Preliminary LCA study of an inter-seasonal heat storage reactor for central heating

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L.C.A conference — A tool for strategic decision-making

Background

As an alternative to fossil fuels for residential central heating and sanitary hot water production, a system stores solar heat using salts, water vapour and a reversible chemical reaction:

$$S.xH_2O \Leftrightarrow S.(x-y)H_2O + yH_2O$$

where "S" is a hygroscopic salt (Fig. 1). The system is currently studied at the prototype scale. Reactions with a high enthalpy per volume unit determine best candidates for "S".

Method & Functional unit

- Data collection originates from a system under development:
  - Collectors: existing products from ESE with selective coating
  - Heat storage performances: lab scale tests (Umons)
  - Heat demand: meteorological modelling (ULg).
  - W/o sanitary hot water
  - Reactor: design from ESE
- "S" = $CaNO_3$, $CaCl_2$ or $MgSO_4$. Calculations not complete: $SrBr_2$.
- Generic data from EcoInvent v2.2 – impact calculated via Impact 2002+ (endpoint)
- F.U.: 30 years central heating of a family house (100 m², K=50)

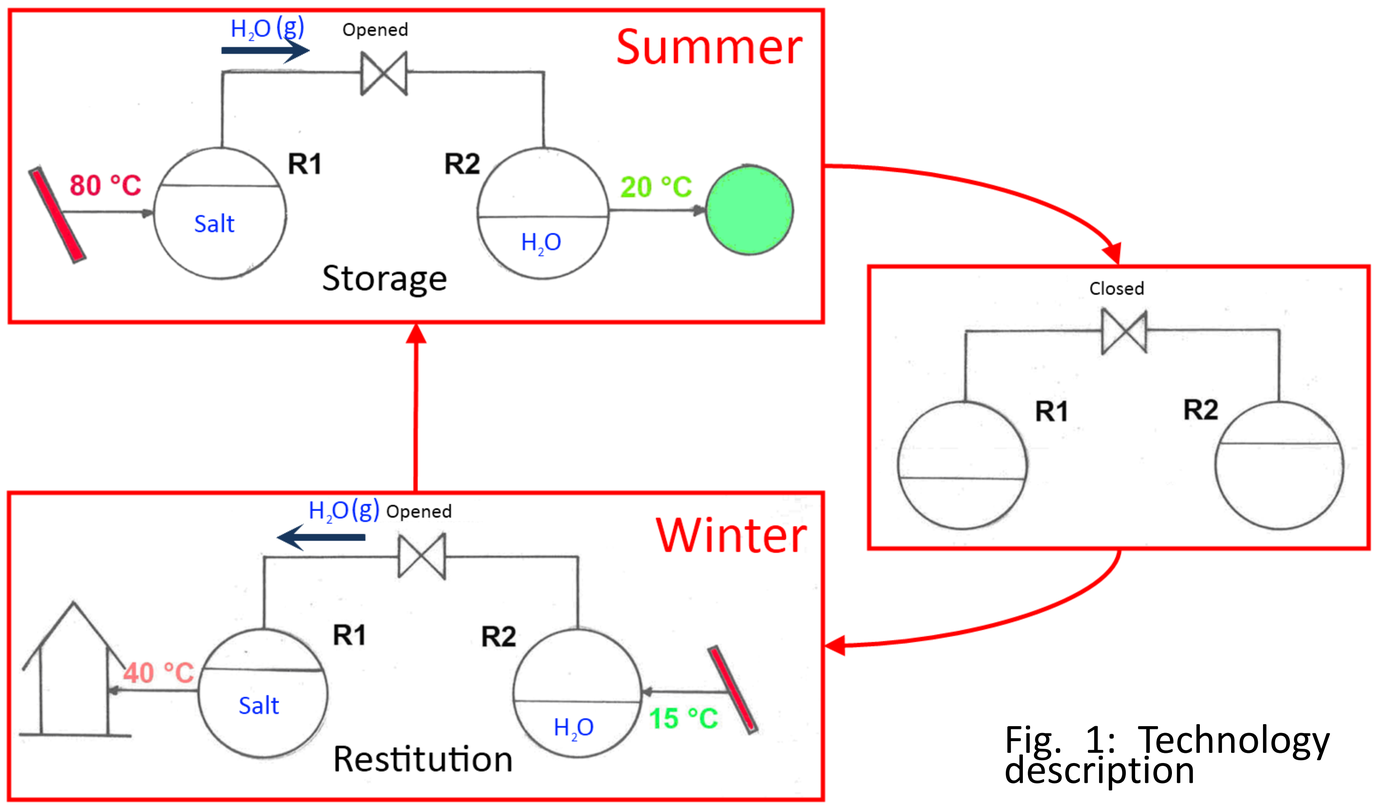

Fig. 1: Technology description

Goals

- "Lower bound" of the impacts: relevance of the proposed technology?
- Comparison between candidates for "S" and assistance in their selection. Identify necessary improvements.
- Comparison with a conventional system.
- Identification of missing LCA data

LCI & LCIA

Five thermal collectors of 2,32 m² are necessary to provide the house with heat. Dimensions of the reactor depend on the performances of the individual salts, which determines the amount of materials for the container and the heat exchanger (Fig. 2).

