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INNOSTORAGE – USE OF INNOVATIVE THERMAL ENERGY STORAGE FOR MARKED ENERGY SAVINGS AND SIGNIFICANT LOWERING CO_2 EMISSIONS

Beneficiaries:

Partners:

D7.2 -Report on Staff Exchanges

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1 Objectives

The main objectives of this study is to complete the life cycle assessment (LCA) and find the environmental impact of Merit project and the Field Test Demonstrator (FTD) system which is built and tested within the Merit project. This study also aims to identify the advantages of Merit system from a typical solar combisystem (reference system) in terms of environmental impacts.

2 Introduction

Seasonal storage system (S3) or MERIT system is based on novel high-density materials. This system is designed to use renewable energy (solar energy) to supply all heating and cooling requirements of the house. In addition, 100% of domestic hot water demand is supplied with this system. For testing S3 system a Field Test Demonstrator (FTD) is built which is downscaled from S3 system. FTD system is located in Lleida, Spain. FTD is built in the 45-foot sea container and has three main compartments: storage compartment where short term and long term storage systems (8 TCM modules), domestic hot water system and cooling system (Solabcool) is located, external equipment compartment which is mainly use for controlling and monitoring the system and building simulation compartment. Four solar collectors are directly mounted on top of this container. So the FTD system considering downscaling has four solar collectors of 3 m^2 each, short term buffer vessel with capacity of 300L, and 480MJ energy storage capacity for 8 TCM modules [1, 2].

3 Description of work, Materials and Methodology

Applying LCA analysis is accomplished in four steps: definition of goals and scope, life cycle inventory, life cycle impact assessment and interpretation [3]. So in this study also at first, objectives and the boundaries of the project are identified. As it is mentioned earlier, the full size Seasonal Storage System (S3) and the Field Test Demonstrator (FTD) are analysed in this study. The S3 and FTD system are designed to supply all heating, cooling energy requirements as well as domestic hot water (DHW) demands from renewable energy. The whole system consists of solar collectors, short term buffer, long term storage which is thermo chemical energy storage system (TCM), an absorption chiller(solabcool). For next step which is the inventory analysis, all inlets (energy, water and materials use) and outlets of a system needs to be identified and quantified. To complete this step, all components in the system are identified and listed. For the third and last step, life cycle impact assessment and interpretation respectively, LCA manger software which works based on Eco-indicator 99 database is used. Results from this software show the potential environmental impacts for each component or material in the systems throughout the life cycle. The impact assessment from this software includes ecosystem quality indicators, human health and resources indicators. Finally at the last step, processes and materials that have highest environmental impacts are identified.

4 Results

The first task was to identify the components in the system. So I visited the site .Then I received some manuals of components and documents about specifications of components from colleagues in university of Lleida. From reviewing of these documents an excel file has been prepared which contains summery of specifications of main components in the system. This file under name of bill of materials has been attached to this report. I also visited the site few more times to check and understand the piping system there.

At next step, I got familiarised with LCA manager program. All main components such as solar collectors, short term storage vessel, auxiliary heating, expansion vessel, etc... have been entered into the program. Then from *indicators* tab all indicators related to Ecosystems quality, Human Health and Resources were selected. Finally, at the *result* tab values for indicators for each component is calculated and shown. Table below shows values for three components of expansion vessel, short term storage vessel and insulation of the short term storage (Rockwool is used for insulation) as an example. An excel file with more details is attached to this report under the name of *imported results from LCA prog*.

