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Cost-benefit analysis for the assessment of environmental aspects of mining industry

Key words

Life Cycle Assessment (LCA), Cost-benefit analysis (CBA), mining waste management

Abstract

Environmental issues are having an increasing influence on the mining industry. Mining and metallurgical processes are burdensome to the environment, mainly due to large bulk of material to be transported and processed. It is impossible to contain such extensive activities within a limited area so the spheres of influence cover considerable areas, even changing the landscape. The primary non-ferrous industries are particular examples of this, as non–ferrous ores contains only a few percent of metals. The rest of extracted mineral has to eliminate gradually in the successive stages of production. Thus, it is technology that decides the quality of the streams of separated waste and their total amount cannot deny the law of mass conversation.

Introduction

Waste from the mining industry represents a major waste stream in the EU, amounting to approximately 29% of the average waste annual production. In Poland and in other Associated Candidate States it represents higher value, as the mining industry had been extensive developed in central planned economy. Therefore, many Associated Candidate States are now the main European producers of mining waste, i.e. in Poland 49,4 Mt of waste came from mining industry (i.e. 36% of total produced waste) in 1999, and 43,7 Mt (i.e. 35%) in 2001; in Romania out of

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80 Mt of produced waste 49,4 Mt (61%) came from mining industry in 1999 (Environmental Protection, 2002).

Volume of mining waste[1] and cost of its management depend on the geological and technological characteristics as: geological settings, reserves characteristics, the type of mining operation (surface or underground mine), mining methods (recovery, dilution, etc.), the volume of the operation, applied processing methods as well as waste management activities, tailing dumps closure design and post-closure cost. The other costs of waste management depend on legislation in every country, environmental requirement and taxes levied on producers. Even, in EU there is a proposal for Mine Waste Directive, the environmental charges connected with mining waste management is regulated by country's legislation. Generally, for EU Member Sates there is no comprehensive overview of the effectiveness of environmental taxes, however data on tax revenues are collected on an annual basis and provide an indicator of the importance attached to environmental taxes and the way in which they have developed over time. Revenue from environmental taxation, expressed as a share of total tax revenue and social contributions, remained more or less constant during the 1980s, increased slightly in 1990s and has levelled off since then. On the three main categories in environmental taxation, energy tax contributes the most to revenue, followed by transport tax. Tax on pollution and resource continue to be of minor importance in term of revenue raised (Environmental Signals, 2002). Different situation takes place in Associated Candidate States, where share of environmental charges imposed on producers is significant. For mining producers — according to "Legislation on mining waste management in the Central and Eastern European Candidate Countries" — there are as follow:

Poland

In Poland the introduction of a minerals industry policy in 1989, which focused on sustainable development, resulted in implementation of high fees and fines for environmental pollution. According to Polish environmental legislation — every entity that uses the environment must pay for it. For non-ferrous mining production in Poland the main cost are connected with disposal of solid waste. The cost of placing 1 tone of non-hazardous tailings — according to latest Ordinance of Cabinet from March 18, 2003 — is 8,20 PLN/tonne, i.e. about 2 Euro/tonne (Dz. U. 03.55.477 from March 31, 2003, attachment No 1, position No 010381). It means that, the largest Polish non-ferrous metal producers, KGHM Polska Miedź S.A. pays about 15 M Euro yearly.

Estonia

There is a pollution tax concerning waste landfills, i.e. in practice, when part of mining waste is used on mining area it is not taxed, when it is landfilled outside of quarries (after enrichment), then it is taxed. It is regulated by Waste Act — passed June 10, 1998 entered into force on December 1, 1998.

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[1] Waste is defined according to the EU's Waste Framework directive, and in the context of mining this includes rock and overburden, whether inert or not, as well as tailings. They are defined as follow: overburden — the soil and rock that must be removed to gain access to a mineral resources, waste rock — rock that does not contain enough mineral to be of economic interest, tailings — a residual slurry of ground-up ore that remains after minerals have been largely extracted.

