LCA of thermally driven adsorption heat pumps for substitution of electricity and fossil fuels

Christine Schärer

Within the huge research project on Thermally driven adsorption heat pumps for substitution of electricity and fossil fuels (THRIVE) this thesis shows different application scenarios for thermally driven adsorption heat pumps in Switzerland. The advantage of an adsorption heat pumps consists in the fact that thermal energy for cooling and heating of buildings is delivered by means of waste heat e.g. from industry, cogeneration plant, solar thermal or geothermal energy. With this strategy heating can be done with a minimum amount of electricity. Further the aim of the THRIVE project is to construct an optimized adsorption heat pump. To see which part of the system contributes most to environmental damage impact and which application is optimal, a Life Cycle Assessment (LCA) is done. a life cycle impact assessment method which comprises harmonized category indicators at the midpoint and the endpoint level (ReCiPe) is used for the Life Cycle inventory analysis (LCIA).

The key component of an adsorption heat pump is a solid absorber material having the feature to release thermal energy by adsorption of the refrigerant. But it's also possible to deliver cooling power to the environment through this technology. By means of estimations of THRIVE experts, the environmental impact of the heat pump and its applications are estimated. The crucial life cycle phase is the production of the materials and of the heat pump components. The main impact towards ReCiPe is because of the complex activated Carbon absorber production. Another absorber which is considered is a silica gel absorber which is produced out of sodium silicate. This absorber has less than half the impact on environment. A further crucial material which is used in many of the heat pump components is copper. It contributes much to the environmental impact referred to the ReCiPe Endpoint impact assessment. The reason is the copper production where human toxic compounds are released. But according to cumulated energy demand (CED) the absorber heat exchange system and the aluminum case are more relevant. This can be explained by the fact that the aluminum case production needs a lot of energy. After having used the system, the system should be totally recycled and the environmental impact and the CED will be minimized. For the LCIA calculations a recycling rate of 90% for copper and aluminum are assumed.

For the Swiss energy landscape, there are several possible applications of a large scale adsorption heat pump. Besides the application in data centers, the combination with solar thermal collectors and district heat as operating power are considered. The result of the SimaPro calculations of the application scenarios shows, that the difference between the different ReCiPe damage impacts in the weighted sum is relative small. The reason is, that the use phase of the adsorption heat pump has a little environmental impact if waste heat from industry, cogeneration plant, solar thermal or geothermal energy is used as thermal energy source.