the efficiency of use, the consumption gain factors, environmental safety, etc.

In research for oil shale mining it is possible to measure predicted mining capability, minimal output production, mining capability reserve and deficit, mining capability boost, necessary investments for machine purchases (medium or large sized). Economic activity balance and consumption forecasts were done for the next years, price modelling were calculated also. As a result, proposals to improve the management were offered. Mining costs increase due to high prices of purchased materials, especially explosion and metallic prices, also salary increase. The main idea is that the company mining capability depends on productivity [5].

Another useful research Building for Environmental and Economic Sustainability (BEES) is used in the United States of America for building constructions. BEES is an elaborated computer program and it measures the environmental performance of civil engineering products. For measurements it uses the life-cycle assessment approach specified in the standards of ISO 14000. All stages of construction engineering are analyzed: raw material purchasing, manufacture process, transportation, installation and construction as well as waste management and recycling. Economic performance is measured with the help of American Standards, which cover all costs [6].

Risk Assessment Methods in Estonian Oil Shale Mining Industry research is related to the mining industry, there are various conventional methods available; however, methodology shows the greatest promise for defining hazardous influences. It allows to develop methods for avoiding or reducing negative factors. The method helps to solve quickly, conveniently and qualitatively operate, find optimum variants for existing problems in oil shale mining industry, to predict with the minimal expenses during the project stage how to flexibly avoid the subsequent problems. The method is based on statistical analysis and consists of three general approaches depending on the type and quality of the assailable data. Method involves the following problems: stability of a mining block, application of advanced mining technology; extraction of mineral resources, loading, transportation and their influence on the environment. The risk assessment can be used for different purposes and at different levels: as a basis for decision-making while selecting among the different remedial actions for a mined out area within time and financial restraints; to relate ground surface subsidence risk levels to acceptable risk levels established by the society for other activities. The results of the risk assessment are of particular interest for practical purposes. Risk assessment methods are applicable in various fields of Oil Shale mining production [14].

For the southern countries and African countries (Uganda, Tanzania, Mozambique, Lao PDR etc) a Toolkit is created by ASM (artisanal and small-scale mining) system that can lead to improve policies, extension services, interactions between the large-scale mining companies and the artisanal miners—and ultimately, to improve development impacts for men, women, and artisanal mining communities. This is a very important tool to improve the situation in those countries. Whether newly begun or long established, ASM has the potential to help men and women out of poverty when conducted in an informed and responsible way. In different communities, different techniques are used, and men and women share different divisions of labor, risks, and opportunities.

Understanding the social, economic, and environmental aspects of ASM is essential for governments, nongovernmental organizations, mining companies, and researchers to be able to contribute to positive socioeconomic and environmental outcomes from this sector. This Toolkit—including the detailed analytical framework and instructional modules—is a unique instrument to guide research and researchers to ask the right questions and come to a gender-sensitive understanding of ASM activities [15].

The appearance of the "sustainable development" is a responsibility concept in the mining of natural resources, which allows to make corporations useful by applying a long-term environmental management. For this purpose a Sustainable Development Model (SDM) framework was created to illustrate the integration sustainable development into the "whole" ecosystem. The ecosystem approach is a framework that covers the natural environment opportune futures and enforcements. This management model system uses four main components that determe resource development for products that require disposal into the environment: use of land, water, and atmospheric resources and an outcome assessment process. Quality of the processes is governed by standards, permits and limitations; it helps to measure the ecosystem productivity. The main idea of Sustainable Development is to achieve whole ecosystem sustainability [19]. This framework also provides a four matrix system as a decision support model.

Nowadays existing and popularized methodologies, like life-cycle assessment approach, specified in the International Standards Organization ISO 14004 "Environmental management systems", EMAS Easy system, Waste water Exergia analyze and Occupational Risk Assessment by British Standard OHSAS BS 18801 „Occupational health and safety management systems" are using different data, which is strictly directed to separate fields of this investigation not absorbing all necessary ones (economics, technical feasibility, socio-cultural indicators).