Hungary

According to Environmental Protection Act, the charges providing cover for the measures abating the loading and the utilisation of the environment are: environmental load charges, utilisation contributions, product charges and deposits. The magnitude of the charges shall be established in such a way that they should encourage the users of the environment to reduce the use of the environment. The charges shall be paid to specialised by law funds. No utilisation contribution shall be paid for the utilisation of an environment component for which the users of the environment pay mining royalities (Mining Act, section 20). The mining operators are not obliged to pay any other environmental charges either. However, in accordance with the Waste Management Act, the New Ministerial Decree on Mining Waste Management shall contain provisions on this issue. It is regulated by the Act XLIII of 2000 on waste management, which was published on June 2, 2000 and came in force on January 1, 2001.

Latvia

Dumping or escape of contaminants into the environment as a result of any kind of economic activities (including mining activities) are taxable in compliance with the law: "On the Natural Resources Tax". Based on the features of mineral production in Latvia, the above tax is levied on the air and water contamination as a result of production and processing of minerals. The calculation and payments are made each quarter. There is also tax for contamination, which is calculated based on tax rate for each unit of contamination. It is regulated by the law "On Waste Management" passed in 2000 and the following Regulations of the Cabinet of Minister approved in compliance with the above law in 2001 and 2002, e.g. no 191 — Regulations on the types of waste storage and processing (2001); no 15 — Regulations regarding requirements for the establishment of landfills, as well as management, closure and remediation of landfill and dumps (2002).

Bulgaria, Lithuania, Slovenia

There are no environmental fees, taxes or any other financial contributions for mining waste. Additionally, cost of waste management depends on special local authorities requirements, e.g. a fixed amount that has to be paid before production starts as an environmental bond to cover the cost of environmental rehabilitation of the mine site. Similar situation takes place in some EU countries, e.g. in Ireland in Lisheen zinc-lead mine, investor had to lodge a bond of value exceeding 16 M$ to secure closure and rehabilitation cost. In the same time 51% of the tailings was to be mixed with cement and used as backfill underground (MMSD 2002).

Cost of mine closure and reclamation calculation

Process of environmental rehabilitation, reclamation and mine closure is costly, and the capital should be gathered during the production stage. There are primarily two methods of accounting, used by mining companies:

— accrual of the estimated future environmental costs over the life of the mine on a unit of production method,

— accrual of the full net present value of the estimated future environmental costs with a corresponding increase in capitalised cost attributable to the mine.

All companies within the traditional mining bases dissolved an accounting policy with respect to the environmental rehabilitation, reclamation and closure cost.

Generally the companies used different methods, e.g.

— 33% of the companies that accounted for an environmental provision disclosed their total estimated future environmental costs,

— 38% of the companies that accounted for an environmental provision calculated the provision on a discounted basis, and 31% of these companies made a specific discount rate used. Only three companies made a specific distinction between decommissioning and other environmental rehabilitation, reclamation and closure costs (KPMG, 2003).

For example in Anglo American Corporation Limited estimated long-term environment obligations, comprising pollution control, rehabilitation and mine closure are base on the group management plans in compliance with current technology, environmental and regulatory requirements. The discounted amount of estimated decommissioning costs that embody future economic benefits is capitalised as property, plant and equipment when commercial production is reached and concomitant provisions are raised. These estimations are reviewed annually and discounted using a pre-tax risk-free rate that reflects current market assessment of the time value of money. The increase of decommissioning provisions is charged to net investment income.

Cost of waste management calculation

The improvement in environmental protection and environment conditions involves a corresponding increase in the investment expenditure on waste management system and in the operating cost incurred in every phase of mining productions. The identification of all costs of waste management and the development a transparent methodology for cost of waste management calculation would be possible after preparing full Life Cycle Assessment analysis (including Life Cycle Cost calculation) for an individual company. The main purpose of LCA is to identify and quantify the environmental impact of goods and services during their entire life cycle. LCC encompasses all the economic implications during the whole life cycle. LCC is defined as the sum of total costs estimated to be incurred in the design, development, production, operation, maintenance, support, and final disposal of a major system over its anticipated useful life span.

Mining producers can reasonably expect that implementation of Life Cycle Assessment and Life Cycle Cost will lead to:

— the improvement of the environmental performance, by indication the most environmental friendly and economy feasible investment solutions,

— the reduction of cost of waste management (cost savings through reducing waste emissions, energy, water consumption, etc., as well as diminishing the environmental charges), and to

— the improvement of the image of producers on the world market.

