Life cycle assessment of the heat supply for a Minergie-P one-family house

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Goal

The aim of this short study is to examine the environmental impact, the cumulative energy demand and the emitted greenhouse gases caused by the heat supply for a Minergie-P one-family house. The heat is produced by solar thermal power with an auxiliary wood furnace which together cover heating and hot water demand of the house.

Method and Data

The inventory data for this study are based on measurements and calculations by Sebasol [5]. The data refer to a 15.5 m² self-made copper-wood flat collector which annually delivers about 5'700 kWh solar heat used in a four-person Minergie-P house with 160 m² located in the canton Fribourg. Additionally to the solar heat, about 1'071 kWh heat is delivered by a wood furnace consuming 350 kg wood logs annually. Together this covers the heat demand of the house. Background data for the LCA are taken from the ESU-services database [1].

Data include the entire life cycle from cradle (origin of the plant components, plant production, and wood production) to grave (disposal of the plant components). The environmental impact is determined by means of the ecological scarcity method 2013 [2] and summarised to ecological scarcity points (eco-points). Furthermore, the cumulative energy demand (CED) and the greenhouse gas (GHG) emissions are determined for the heat supply of one year.

Results per year

Depending on the evaluation method the different results are shown in the figures 1 and 2. For each method, the overall environmental impact of the heat supply is subdivided by solar and wood based heat production and secondly more precisely classified by the source of origin.

The annual heat demand of a Minergie-P house as described above involves 545'000 eco-points, 30'700 MJ-eq and 127 kg CO_2 equivalents. Per person the impact amounts 136'000 eco-points. This is much lower than the impacts of average consumption of heating energy for in Switzerland which amounts to about 1.1 million eco-points per person and year for heating and hot water demand (2015) [3].

The environmental impact of the solar heat measured by eco-points is mainly caused by the production of the solar panel. Regarding wood based heat supply, the emissions of the combustion are the main factor.

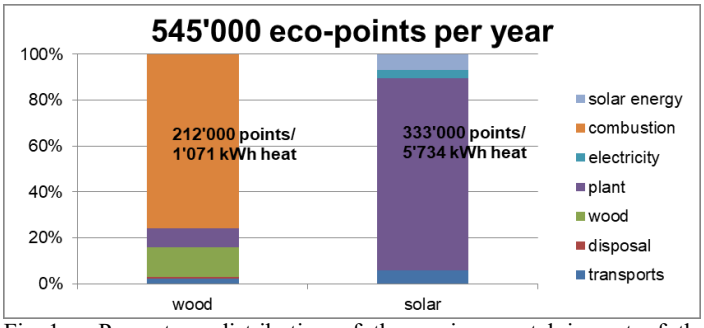

Fig. 1: Percentage distribution of the environmental impact of the solar and wood based heat supply of a Minergie-P house

Results per MJ

The solar irradiation results in the main share of the CED for solar heat. Equally, the wood supply makes the most CED regarding the wood based heat production.

The distribution of the greenhouse gas emissions' origin is similar to that one of the environmental impact measured in eco-points. But the emissions of the wood combustion matter less for the greenhouse gas emissions compared to eco-points.

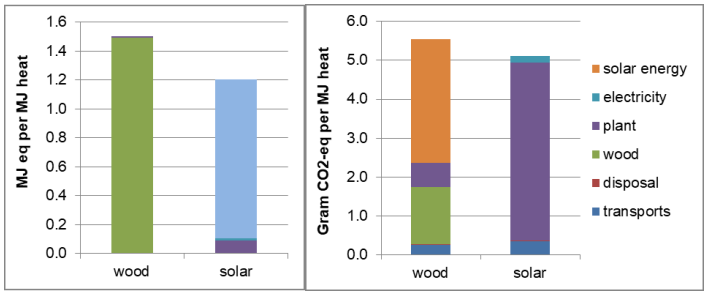

Fig. 2: CED (in MJ-eq per MJ heat) and GHG emissions (Gram CO_2-eq per MJ heat) referring to the heat supply for the house

Discussion

Regarding the ecological scarcity method and the GHG emissions, the results for solar heat show that the plant production is the crucial factor for an environmental assessment since solar energy doesn't directly cause any emissions. To minimise the environmental impact the technology should be further improved prolonging the lifetime or reducing the material input for one plant. These are goals of the SEBASOL activities. The solar energy having the largest share of the CED is renewable.

About 80 % of heating and hot water demand is covered by the solar thermal collector system. This example shows that these systems can provide an important share of the heating demands in well insulated buildings and that this can even be achieved with lower impacts than modelled so far in LCA for solar thermal systems [4].

Also the wood consumption is so small that there would be sufficient supply to cover the demand of many such houses in Switzerland. The wood-based energy supply is renewable as well and has comparable low CO_2 emissions. Still there are some relevant emissions due to uncomplete combustion as the greenhouse gases methane and dinitrogen oxide.

The example shows that a substantial reduction of environmental impacts due to heating can be achieved by state of the art insulation of houses combined with renewable energies.

Background

This short analysis was conducted as part of an internship at ESU-services. ESU-services has previously developed a key parameter model that is used by SEBASOL for assessing the primary energy consumption of solar thermal systems. SEBASOL is a non profit organisation involved in scientific research for de-growth, DIY, solar thermal and other low-tech/ cost/ footprint renewable energy domestic systems.

Literature

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