Interest in the environmental capacity of organizations is growing incessantly. Working and operating without taking into account the environmental investigations and importance of company activities becomes almost impossible. Different companies with a professional activity accession to environmental challenges look for new methodologies to improve their environmental performance. EMAS is the premium environmental management system which can help to achieve this. This system helps to promote productivity, credibility and transparency of companies. At the present time, more than 4,500 organizations and almost 7,800 sites all over the world are using EMAS system [4].

A solution to the sustainability paradigm problem cannot be solved with existing trials – they are circumstantial and oblique for mining. Sustainability Assessment, helps to identify the weakest or the strongest company aspects of the four, which determine sustainability: economics, environment, technical feasibility, socio-cultural. Assessment can be used in the full version for carbonate rock quarries and in an abbreviated version for oil shale mining. A brief version of the analysis could be also done without any economic calculations. In that case, the results can be observed graphically and can be more easily perceived visually than tables (Fig. 1 and Fig. 2).

III. Analysis Methodology

This research gives a convenient method for the gradation and sustainable assessment analysis of carbonate aggregates excavated on Estonian quarries and deposits, also brings future suggestions for the sustainable development. Investigation has shown that no one nowadays used approach does not indicate the company and does not check the achieved results by formulas. The Sustainability Assessment methodology will be demonstrated in detail in the next paragraph.

Research is focused on working out an analysis, which consists of a unique evaluation system. In order to carry out an optimal analysis of sustainability, a Module Analysis should be used. This analysis uses a matrix table containing influence risk values, where the final product considered as a process and overall matrix is divided usually into four modules or parts: Economical, Environmental, Technical and Social–Cultural. There are a number of indicators in each module, which are used for assessment of mining sustainability (described on Fig. 1. and Fig. 2). The indicators used in the module analysis are determined by Estonian legal acts and standards. Being mostly based on European Union standards, directives and regulations, these include the Mining Law, Water Statute, Waste Statute, Waste Oil Management Requirements, Municipal Waste Sorting Procedures, Fire Safety Requirements, Occupational Health and Safety Acts, etc., 39 in total [16].

Sustainable Assessment consists of a four module system, each module is divided into different indicators; which are considered as a process and measured by risk level (Table I).

Economical and environmental part of this methodology consists of a selective analysis of the annual reports and obtained data modernization. For assessment of economical sustainability different parameters should be used, taking Pareto principle as a basis. Sustainability supposes that all parameters and processes are important and should be equal [6].

For quick and easy environmental analyze could be used not only annual reports but also mapping idea by ecomapping EMAS Easy system, it is advised to use a map of the whole territory of the open-pit mining with aquifers and mining allotment area as it is shown in the example (Fig.4).

Ecomapping is an easy technique to note different environmental impacts and problems. The most important environmental information of the company is gathered systematically and is followed by local legislatives and standards requirements. This systematic method builds up a picture of environmental information on a map or plan of the site by using simple symbols. Ecomapping helps to very easily understand visually environmental impacts which are positive for company owners, employees and stakeholders. It also permits to get more people involved at the early stage of an environmental problem [17].

TABLE I

Risk Control Action Plan [13]

Level of Risk	Action Plan
Invial	No actions required, no need to keep records
Tolerable	Existing controls are adequate, but monitor to ensure this is required
Moderate	Implement, with deadlines, measures to reduce risk. Take into account the cost of effectiveness of such measures.
Substantial	Stop work until risk is reduced, allocate sufficient resources to significally reduce the risk.
Intolerable	Stop work until risk has been reduced, this may necessitate the allocation of unlimited resources.