Using Life Cycle Cost (LCC) it is possible to determinate all technical and environmental costs, whereas using Life Cycle Assessment it would be possible to draw the correct conclusions concerning environmental improvement approaches, and to determine the benefits both for the producer and the environment. In mining industry the LCA and LCC study should be prepared or for every phase, i.e. from pre-production phase to waste management and closure and reclamation (*from cradle to grave*), or only for chosen one, i.e. waste management.

Cost-benefit analysis for mining industry

As industry has evolved, the complexity affects not only production aspects, but has also special relevance for environmental decision making. Environmental issues are also having an increasing influence on the mining industries, either through legislation or public policy. Mining and sustainable development can be compatible, but successful environmental management solutions require proper and innovative tools as e.g. Life Cycle Assessment or Cost-benefit analysis.

Cost-benefit analysis is a decision support tool that provides a format for enumerating the range of benefits and costs surrounding a decision, aggregating the effects over whole life cycle using an approach called discounting, and arriving at denominated „present value" that, in concept, is comparable with other uses/solutions/alternatives. Carrying out the present value calculation (using discounted cash-flow analysis — DCF) is mechanical, but the choices of values for input variables will ultimately determine the results of the analysis. Choices may be divided into parameter values (i.e. the discount rate, future rates of economic growth, population growth or technological change) and benefit and cost values.

General characteristics (including main advantages) of cost-benefit analysis are as follows:

— CBA imposes an accounting framework that prescribes classes of benefits and costs to consider, means to measure them, and approaches for aggregating them;

— CBA imposes a strict template on the economic foundations of decision making;

— The technique is flexible — it can be used to choose among a range of alternatives (also within the LCA model), i.e. to compare projects of different life span;

— CBA answers issues of public & industrial policy;

— CBA supplies key parameters, like the discount rate, what enables recognising inherent uncertainties and ways to deal with these uncertainties;

— The technique focuses on trade-offs, alternatives and opportunities given up.

Of course, no tool is perfect, and CBA suffers from many criticisms. In this case the most often raised disadvantages are:

— The technique is difficult and specialised;

— CBA is costly to apply;

— Environmental concerns fall properly under the realm of ethics, rather than economics;

— The equity concerns left unrecognised in the present value calculation.

One of the most significant aspects of CBA is economic efficiency. It is defined as a measure of the *net* contribution of any activity or any project to overall environmental issues or whole life cycle of the investment. Thus, economic efficiency is designed to answer the question of whether the redistribution of resources implied by a project results in any improvement. In other words, CBA measures the economic efficiency of the proposed project and enables interpretation of the LCA analysis results for the alternative scenarios.

Cost-benefit analysis for environmental aspects of mining industry

Using LCA and LCC the environmental burdens can be identified and assessed, and in some cases the improvement process could be proposed. The cost of such environmental improvement can be evaluated. The determination of environmental benefit in monetary terms is much complicated, but in Poland it can be done using the environmental fees, which are regulated by law. Therefore it would be possible to develop the financial cost and benefit analysis for environmental improvements. Based on Life Cycle Assessment, it is shown the environmental aspects of mining industry, which should be used for cost-benefit analysis (Table 1). Using LCA it is possible to prepare cost-benefit analysis or for the whole life of mining process or for only one mining phase, e.g. waste management or close and reclamation.