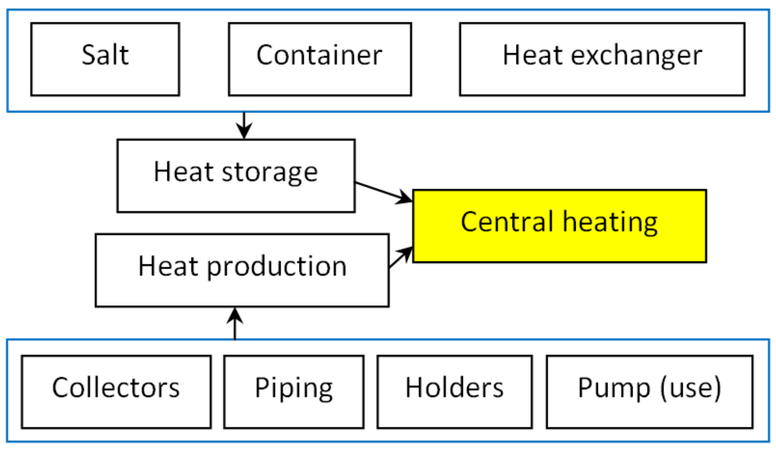

Fig. 2: Simplified inventory of components

For instance, the $MgSO_4$ option necessitates 20,7 tons salt, 4,7 tons steel and 730 kg copper.

Comparing the options, $MgSO_4$ is a more suitable candidate than $CaNO_3$ and $CaCl_2$ (Fig. 3). $CaNO_3$ is penalized by both its ecoprofile per kg and its low thermal performances.

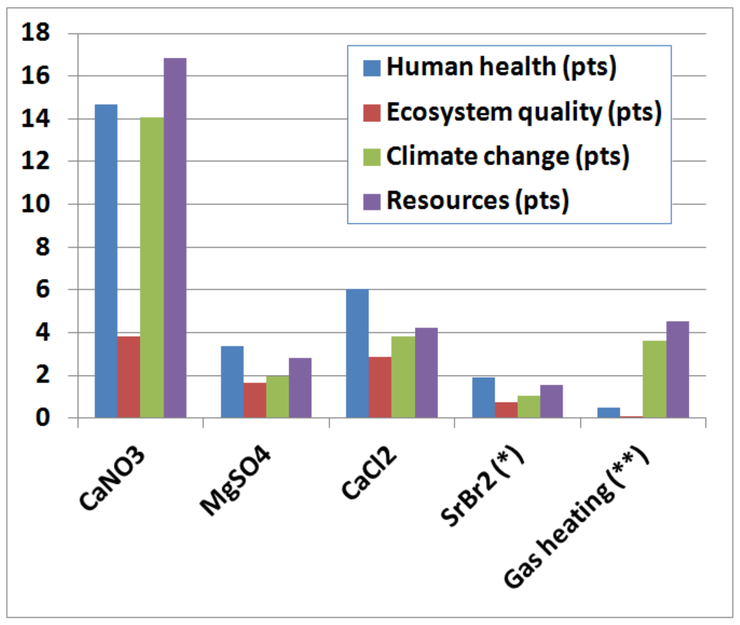

Fig. 3: Comparison of the technological options

(*) incomplete data
(**) data from literature as a guide: "heat, natural gas, at boiler condensing modulating <100kW" (Ecoinvent Centre (2007), ecoinvent data, v2.2. ecoinvent reports No.1-25, Swiss Centre for Life Cycle Inventories, Dübendorf, 2007, retrieved from: www.ecoinvent.org.)

In contrast, with only 8,5 tons, $SrBr_2$ drastically reduces the reactor dimension and impacts.

The present system may already improve on climate change and/or primary energy consumption. Even more efficient schemes are yet to identify resulting in smaller reactors and less human health impact.

Impacts mainly originate from the reactor itself and the salt. The selective coating of the absorber can be neglected at the system storage scale (Fig. 4).

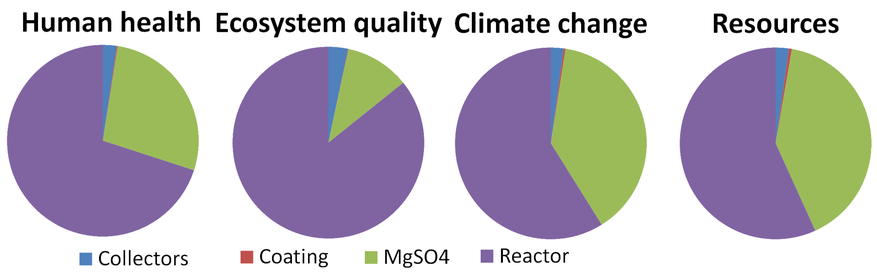

Fig. 4: Components contributions for $MgSO_4$

Conclusions

According to these LCA results, thermochemical storage of heat to provide the residential sector with central heating is a promising way to reduce climatic impacts and the use of non-renewable energies, according to LCA. However, this technology requires massive reactors and several tons of salts, generating high impacts on human health during the production phase. Attention should be paid to the improvement of the performance per volume unit and the selection of more durable materials for the reactor.

Perspectives:
- Identifying recycling paths; how to recover the salts?
- Refining the lifetime assumption using corrosion data. Coupling of LCA and corrosion tests.
- Including more candidates in the analysis – need of data for bromides.
- Including more field data on the system performances.
- Time issue in LCA for long-term modelling.

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