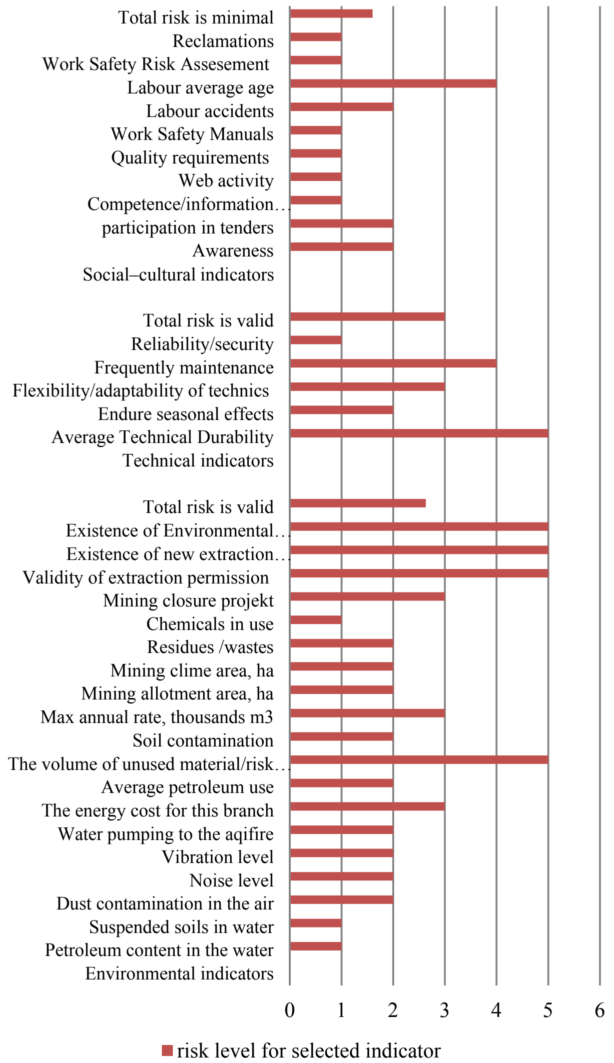

Fig. 1. Kareda dolostone- central Estonia quarry analysis results observation

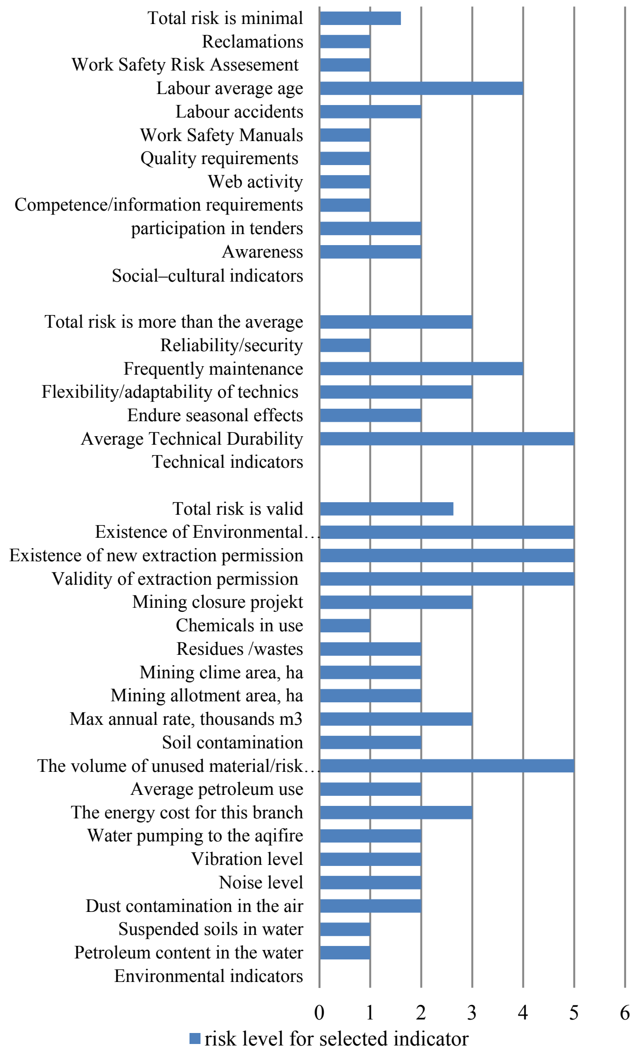

Fig. 2. Observation of north Estonia Tondi – Väo quarry analysis

Assessment steps can be easily followed by the Fig. 3, where it shows, that all the results should be controlled and only after that indexation of the company wellbeing and sustainability can be made. Indexation value leads to goals achievements and helps to specify the solutions for sustainability improvement. Sustainable Module analysis can be held by introduced module in Fig. 3.

