Life Cycle Assessment of Cloudburst Management Plans in Adaptation to Climate Change in Copenhagen, Denmark

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The City of Copenhagen has developed Cloudburst Management Plans to flood-proof the city with regards to an expected increase in extreme rain events due to climate change (The City of Copenhagen, 2012). The plans are largely based on green infrastructure, as opposed to traditional solutions based on underground pipes and retention basins. While cost and flood risk assessments are inherent parts of storm water management (SWM), the environmental impacts are often not analysed. In this study, these impacts were quantified using Life Cycle Assessment (LCA), and compared for two different SWM scenarios for the sub-catchment Nørrebro (2.6km²):

- “Green” scenario: Green infrastructure is utilized to retain, infiltrate and discharge runoff above the surface as proposed in the Cloudburst Management Plan;
- “Grey” scenario: Runoff is handled in underground pipes and retention basins, and is cleared at a wastewater treatment plant before discharge.

To analyse the contribution of the different flood safety levels, the impacts were allocated to the three different flood safety levels.

**METHODS**

An LCA according to international standards [2] was carried out for both systems. The emissions of processes are quantified, and converted to impacts in different environmental categories. The impacts are then normalized with reference to the average impact per person per year (Figure 3).

To allow comparison, alternatives need to have the same primary function [3]. The provision of different flood safety levels in adaptation to climate change over 100 years (Figure 4).

**RESULTS & DISCUSSION**

Eight midpoint impact categories were selected. The impacts of both scenarios are dominated by the material production life cycle stage, which accounts for 42 to 75% of the total impacts in the “green” scenario, and 62 to 96% in the “grey” scenario. Production of concrete is contributing significantly in both systems. Additionally, in the “grey” scenario, steel for basins and road materials cause high environmental impacts.

The sensitivity analysis shows that the major uncertainties relate to the accuracy of the input data extracted from planning documents, and to the 100 year time horizon of the assessment. Even though the results deviate significantly from the baseline scenario (up to 72% for the “green”, and up to 18% for the “grey” solution), the impacts of the “grey” scenario remain higher in all tested configurations (Figure 6).

**CONCLUSIONS**

- The Life Cycle Assessment shows that the environmental impacts of a green infrastructure based (“green”) system are lower than for a subsurface (“grey”) alternative in the Nørrebro catchment.
- Material production is the main contributing life cycle stage. This highlights the possibility to significantly influence the environmental impacts of systems in the design phase.
- The sensitivity analysis shows that single parameters significantly influence the results, but the impacts for the “grey” system remain higher for all tested scenarios.
- The choice of flood safety targets influences the environmental impacts, which can be assessed by allocating the impacts to the different safety levels.
- Management of extreme events (domain C) causes higher impacts in the “green”, than in the “grey” system. Small rain events (domain A) cause minor impacts in both systems.

**INTRODUCTION**

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