TABLE 1

Cost-benefit analysis for environmental aspects of mining industry

TABELA 1

Analiza korzyści i strat do oceny aspektów środowiskowych przemysłu wydobywczego

<table>
<tr><th>Phase/cost/benefit</th><th>Internal</th><th>External</th><th>Global</th></tr>
<tr><td colspan="3">COSTS</td><td rowspan="11">Global
=
internal
+
external</td></tr>
<tr><td>Pre-production</td><td>Depletion of land use, depletion of resources, energy consumption, land degradation</td><td rowspan="4">Ecological impact on:
— Climate change
— Acidification
— ozone formation
— ecotoxicity
— eutrophication
— oxygen depletion
— biological diversity</td></tr>
<tr><td>Production</td><td>Depletion of land use, depletion of resources, energy consumption, mining water discharge — also salted water; dust and gas emission</td></tr>
<tr><td>Waste disposal</td><td>Land use, waste storage and disposal</td></tr>
<tr><td>Closure and reclamation</td><td>Improvement of the environment</td></tr>
<tr><td colspan="3">BENEFITS</td></tr>
<tr><td>Pre-production</td><td>—</td><td rowspan="4">Impact avoided due to energy and material recovery, internal recycling, or reuse of waste</td></tr>
<tr><td>Production</td><td>Energy and material recovery, reduction of environmental burdens</td></tr>
<tr><td>Waste disposal</td><td>Reuse, recycle</td></tr>
<tr><td>Closure and reclamation</td><td>Revitalisation</td></tr>
<tr><td>Net</td><td colspan="2">Net cost = cost — benefits</td></tr>
</table>

Conclusions

CBA is an analytical tool that takes into account the broader set of benefits and costs the public policy maker and producers must address. It calculates the present value of net costs and benefits indicating the decision that obtains the greatest benefit at least cost. The Net Present Value (NPV) is proposed to evaluate and select the best solution for new investment plans and for evaluation of the economic feasibility of new solutions. For assessment the environmental benefits and cost the LCNPV (Life Cycle Net Present Value) calculation methods should be used. The LCNPV calculation can consist of the sum of capital and current cost, costs of environmental charges, potential benefits for mining, processing and waste management stage during the whole life span of the mine, i.e. including pre-production, production, waste disposal and closure and reclamation phases.

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WYKORZYSTANIE ANALIZY KORZYŚCI I STRAT DO OCENY ASPEKTÓW ŚRODOWISKOWYCH PRZEMYSŁU WYDOBYWCZEGO

Słowa kluczowe

Ocena Cyklu Życia (LCA), Analiza korzyści i strat (CBA), gospodarka odpadami górniczymi

Streszczenie

W ostatnich latach w przemyśle wydobywczym coraz większego znaczenia nabierają badania i inwestycje mające na celu ograniczenie zagrożeń oddziałujących na środowisko naturalne. Pojawiają się nowe techniki stosowane w zarządzaniu środowiskiem, np. Ekologiczna Ocena Cyklu Życia (LCA). W przypadku górnictwa celem LCA powinno być ustalenie, jaki wpływ na środowisko wywiera cały proces produkcji danego surowca (od poszukiwań geologicznych po końcową utylizację produktu i rekultywację terenów pogórniczych) oraz określenie, w których fazach procesu zagrożenia dla środowiska są największe. Stosowanie analizy LCA przynosi istotne korzyści przedsiębiorstwom, którym zależy na ograniczeniu negatywnego wpływu ich działalności na środowisko naturalne. LCA jest bowiem narzędziem, które pomaga w podejmowaniu decyzji dotyczących ochrony środowiska ludziom za nie odpowiedzialnym. Dzięki wynikom LCA można wskazać optymalne rozwiązania, mające na celu minimalizację

wpływu danego procesu lub produktu na środowisko. Pozwala ona bowiem nie tylko dokonać analizy globalnej, ale także przyjrzeć się poszczególnym fazom procesu, np. procesowi zarządzania odpadami. Dodatkowo, przeprowadzając badania LCA można badać strukturę kosztów (LCC — koszty cyklu życia) w „całym okresie życia projektu". Wyniki LCA i LCC mogą stać się podstawą do prawidłowego i szybkiego przeprowadzenia analizy korzyści i strat, która uwzględniać będzie wszelkie aspekty środowiskowe. Analiza korzyści i strat jest analitycznym narzędziem, w którym bierze się pod uwagę zbiór kosztów i korzyści i analizuje się je z punktu widzenia producenta i odbiorcy. Wyrażenie ich w jednostkach finansowych przy użyciu metody zaktualizowanej wartości netto (NPV) umożliwia na wskazanie rozwiązań przynoszących największe korzyści. Przy uwzględnianiu aspektów środowiskowych — w niniejszym artykule — zaproponowano, aby przy poszukiwaniu rozwiązań optymalnych z punktu widzenia środowiska i ekonomii stosować zaktualizowaną wartości netto całego cyklu życia (LCNPV) badanego przedsięwzięcia.