Journal of Cleaner Production 9 (2001) 233–242
Journal of Cleaner Production
www.cleanerproduction.net

An inventory analysis of oil shale energy produced on a small thermal power plant

Siret Talve [a,*], Valli Riipulk [b]

[a] Department of Environmental Engineering, Tallinn Technical University, Ehitajate tee 5, 12612 Tallinn, Estonia
[b] AmStandard OY, Pihlaka 6, 11202 Tallinn, Estonia

Received 11 October 1999; accepted 15 July 2000

Abstract

Energy produced in Estonia from oil shale is studied using the inventory analysis of the product life cycle assessment (LCA) method. The life cycle is taken as an oil shale mine and thermal power plant with consumer supply systems, which are close to each other and are technologically interconnected.

The effectiveness of energy production over the whole life cycle is calculated and the energy and the material balances are presented. Local environmental effects of the oil shale extraction and the energy production are briefly described.

The first step in defining the oil shale energy as an important input parameter for the LCA studies of all other products of Estonia is made. The collected data can serve as a basis for the environmental improvement programs.

Keywords: Product life cycle assessment; Energy; Environment; Inventory analysis; Oil shale

1. Introduction

Life cycle assessment (LCA) is an environmental management tool that establishes an overview of the environmental consequences of the existence of a product through its life cycle. LCA covers the entire life of the product, i.e. from the extraction of raw materials for the manufacturing process, through the production and the use of the product and its possible reuse and recycle, taking into account the entire product system. Using the LCA method is most effective when the product meets the following criteria: high market potential, simplistic lifetime process and low environmental performance [1]. A product LCA consists of three equal parts — inventory analysis, impact assessment and improvement assessment [2]. The inventory analysis forms the basis for the impact and the improvement assessments of the product LCA. During the inventory analysis, the flow chart of the process is specified, all the inputs and outputs of the product life cycle are defined, and the material and the energy balances are calculated.

In Estonia the LCA principles were first implemented in 1994 in a joint Estonian–Danish research project for the mapping of the mercury and cadmium (Hg and Cd) flows in Estonian society [3]. Using the research material as a framework, flow analyses of Hg and Cd have been done and it has been concluded that the biggest cadmium and mercury emissions in Estonia originate from oil shale energy production (see Figs. 1 and 2).

Oil shale is fossil fuel which is burned on thermal power plants (TPP) to produce electricity and heat. In 1992, oil shale fueled plants produced more than 93% of Estonian electricity [3], making the oil shale energy production the strategic industry in Estonia, which uti-

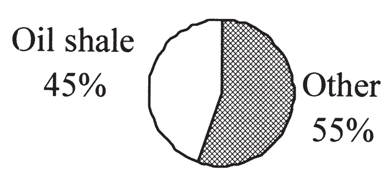

Fig. 1. Share of oil shale energy in total Cd emission in 1992 (adopted from [3]).

* Corresponding author. Tel.: +372-56-68-7117; fax: +372-6-20-25-01.
E-mail addresses: siret@staff.ttu.ee (S. Talve), valli.riipulk@mail.ee (V. Riipulk).

0959-6526/01/$ - see front matter
PII: S0959-6526(00)00056-1

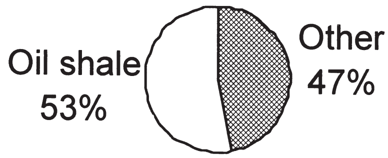

Fig. 2. Share of oil shale energy in total Hg emission in 1992 (adopted from [3]).

lises tremendous amounts of natural and human resources. These facts make oil shale energy production the major source of industrial pollution in Estonia, which should be constantly supervised from an environmental point of view.

In this study, the LCA method is used as a new scientific approach to the assessment of oil shale energy production. The product investigated in the current LCA study is the oil shale energy produced on a small Estonian thermal power plant. In this paper, only the inventory analysis of the LCA is presented. The special characteristic of this plant is that it produces steam for district heating, and electricity is only the by-product of the plant. The TPP is fuelled by the oil shale extracted at the underground mine, which is located close to the TPP. The produced heat is consumed in the immediate surroundings of the TPP. This makes the product system geographically localised and relatively simple for the LCA study.

2. Inventory analysis

2.1. System definition

2.1.1. System boundaries

The life cycle of the product–energy produced at investigated TPP consists of three principal stages: mining of oil shale, energy production and consumption. The flow chart of the life cycle is presented in Fig. 3.

The production process and transport of auxiliary materials, such as water treatment reagents, steel etc., were not included in the life cycle. Capital goods, general infrastructures, accidents, immaterial commodities and human resource were also excluded.

2.1.2. Geographical aspects

The investigated life cycle takes place in a limited geographical area. The plant is supplied by the oil shale from the mine situated next to it and produces heat and electricity. Heat is also consumed in the neighbouring community.

2.1.3. Time frame

All inputs and outputs to the life cycle were studied during a period of 1 month (November 1997).

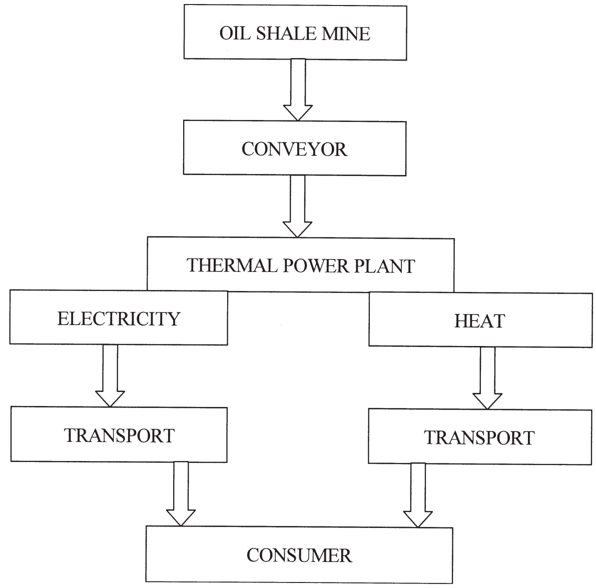

Fig. 3. Scheme of investigated life cycle.

2.1.4. Technological level

This TPP was established in 1951 and has worked without major reconstruction. So the technology and equipment used have depreciated, as have the consumer supply systems.

2.1.5. Social aspects

When using the LCA tool for evaluating public services like energy production, it is worthwhile considering the zero-alternative (what would happen if the product was not produced at all?) [4].

However, in this investigation this alternative was not included. If local energy production was reduced, tremendous social and economical problems would inevitably result. Additionally, diminishing the amount of oil shale extracted has already caused high unemployment in the region. At present, Estonian economics could not withstand the importation of most of its energy requirements; the merchandise trade deficit would rise significantly. Having local energy resources gives remarkable economical advantages for every country.

3. Data collection

The data collection strategy for inventory analysis was to use all available information from the enterprises, the environmental board, various environmental reports and literature.