Life Cycle Assessment of Electricity Production in the Czech Republic-Case-Study of Lignite Combustion and Hydropower

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Abstract
Environmental impacts of various types of energy production are compared in the scope of an ongoing national research project "Life Cycle Assessment of Energy Production". The project is using the LCA method to compare the potential environmental impacts of selected energy sources throughout their whole life cycle. The energy sources are representative for the energy grid of the Czech Republic. The inventory data used for the LCA are based on case studies of selected Czech power plants. Presented article is showing the preliminary results – the comparison of environmental impacts of two electricity sources. Lignite power plant and a hydroelectric power plant are compared. Only the impacts of plant operation are compared so far, the construction and decommissioning are not included in the current analysis.
Keywords: LCA, electricity production, case-study

1. Introduction

The continuously increasing worldwide electricity consumption is highlighting the concerns about its environmental impacts. These concerns are even higher in countries like the Czech Republic, which is heavily relying on combustion of domestic coal (52 %). [1]
The production of domestic coal is expected to significantly decrease in the next 20 – 25 years as the reserves run low. Large transformation of the whole energy sector will be necessary, as stated in National Energy Concept. [2]
The main goal of the project is to provide information about the severity of environmental impacts for different domestic energy production technologies.

2. Methodology

2.1 The LCA

The environmental impacts of different energy sources were compared by the LCA method according to ČSN EN ISO 14040 and 14044. The life cycle is divided into three parts:

1) Power plant manufacture/construction
2) Power plant operation
3) Power plant decommissioning

The results presented in this paper cover only the phase 2) Power plant operation (the construction and decommissioning are not yet available and will be investigated later). The results are compared per 1 kWh of electricity supplied to the grid. The analysis is reflecting technological, geographical and other specifications of the Czech Republic, and time specifications of 2015 - 2017. The characterization model ReCiPe 2016 is used to evaluate the mid-point environmental categories. The environmental impacts are fully allocated to the main product – electricity – all other by-products are considered in the form of negative/prevented environmental impacts.

2.2 Data Acquisition

The inventory data were collected from the years 2015 – 2017, an average yearly value from the selected period was used to minimize the influence of rare events (unplanned down-times, repairs etc.). The inventory data was obtained from the power plant owners and operators on a non-disclosure basis. For this reason, the inventory data, the power plant name, exact technological specifications or the plant owner cannot be published. Only general power plant information is provided.

2.3 Selected Cases

Case A: Coal-fired power plant with nominal output over 300 MWe.

The power plant consists of multiple units/boilers with a total nominal output over 300 MWe. The boilers are combusting pulverized domestic brown coal with very low heating value (generally between 8,5 – 12 MJ/kg). Steam parameters are sub-critical (typically 18 MPa and 535 °C). The power plant is located in the immediate vicinity of the mine and is utilizing part of the low-pressure steam for heating purposes. The resulting ash is either being used for land reclamation or sold as a building material in the form of Energo-Gypsum.

Case B: Hydropower plant with nominal output 10 – 100 MWe.

The power plant is equipped with several Kaplan turbines (suitable for high flow rates and low head ranges up to 70 m) with a total nominal output between 10 – 100 MWe. The power plant´s purpose, beyond producing electricity, is also to regulate the water level in the river. The power

plant also collects waste from the river and is equipped with fish pass.

3. Results

The selected cases A: coal-fired power plant and B: hydropower plant were compared with one another on Mid-point level. For better comparison, the average values for lignite and hydropower plant from the GaBi software database are included in the graphs. It is important to remember that the preliminary results do not yet include the power plant construction and decommisioning hence the preliminary results of the case-studies are expected to have lower environmental impacts than the database values.
The Case A is shown in Figure 1 and Case B is shown in Figure 2.

4. Conclusions

The presented article compares environmental impacts of two power plants´ operation – Case A: coal power plant and Case B: hydropower plant.

For the Case A: Coal-fired power plant two processes were identified as the main contributors to environmental impacts. The combustion process and mining. As was expected in almost all midpoint categories the environmental impacts are lower than the database value, as only operation phase was included in the analysis so far. The exception is human toxicity - the reason is probably the use of more detailed inventory data compared to database values. We can conclude that the operation of lignite power plant is the major contributor to the environmental impacts**.** The construction and decommissioning are expected to be smaller; however, not negligible.

For Case B: Hydropower plant the consumption of grid electricity was identified as the main contributor to environmental impacts. The selected case-study had surprisingly large consumption of grid electricity probably caused by its regulatory purpose. Another explanation might be the fact that the evaluated time period 2015 – 2017 was exceptionally dry in the Czech Republic and the electricity production from hydropower plants in general was relatively low. This fact is obviously driving several impact categories over the database values, considering the coal-heavy CZ energy mix. Nevertheless, we can still conclude that the operation of the Case B: hydro-power plant has negligible environmental impacts compared to Case A: coal power plant.

Acknowledgement
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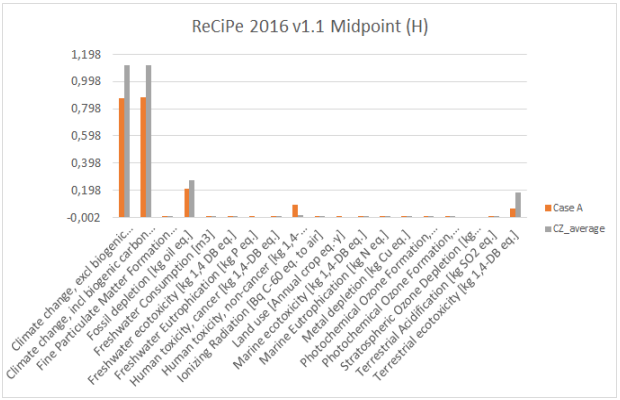

Figure 1. Environmental impacts per 1 kWh supplied: Case A – coal(lignite) power plant

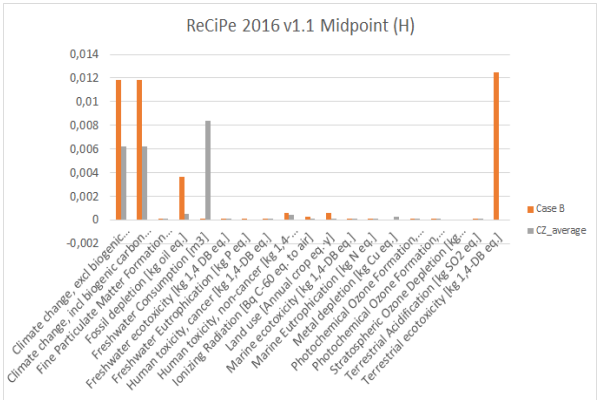

Figure 2. Environmental impacts per 1 kWh supplied: Case B – hydropower plant