Methodology development for implementing Life Cycle Analysis of energy production in the Czech Republic

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Abstract

Energy mix of the Czech Republic includes various types of fossil energy sources, which currently do not have comprehensive methodology for assessing their environmental impacts. Life Cycle Assessment (LCA) is important tool for assessing such impacts through the whole life cycle of the sources. Ongoing national project "LCA of energy production in the Czech Republic" is focusing on implementing LCA on several case studies to analyze and compare different national energy sources and technologies from environmental point of view through the three phases of the life cycle – construction, operation and decommissioning. Such an extensive study requires development of methodology which covers necessary technological boundaries and parameters, as well as general principles of LCA methodology. The paper depicts the procedure of the methodology development for implementing LCA tool for energy production of various fossil, nuclear and renewable sources. Methodology will focus on technological and inventory criteria, LCA boundaries for various sources, selection of functional unit and identification of specific problems regarding LCA of energy sector.

1. Introduction

The production and distribution of the electric energy and heat are the one of the crucial aspects of the Czech economy and many other industrial activities are highly dependent on it. There are many approaches how the technology of energy production could be assessed. Besides the environmental approach it is also price, reliability of the energy distribution and dependency on imports. The national project "LCA of energy production in the Czech Republic" is focused on the environmental assessment based on life cycle assessment of the several energy sources which belongs to current Czech energy mix. The first phase of the project is explaining the development of the methodology in the following chapters:

- The choice of the energy sources for LCA
- Determination of the range of input data and inventory criteria
- General LCA methodology description for electricity production

2. Choice of the energy sources for LCA

In the first phase of the project LCA will be performed for the electricity production. The sources for electricity production will consider non-renewable and renewable sources which are divided according to fuel type, technology and output power range (**Table *1***).

Table 1. Division of electricity sources for LCA analysis

Fuel	Technology	Power output (MWe)				
		< 1	**1-10**	**10-100**	**100 - 300**	**>300**
Hard coal	Steam sub critical	-	-	-	-	1x
Brown Coal	Steam sub critical	-	-	-	1x	3x
	Steam super critical	-	-	-	-	1x
	IGCC	-	-	-	1x	-
Natural Gas	Combine cycle	-	-	-	-	1x
Nuclear power	Pressurized VVER	-	-	-	-	2x
Hydro energy	Accumulative	1x	1x	1x	1x	1x
Wind Energy	Wind turbine	2x	2x	2x	-	-
Solar energy	Photovoltaic	2x	2x	2x	-	-

3. Determination of input data and inventory criteria

The input data for the LCA create important aspect for the holistic assessment and thus three phases of the energy production life cycle are considered-construction of energy source, operation and decommissioning. Each of the phase is considering following data:

- Inputs into the system defined by main medias entering the energy source (fuel, water, chemicals, etc.).
- Outputs from the system defined by waste streams, emissions and main or secondary products for next utilization (electricity, heat, construction materials).

- Production block (change of energy into main product-electricity/heat) which can consist of another sub-systems
- Auxiliary systems (technology supporting the operation of the system as water or oil treatment facility)
- Other systems specific for certain type of energy sources (e.g. flue gases treatment, radioactive waste treatment, reserve source, etc.)

The inventory criteria for data collection are based on 3 options:

1. Real operational/measured data (such as fuel consumption, water and sorbent consumption etc.). Data are analyzed from 3 years of the source operation (years 2015-2017).
2. Calculations according to known procedures and methods (e.g. volume of combustion air).
3. Professional assumptions according to the published data

4. General LCA methodology description for electricity production

This chapter is describing only general steps of LCA methodology which is common for all further LCA studies in the project. Here, we consider the definition of goal and scope of the study and definition of general system boundaries. Life Cycle Inventory, Life Cycle Impact Assessment and Interpretation will be specified for concrete energy sources in their LCA studies.

4.1. Goal and scope of the study system boundaries

The first step for any LCA study is the definition of the goal and scope. In our case it is to define the impacts of centralized and decentralized energy sources in the frame of the full life cycle. LCA will determine system boundaries of energy production. Also, LCA will determine the important environmental impact categories and their characterization factors.

4.2. System boundaries and functional unit determination

Technical specification of the study consists of the function and functional unit determination. In the case of electricity production the functional unit is the production of 1kWh. The system boundaries are specifying the range of the LCA study and the detail of inventarization. The life cycle of energy sources consists of three phases:

1. Construction processes of energy source (marked as C)
2. Operational phase (marked as O)
3. Decommissioning – final treatment (marked as D)

Each of these phases require material and energy flows and generate the outputs. Inputs and outputs are marked as modules where number 1 stands for inputs, number 2 for operation and number 3 for outputs of each phase. The following picture (Figure 1) depicts the modules.

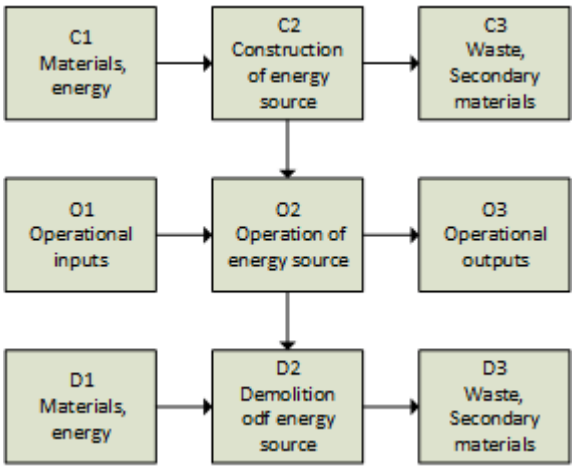

Figure 1. Modules of LCA system boundaries

The latter described system boundaries for LCA of electricity production is inspired by Product Category Declaration [1] which is dividing the life cycle of electricity production into the upstream, core and downstream modules.

5. Conclusion

The specification of the correct methodology for LCA of energy systems in the Czech Republic is an important part for the initiation of the whole analysis. Systematic choice of the energy sources of certain power range is assuring that the LCA will be robust and covers the full energy potential of the Czech Republic. Careful definition of functional unit and system boundaries can avoid further methodological errors and makes sure that LCA will compare correct and reasonable systems (nonrenewable vs renewable). The further specific results for each chosen energy sources will be the subject of the future project development.

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