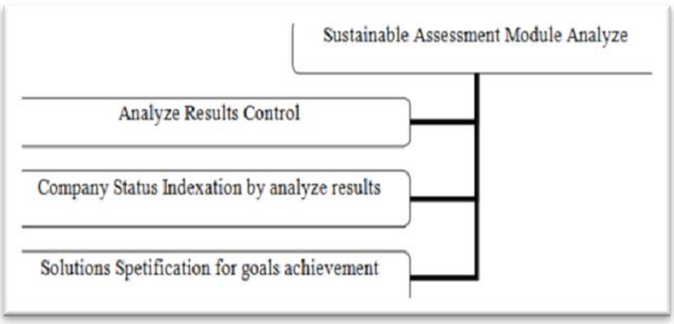

Fig. 3. Sustainable Assessment Analyze Steps

IV. Results Control

After each module parameter was measured by risk level, results control should be made by the following equations.

For economic indicators summarized trading income could not be approximately equal to economical activity profit (1) and summarized trading income should be greater than its economical activity profit (1). If the company is divided into different branches, then additional economic control should be calculated for branches in that case branch summarized trading income should be greater than 20% (3).

$$TI_{SUM} \neq EAP \quad (1)$$

$$TI_{SUM} > EAP \quad (2)$$

Where TI_{SUM} is summarized trading income and EAP is economic activity profit. Module analysis should be done also for branches using additional data control of economic parameters in comparison with all company data.

$$TI_{SUM}>20\% \quad (3)$$

Control of Environmental Indicators and risk data is available by the next equation, taking into account the country's (Estonia in this case) ecological footprint (FP_{EST}) in gha/pers if divided by an average value environmental indicators (RL_{ENav}), then risk levels for environment (RL_{EN}) should be alike if the data is correct. (4) is valid thru also for dolostone mining, and is improved by the research. For the other European countries should be used appropriate ecological footprint in gha/pers taking into account country location.

$$RL_{EN} = FP_{EST} : RL_{ENav} \quad (4)$$

Control of Technical indicators and Feasibility should be calculated for Average Technical Durability as (5), where summarized years of machines divided to amount of the machines, this parameter should not be larger than 7 years, in other cases the risk is higher than 2 points.

$$\Sigma TDn : n \leq 7 \quad (5)$$

After that the company status indexation should be made using analysis data and its results and next equation (6). Last step of the sustainable assessment is solutions specification and probably suggestions giving for main goals achievement. Obtained analyze results are estimated by theoretical work and experts opinion, also experimental data was controlled by different formulas in several research activities.

