TECHNISCHE UNIVERSITÄT BERGAKADEMIE FREIBERG

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SMART MINING

Development of an integrated model for sustainability assessment of a new "Smart Mining Technology"

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INTRODUCTION

The steadily growing population and the rapid industrialization of the world lead to a strongly growing demand for mineral materials including fluorite, copper and other strategic metals. Many of these minerals occur also in vein deposits. The extraction of minerals from vein deposits is becoming more and more important. However, conventional mining operation methods may not be feasible due to technological and economic restrictions. Hence, the development of an innovative extraction method to increase the selectivity and productivity in vein deposits is essential.

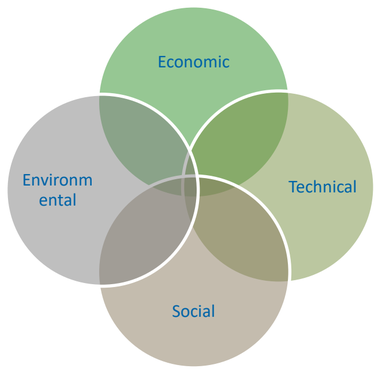
Within the research project “InnoCrush”, scientists at TU Bergakademie Freiberg develop an innovative “Smart Mining Technology” (SMT). The project focuses on the application of SMT in vein deposits with the intention to:

- develop and optimize a highly automated technology for high selectivity in mining and dry pre-concentration,
- develop an integrated model for the assessment of SMT related to economic, social and environmental benefits.

For the establishment of SMT, it is important to identify and assess its economic feasibility, its environmental impacts and its impacts on stakeholders. For this purpose, an integrated “economic-techno-enviro-socio evaluation model” will be developed.

The major objectives of the research work can be defined as follows:

- Cost analysis of the application of SMT,
- Assessment of the technical performance of SMT with Quality Function Development (QFD),
- Assessment of the environmental performance of SMT with Life Cycle Analysis (LCA),
- Assessment of social performance with stakeholder analysis,
- Evaluation of SMT with optimization model.



COST ANALYSIS OF THE APPLICATION OF SMT

The total discounted costs of the application of SMT are modelled. These costs comprise initial investment costs for equipment, initial overburden removal, construction, etc. and operating costs during the life time of the mine for labour power and water consumption, consumable materials, and maintenance. Total costs can be calculated by:

$$C = D_{t_0} + \sum_{t=0}^{m} \frac{OC_t}{(1+i)^t}$$

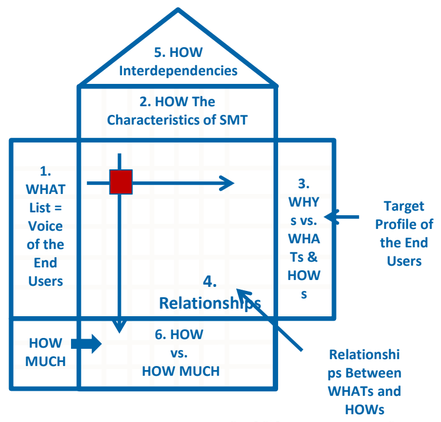
D_{t_0} stands for initial investment costs

OC_t represents operating costs in year t with $t = 1, 2, \dots, m$

i stands for the discount rate.

ASSESSMENT OF THE TECHNOLOGY PERFORMANCE OF SMT WITH QFD

This method enables the mapping and evaluation of needs and priorities of mine operators onto technical specifications of SMT to be designed:



- Identify the requirements of SMT users thought a questionnaire,
- Identify the technical specifications of SMT,
- Comparison of SMT with other mining methods with respect to the fulfilment of requirements of users.

ASSESSMENT OF THE ENVIRONMENTAL PERFORMANCE OF SMT WITH LCA

For each step of the life cycle, relevant inputs, such as energy consumption, water use, materials use and outputs, such as useful products, waste water release, waste are identified and assess with respect to their environmental impacts. As a result, an over-all impact on the environment can be calculated and assessed using the UMBERTO software.

ASSESSMENT OF THE SOCIAL PERFORMANCE OF SMT WITH STAKEHOLDER ANALYSIS

Though grouping and analyzing stakeholders and their intentions, the social impacts of and on a mining operation can be assessed. Identification and assessment of stakeholders.

EVALUATION OF SMT WITH OPTIMIZATION MODEL

All costs and technical, environmental and social benefits are integrated in an optimization model for providing a basis for decision-making on the application of SMT:

$$Minimize = \sum_{j=1}^{n} x_j C_j$$

$$Maximize = \sum_{j=1}^{n} x_j B_j$$

Subject to:

$$\sum_{j=1}^{n} x_j C_j \leq M \quad \text{with} \quad C_j = D_{t_0}^{j} + \sum_{t=0}^{n} \frac{OC_t^j}{(1+i)^t}$$

$$\sum_{j=1}^{n} x_j B_j \geq S \quad \text{with} \quad j = 1, 2, \dots, n$$

$$x_j = 0 \text{ or } 1 \quad \text{with} \quad \sum_{j=1}^{n} x_j \neq 0$$

x_j represents a decision variable identifying a component of SMT in a mining process taking the values 0 and 1. A value of 1 implies that the component is part of the process and a value of 0 implies that this component is not included. C_j represents the costs of component x_j, $D_{t_0}^{j}$represents the development costs of component x_j at time t_0, OC_t^j represents the operation costs of component x_j at time t

B_j denotes the benefit of using SMT defined as a function of its technical impact *T*, its environmental impact *E*, and its social impact *S*

M stands for the available budget

S stands for the minimal technical, environmental and social benefit which SMT must achieve.

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