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ECO-EFFICIENCY MODELING BASED ON LIFE CYCLE ASSESSMENT

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ABSTRACT

In this paper modeling of eco-efficiency based on life cycle approach was presented. Own methodology of eco-efficiency assessment was shown. Material Flow Network of eco-efficiency modeling were performed on the example of power generation via the Shell gasification process. According to EN ISO 14045:2012 eco-efficiency indicator is measured relating environmental performance of a product system to its product system value. In this paper for eco-efficiency analysis was used Life Cycle Assessment (LCA) and Life Cycle Cost (LCC). Material and energy flows of each unit process was done with Umberto for Eco-efficiency 5.6 software. System boundary included for eco-efficiency study comprised the all of life cycle phases: construction, operation and disposal.

INTRODUCTION

In this paper eco-efficiency was modeling to integrate economic and environmental indicators for the case study of Clean Coal Technologies (CCT). CCT allow to energy efficient and environmentally friendly use of coal. CCT include: coal upgrading, improvements in efficiency of existing power plants, advanced power generation technologies (eg Integrated Gasification Combined Cycle, IGCC), near zero-emission technologies and technologies for carbon capture and storage (CCS). IGCC could potentially capture and store carbon dioxide. It is important for further improvement of IGCC in terms of its economics and environmental impact (Smoliński et al. 2010). Thus model of eco-efficiency for IGCC (Shell gasifier) was done.

The eco-efficiency concept was first defined in 1989 by The World Business Council for Sustainable Development (WBCSD) as being achieved by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life cycle to a level at least in line with the earth's carrying capacity (www.wbcsd.org, 2013). According to EN ISO 14045:2012 eco-efficiency is an aspect of sustainability relating the environmental performance (measurable results related to environmental aspects) of a product system (collection of unit processes with elementary and product flows, performing one or more defined functions, and which models the life cycle of a product) to its product system value.

An eco-efficiency is a relative concept and a product system is only more-or-less eco-efficient in relation to another product system. Environmental assessment in eco-efficiency evaluation shall be based on Life Cycle Assessment (LCA) according to ISO 14040:2006. More information about LCA quantification of chosen production system was done by Burchart-Korol (2013).

The result of Life Cycle Inventory (LCI) study may be used directly as input to an eco-efficiency assessment. The product system value assessment shall consider the full life cycle of the product system. Material Flow Analysis (MFA) is a method to establish an inventory for an LCA. MFA is a systematic assessment of the flows and stocks of materials (Brunner et al. 2004). Eco-efficiency is important tool in the sustainable development.

MATERIALS AND/OR METHODS

Eco-efficiency indicator according to own methodology is measured relating environmental performance of a product system based on LCA to its product system value based on LCC (Life Cycle Cost) (Figure 1).

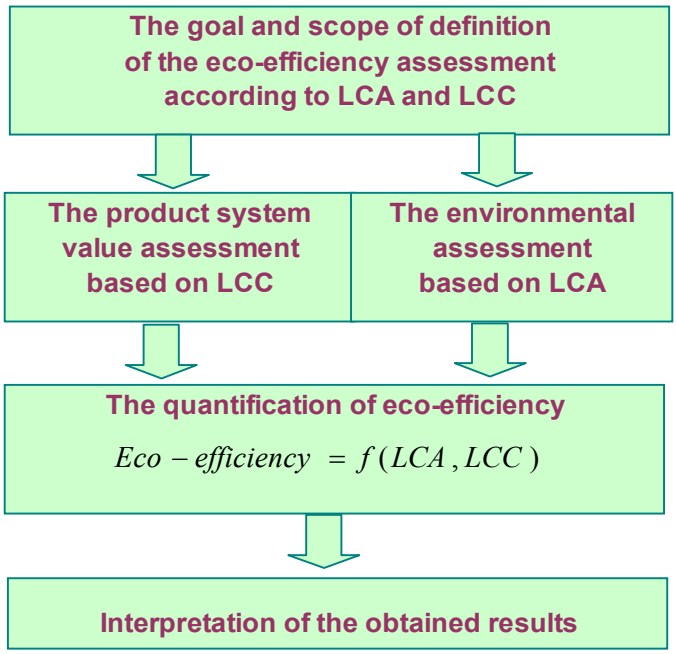

Figure 1. Eco-efficiency methodology with life cycle approach
Source: Own analyses based on EN ISO 14045:2012

The power generation via the Shell gasification process was developed with the software tool Umberto for Eco-efficiency (using inventory data from ecoinvent database) which is modeling tool for Material Flow Networks.

