Contribution to Topic 2

Detailed components and materials analysis of a German biomass CHP plant: A contribution to data quality improvement for LCA's of bioenergy systems

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Abstract

Background and purpose. Biomass fired energy conversion systems presently are assessed in life cycle assessments (LCA) more or less as black boxes with usually only little respect to technical details like components and materials used to build up the whole plant. Thus, IER carried out a detailed investigation of the natural wood fired CHP plant in Pfaffenhofen, Bavaria to provide more detailed data for future applications.

Subject of study. The CHP plant Pfaffenhofen is known as one of the leading and most innovative concepts for co generation of district heat and cooling energy at several temperature levels in combination with power production and thus was selected as case study. It has a combustion capacity of 26,7 MW_{th}. The extraction condensing steam turbine has a nominal electrical load of 6,1 MW_{el}. As typical full load mode situation at about 4 MW_{el} a maximum thermal output of about 22 MW_{th} at the heat exchangers is achievable. Heat extraction takes place at about 210°C as process steam (13 bar), high temperature district heat at up to 130°C (cooling energy production is operated at this temperature as well with absorption refrigeration machines), middle temperature district heat at up to 90°C and low temperature district heat at about 45°C optionally (not yet installed). The plant is operated with several origins of natural wood fuels (wood chips and saw dust as residues from saw mills and timber industry, residues from forestry and from landscape conservation measures).

Assessment approach. The data required fore the mass analysis of all technical components of the plant were obtained from the fully accessible power plant documentation in hard copy. The mass flow details for the buildings were derived from the final service and cost statement of the involved architect. To obtain a clear documentation of the data, the whole plant was subdivided into several modules for a detailed presentation of the results.

Results. The overall materials input for the whole CHP plant totalled to almost 15 333 t. The required buildings (boiler house, fuel storage, sheds for containers and equipment, office building) had a share of 91,29 % (13 997 t) of total input, machinery components contributed 7,29 % (1 117 t) and electrical components like electric cables, the generator, power transformers etc. contributed 1,42 % (218 t) to the overall materials input for the plant. Referring to the most common materials used for building the plant, the highest share was caused by concrete with 49,58 % (7 602 t), followed by gravel with a share of 25,34 % (3 885 t), construction steel with 13 % (1 994 t) and wall materials with a share of 6,6 % (1 012 t).

Conclusions. The materials assessments shown above were broken down also for each component belonging to one of the main defined plant modules. The provided data served for further calculations of environmental loads related to single modules, material inputs and to the whole life cycle of energy supply from biomass. For this purpose the data were connected first of all to their corresponding process chains from raw material to end product, e.g. carbon steel. Secondly it was required to define further details about the efficiency, materials and fuel input during the period of operation for description of the whole life cycle. Finally for a complete LCA of power and heat production from this CHP plant the assessment of the power plant break away and the disposal/recycling of materials after use was required. Conclusively specific figures were derived of resource depletion and environmental burdens connected to the supply of one kWh of electricity produced over 20 years of operation.

Innovative achievements and prospects. The results achieved in this study may be an excellent starting point for future life cycle assessments of bioenergy systems. The strict separation of all material inputs into several modules generally allows also up- or downscaling of the amounts of inputs into other power plant sizes. Further more, the documentation of detailed amounts of material input allows each user of an LCA software to apply his/her own basic environmental data for process chain definition of construction components and –materials.