INDICADOR / UNIDAD	expansion vessel	Short term storage vessel	Insulation of short term storage vessel
Eco99 (H,A) - Acidification & eutrophication (points)	1.76E-02	8.90E-01	1.13E+05
Eco99 (H,A) - Ecotoxicity (points)	1.91E-01	2.21E+01	1.50E+06
Eco99 (H,A) - Land occupation (points)	3.88E-02	1.74E+00	7.46E+05
Eco99 (H,A) - TOTAL Ecosystem quality (points)	2.47E-01	2.48E+01	2.36E+06
Eco99 (H,A) - Carcinogenics (points)	1.42E-01	6.96E+00	6.52E+06
Eco99 (H,A) - Climate change (points)	9.34E-02	3.56E+00	3.16E+05
Eco99 (H,A) - Ionising radiation (points)	4.33E-03	9.30E-02	5.96E+03
Eco99 (H,A) - Ozone layer depletion (points)	2.73E-05	8.82E-04	9.11E+01
Eco99 (H,A) - Respiratory effects (points)	4.32E-01	2.91E+01	2.30E+06
Eco99 (H,A) - TOTAL Human health (points)	6.71E-01	3.97E+01	9.15E+06
Eco99 (H,A) - Fossil fuels (points)	5.01E-01	1.36E+01	1.35E+06
Eco99 (H,A) - Mineral extraction (points)	1.46E-01	1.95E+01	1.45E+06
Eco99 (H,A) - TOTAL Resources (points)	6.47E-01	3.30E+01	2.80E+06
Eco99 (H,A) - TOTAL (points)	1.57E+00	9.75E+01	1.43E+07

At next step, results from this software will be entered into an excel file to be processed. Since, only units of each material or component were entered into the LCA manager program, results from the software will be modified with actual quantities.

The heat exchanger is not on database of LCA manger, so for this component a different method has been applied to find its environmental impact. Method was used by [4] and finds TGWP the total global warming emissions expressed in equivalent tons of CO_2. Following formulas show the calculations for TGWP.

$TGWP = LCI_{const} * df$

Where LCI_{const} is associate with the construction of the heat exchanger and df is the damage factor.

$LCI_{const} = A(K)* S*\rho_{steel}* \omega_{steel}$

Where A(K) is the heat transfer area, S is the thickness of the tubes in the heat exchanger, ρ_{steel} is the density of steel and ω_{steel} is the LCI associated with the production of 1 kg of stainless steel.

In this study, A(k) is equal to 0.31, S is equal to 20 mm , ρ_{steel} is equal to7800 kg/m^3 and ω_{steel} is assumed 5.2536. So the LCI_{const} for heat exchanger is 254.064. Finally, the TGWP is calculated by multiplying this number in damage factor.

5 Outcomes or future work

The main task for future will be completing the list on the software, slabcool and fresh water station needs to be entered in the software. Then it is required to find the values of indicators for each component based on the actual quantities. This includes values for pipes in the system. The software shows only environmental impact of 1 kg of copper pipes. So it is needed to find the total length for each type of pipe to know the total weight.

Table below shows the dimensions and physical characteristics of copper tubes (type L) [5].

External diameter	Weight of pipe in pound/ft	Weight of pipe in kg/m
15 mm	0.198	0.294
18 mm	0.362	0.538
22 mm	0.455	0.677
28 mm	0.655	0.974

Second, components for reference system which is described in [2] needs to be identified and the environmental impact for reference system needs to be calculated.

Third, calculating the efficiencies for each system and finally writing a joint paper from the work.

6 References

1. *FP7 MERITS. More Effective use of Renewable including compact Seasonal Thermal Energy Storage, D5.7 Specification for design of demonstration systems for field tests*, 2015
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3. Cabeza, L.F et al., *Life cycle assessment (LCA) and life cycle energy analysis (LCEA) of buildings and the building sector: A review*, Renewable and Sustainable enrgy Review, 2014. 29, p. 394–416.
4. Antipova et al., *Multi-objective design of reverse osmosis plants integrated with solar Rankine cycle and thermal energy storage,* Applied energy, 2013. 102, p 1137-1147.
5. The copper tube handbook, 2011, Copper Development Association Inc, New York, NY.

7 Assessment

I am very grateful to have a chance to work with colleagues in university of Lleida under supervision of Prof Luisa Cabeza. It was a good experience to meet other researchers and work with them whose work is in the similar area. I learned a lot about MERIT system and thermochemical energy storage systems as well as advantages of using this kind of systems in buildings.