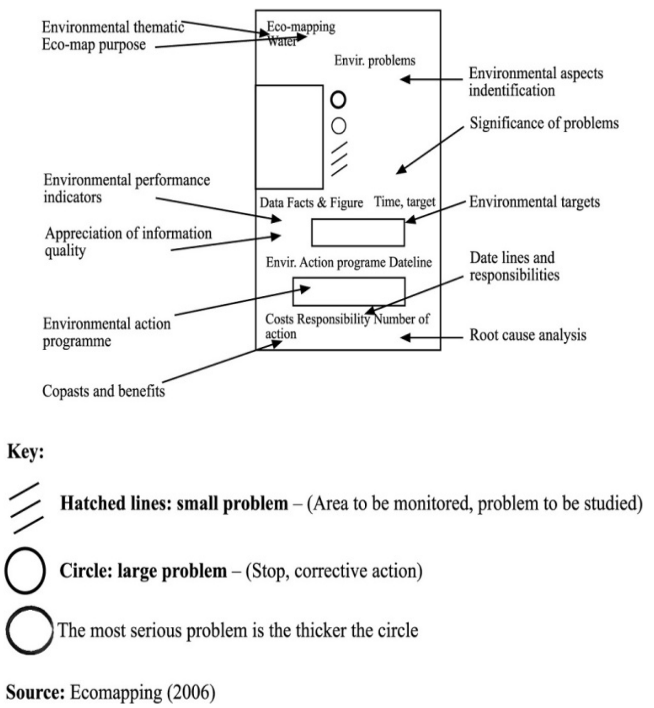

Fig. 4. Ecomapping example scheme with explanations

V. Company Status Indexation

The gradation of company wellness could be estimated by the average of all Sustainable Assessment parameter values as (6) shows, where Ec_i – is average value of Economic Indicators Sustainable Assessment, En_i – is average value of Environmental Indicators Sustainable Assessment and SC_i – is average value of Socio-Cultural Indicators Sustainable Assessment and T_i – is average value of Technical Indicators. Thereafter the Mining Sustainability Index (MS_i) is always a whole number and can by estimated by five basic grades:

Five points „V“ - Company is Sustainably Developed

Four points „IV“ – Successful Company

Three points „III“-Quite Successful Company, but additional activities should be taken to improve the situation

Two points „II“ – no positive activity

Zero till one point “I” – no outcome activity [5].

$$MS_i = 5 : [(Ec_i + En_i + SC_i + T_i)/4] \quad (6)$$

Mining Sustainability Index (MS_i) also shows a possible price range enterprise of mining company in case of purchasing this company. The higher the index, the more successful the company is - accordingly the price should also be higher. It is possible to increase the Mining Sustainability Index (MS_i) after sustainability analysis has been done; it requires investments to be made to the weakest aspects or suggestion improvements which will be described below.

VI. Suggestions for Sustainable Development

After the analysis was held according to the results for companies, where the Mining Sustainability Index (MS_i) is lower than 4 future proposals could be given for sustainable development. If Sustainability Index remains stable at the point 4, additional actions should be followed only by the module analyse table. If Sustainability Index is less than 4 points, then most advantageous solutions could be:

- Right choice of technique and its influence to extracted material. Obviously for the hard rock materials blasting is still the best way to get raw material, because it allows getting maximum better quality. The quality of produced raw material and macadam depends on both, as well as production technology and also deposit properties (especially of compressive strength). The coarser the raw material, the better the aggregate properties will be, because the grain becomes smaller only in latest crushing progress stadiums [8].
- Development of new generation equipment has given good results. For example, the new generation of cone crushers is not working only on pressing method, but also the impacts are added into process.
- Control of the process by using special sensors can give certain results for material quality improvement. If we keep the cone feeding rate on the same level of about 80%, the material pieces will not be crushed by each other. It will reduce the percentage of waste.
- Correct choice of electrical drives increases efficiency and sustainability of mining. As mining machines work in hazardous conditions e.g. higher humidity, dust etc that has an enormous influence on their lifetime and productivity.

- Many used electrical drives and their control systems are out of date. Hence they have low reliability and require more maintenance [7].
- Sales increasement and new customers search with market opening up for fill materials technology using residue materials. In the Estonian mining industry, a wide assortment of fill materials is available. These materials require careful selection of aggregates as a component part in fill mixture. Usable investigation methods and getting results are applicable for different aggregates as a component part in fill mixture [10]. Conversion of industrial waste into valuable and environmentally friendly products is highly important at the moment in the EU as well as all over the world. In general this products will address the challenges of European policies and legislation concerning waste and promote waste recovery and sustainable recycling with a focus on life-cycle thinking and the development of recycling markets [11].
- A successful mining company should produce qualitative materials and aggregates, as the fact it is important to held and arrange particularly precise quality analysis. Previous research has shown, that the higher the percentage of fines content at the sieved raw material - the less fines content should be in other aggregates from the same crusher. If the fines content is consistently stable, then the content of other aggregate fractions should also be consistently stable. Otherwise, we can confident that this is some problems with the crushing process on the crusher itself [12].
- Working actively with the staff, training and competence rising of the employees of all ranks.
- Attracting new investors or sponsors and participating in different tenders.
- Occupational risk assessment defying , safety manuals and its check-up's, carrying out a systematic operational audit, informing employees about working environment risk factors, organizing health check-ups for employees, carrying out the elementary - introductory instruction for an employee starting to work for the enterprise. If necessary, carrying out a supplementary instruction.
- Realization of environmental management systems, which should also be an important part of the management system of the company: controlling, diminishing and preventing environmental problems from the activities of the company and as a result improving its competitiveness. In Estonia, companies have a choice between two systems: the international environmental standard ISO 14001 or EMAS (the European Union Eco-Management and Audit Scheme) [3].
- Process optimisation by minimising costs, minimising energy use and land area required, minimising waste productions; clean water, maximise the score of qualitative sustainability indicators [20].