The eco-efficiency study comprises the all life cycle phases of the power generation system: construction, operation and disposal.

RESULTS

Material Flow Analysis (MFA) and Life Cycle Assessment (LCA) are the most suitable for environmental analysis. In this paper Umberto for Eco-efficiency 5.6 has been applied for Material Flow Analysis. MFA allowed to determine the material and energy flow for process optimization. MFA of power generation via the Shell gasification process is included in Figure 2. The list of inventory for cost and inventory analysis needed for eco-efficiency assessment of chosen power generation technologies is shown in Figure 3. The detailed results of eco-efficiency assessment was presented by Burchart-Korol et. al (2013).

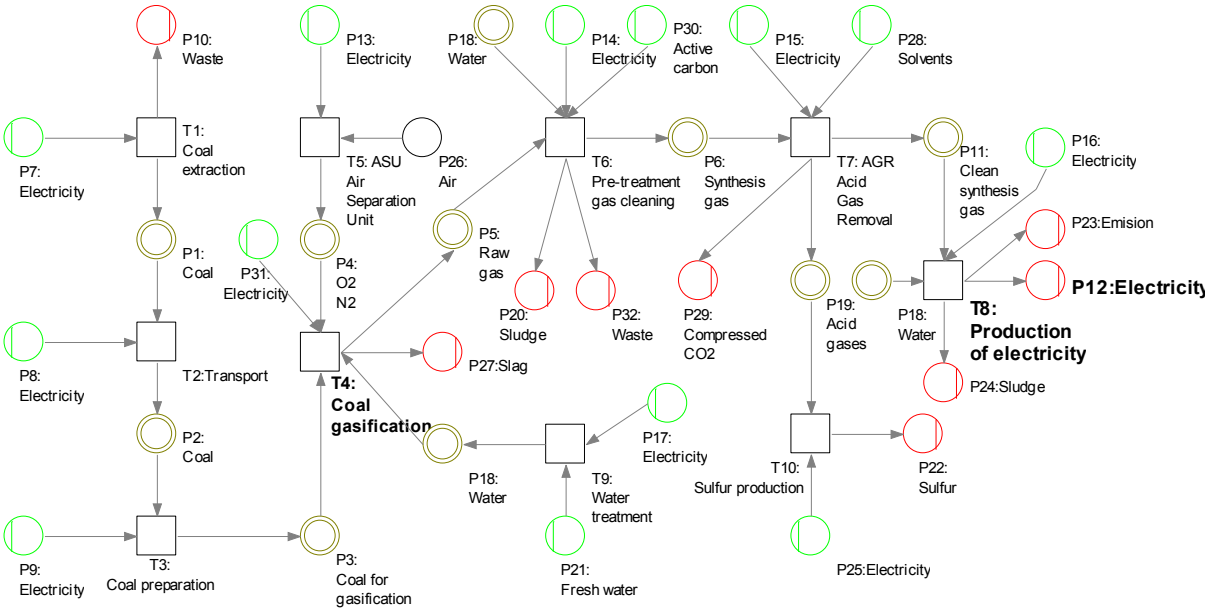

Figure 2. Material Flow Network of power generation via the Shell gasification

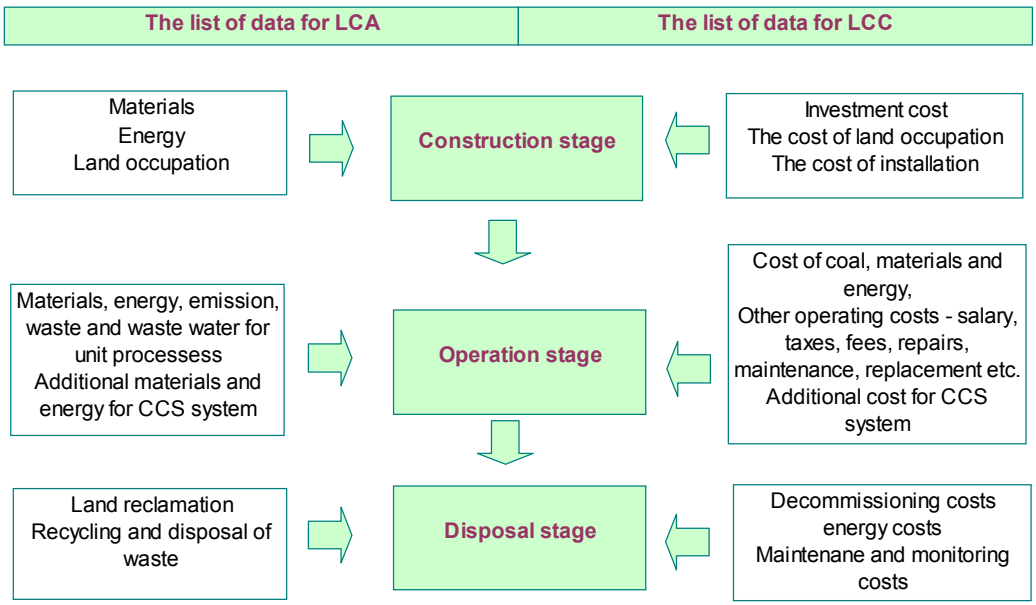

Figure 3. The list of inventory data needed for eco-efficiency assessment

DISCUSSION

Eco-efficiency modeling of power generation via the Shell gasification process with and without CCS, according to the requirements of norm ISO 14045:2012 concerning the rules and guidelines of eco-efficiency assessment, was presented in the paper. Own eco-efficiency analysis methodology was presented. In case of power generation via the Shell gasification process, coal mining and the carbon dioxide emissions are the main environment assessment determinants, whereas the main factor determining the investment cost and replacement investments, then to the cost of coal gasified. In technologies without the CCS the construction stage of the installation and the included costs has the biggest impact on its eco-efficiency. In case of power generation via the Shell gasification process with the CCS, eco-efficiency is influenced by the process of coal mining and its costs, whereas the emission costs are minimal. Detailed results of eco-efficiency analysis performed for the four variants (coal, lignite, with and without CCS) of coal gasification technology (Shell gasifier) were presented by Burchart-Korol et. al (2013).