VII. Conclusion

Sustainability Assessment and Sustainable Development for Estonian Carbonate Quarries is a comparative investigation. This research is collaboration between several local Estonian mining companies and institutions. Scientific work determined the sustainability assessment by module analysis in conditions of Estonian mining taking into account all risks of activities.

The expected result of the study is to explore a new analyzing methodology firstly for sustainability assessment in mining management. A specific monitoring tool and indicators were developed in order to access each branch of mining (Economical, Environmental and Technical Feasibility and Social–cultural indicators). Sustainability Assessment consists of module analysis. For the adequate data and results control were elaborated a complex of equations, which allows to control achieved results. Another nowadays used technologies do not propose a data check-up's with equations After that, some main recommendations and suggestions were made to improve sustainability of mining company.

Sustainability Assessment for Estonian Carbonate quarries helps to identify, manage and reduce different risks and weakest aspects associated with mining company services, business operations and products and it is a decision support model. Assessment serves as an advisor for best development and future company wellness. It gives a possibility for company personnel to monitor and contribute to the mining process, while the nowadays used researches are not committed with data of carbonate rock quarries or mining. Research highlights all aspects needed for sustainable development and it is first and unique methodology, which was developed for quarries.

Analysis involves the monitoring of economic, environmental, technical and social performances in every quarter of the year. The methodology is very useful and defines itself by used methods and relevance for developing future wellbeing program and usefulness of its outputs: like comprehensive training model and technique tool; it could be used by company owners and personnel, potential purchaser, foreign investors or consulting companies as well. Sustainability assessment indicates appropriated future strategies for mining management. The research question is the right one and matters to mining companies in Estonia and other European countries in different geological conditions.

Acknowledgment

Hereby special gratitude is expressed to the Estonian company LTD Väo Paas for providing all necessary data and great teamwork.

The research was also supported by the Estonian Science Foundation (Grant "Backfilling and waste management in Estonian oil shale industry" No ETF8123and grant ATF12007 "Sustainable and environmentally acceptable oil shale mining").

References

1. **Sõstra Y., Notton A.** The geological perspectives for Paleozoic carbonate raw material mining in Harjumaa County, Estonia. *9th International Symposium "Topical Problems in the Field of Electrical and Power Engineering", Doctoral Scholl of Energy and Geotechnology*, Pärnu, Estonia, 14-19.06.2010, Proceedings Tallinn: Elektriajam, p. 244 - 246.

2. **Väli, E.; Valgma, I.; Reinsalu, E.** *Usage of Estonian oil shale. Oil Shale*, 25(2S),2008, p. 101 - 114.
3. Estonian National Strategy on Sustainable Development, *Sustainable Estonia 21,* Approved by Riigikogu (Parliament of Estonia) on September 14, 2005, Available: http://www.envir.ee/166310, [Accessed: 15.03.2013]
4. Indicators of Sustainable Development, Statistics Estonia, 2006, http://www.stat.ee/29175, [Accessed 15.03.13]
5. **Reinsalu E.** „Eesti põlevkivi kaevandamise tõhustamise teaduslik alus“, Tallinn 1994, p. 3- 16
6. **Lippiat B.C., Boyles A.S.** CIB World Buliding Congress, *Building for Environmental and Economic Sustainability*, New Zeland 2001, Available: http://fire.nist.gov/bfrlpubs/build98/art033.html
7. **Sabanov, S.; Šommet, J.; Milaševski, I.; Bashkite, V.; Gulevitš, J.; Beldjaev, V.; Robam, K.** (2010). Sustainability assessment methods for developing advanced mining technologies. In: 9th International Symposium Pärnu 2010 “Topical Problems in the Field of Electrical and Power Engineering” and “Doctoral School of Energy and Geotechnology II”, Pärnu, Estonia, June 14 - 19, 2010:Tallinn University of Technology, 2010, 69 - 74.
8. **Šommet, J.** Influence of extraction methods on the raw material physic-mechanical properties of fillers. Zhao, J., Labiouse, V., Dudt, J.-P., Mathier, J.-F. (Toim.). Rock Mechanics in Civil and Environmental Engineering, CRC PRESS, 2010 p. 841 - 843.
9. Ministry of the Environment, Environmental management, Available on: http://www.envir.ee/67253, [Accessed: 31.03.13]
10. **Pastarus J.-R., Šommet J., Valgma I., Väizene V., Karu V.** Paste fills technology in condition of Estonian oil shale mine. *In: 9-th International Scientific and Practical Conference*, Rezekne, Latvia, 2013. Proceedings. Rezekne, in press.
11. OSAMAT LIFE+ 09/ENV/EE/227 Project overview, Available: http://www.osamat.ee/index.php/en/Projektist/project-overview.html, [Accessed: 1.04.13]
12. **Šommet, J.; Sabanov, S.; Pastarus, J.-R.** . Analyses of crushed limestone quality developed by different methods for conditions of sustainable mining. Проблемы Недропользования. Санкт-Петербургский Государственный Горный Инс, 2010, 189, p.133 - 135.
13. **OHSAS 18000 Toolkit:** Introduction to Risk Assessment, http://18000.drkeyboard.com/18000risk.htm, 15.05.2013
14. **Sabanov S.**, Risk assessment methods in Estonian oil shale mining industry, Tallinn : Tallinn University of Technology press, 2008 ([Tallinn] : Infotrükk), p. 10-11
15. Gender Dimensions of Artisanal and Small-Scale Mining, December 2012, Available: http://www.csmi.co.za/cp/cp_2012.asp, [Accessed: 10.04.2013]
16. **Šommet, J.** Sustainability assessment of Estonian oil shale mining. Oil Shale SE,2010 [in press]
17. Eco mapping - A Creative Tool of Environmental Management System(EMS) Implementation, EMAS "easy" for Small and Medium Enterprises, p. 4
18. **Koroljova A., Voronova V,** "Eco-mapping as a basis for environmental management systems integration at small and medium enterprises", Management of Environmental Quality: An International Journal, Vol. 18 Iss: 5,2007, pp.542 – 555
19. **Hannouraa A.P., Cothrenb G.M, Khairyc W.M.** The development of a sustainable development model framework, Energy vol. 31 (13) October, 2006. p. 2269-2275
20. **Adjiman, C. S., Schweiger, C. A., & Floudas, C. A.** Mixedinteger nonlinear optimisation in process synthesis. In D.-Z. Du, & P. M. Pardalos (Eds.), Handbook of combinatorial optimisation. Kluwer Academic Publishers, (1998). Available: http://titan.princeton.edu/bib.html [Accessed: 06.01.2011]
21. **Pastarus J.-R., Lohk M.,** *Waste management in Estonian oil shale industry.* Sustainable Developement in the Mineral Industry: Aachen International Mining Sumposia, Fifth International Conference , RWTH Aachen University, 14 – 17 June 2011. (Ed.) P. HN. Martens, T. Katz. Essen: VGE Verlag GmbH, Essen, 213 – 218.
22. **Tohver T,** *Utilization of waste rock from oil shale mining.* Tallinn University of Technology. Thesis on Power, Electrical and Mining Engineering D48. TTU Press, 2011, Tallinn, p.123.

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