CONCLUSIONS

The aim of the study was eco-efficiency modeling of chosen production system. Eco-efficiency modeling contains Material Flow Network and eco-efficiency assessment according to EN ISO 14045:2012 (own methodology). It was found out that eco-efficiency as the function of life cycle assessment and life cycle cost connects the basic business target (profit) and the basic production system target (costs) with environmental approach, thanks to which decision-makers in companies have the possibility to create innovative products fulfilling at the same time environmental criteria. In order to eco-efficiency modeling of products and technologies it should be taken into account all input and output for all unit processes and the cost assessment of all life cycle stages.

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REFERENCES

Smoliński A., Howaniec N. 2010: Environment Friendly Coal Processing Technologies for Sustainable Development of Polish Energy Sector, *Ecological Chemistry and Engineering, Vol. 17, No. 3*
www.wbcsd.org, 2013.05.10
EN ISO 14045: 2012 Environmental management — Eco-efficiency assessment of product systems — Principles, requirements and guidelines
Burchart-Korol D., 2013: Life Cycle Assessment of Steel Production in Poland. A Case Study. *J. Clean. Prod., DOI 10.1016/j.jclepro.2013.04.031*
Brunner P. H., Rechberger H., 2004 : Practical Handbook of Material Flow Analysis. Lewis publishers, London
Burchart-Korol D., Krawczyk P., Śliwińska A., Czaplicka-Kolarz K., 2013: Eco-efficiency Assessment of the Production System of Coal Gasification Technology (in Polish), *Przemysł Chemiczny, No 3*