BACHELOR PROJECT

Life Cycle Assessment of small-scale hydrogen-based energy production plant

Life Cycle Assessment (LCA):

LCA is a multi-stage approach from cradle to grave of each component and sub-component of the analyzed system. The purpose of this assessment is to evaluate multiple environmental impacts caused by a system. To do so, we will take into account all the processes, from the extraction of raw materials, to the recycling of the devices.

Here we are in a prospective LCA, which is a method for combining scenario analysis with consequential LCA to assess the potential impacts of technologies and infrastructure systems that are not yet operating at commercial scale.

To evaluate quantitatively the different impacts, we use *Quantis Suite 2.0* software with EcoInvent 2.2 database.

Goals and scope of the study:

We are assessing a solar-driven hydrogen-processing device, combined with a fuel cell to produce electricity and heat to help fulfill the needs in energy of a household in Switzerland. Our work is based on the project of fellow students who are working with Prof. Haussener, from the Laboratory of Renewable Energy Science and Engineering (LRESE). They designed two types of photoelectrochemical (PEC) panels to produce hydrogen, these two solutions are described in the section below.

The main point of this study is to compare, in an environmental way, this new “green” source of energy to currently used energy sources. We will also compare the two possible solutions to find the one with the less negatives environmental impacts.

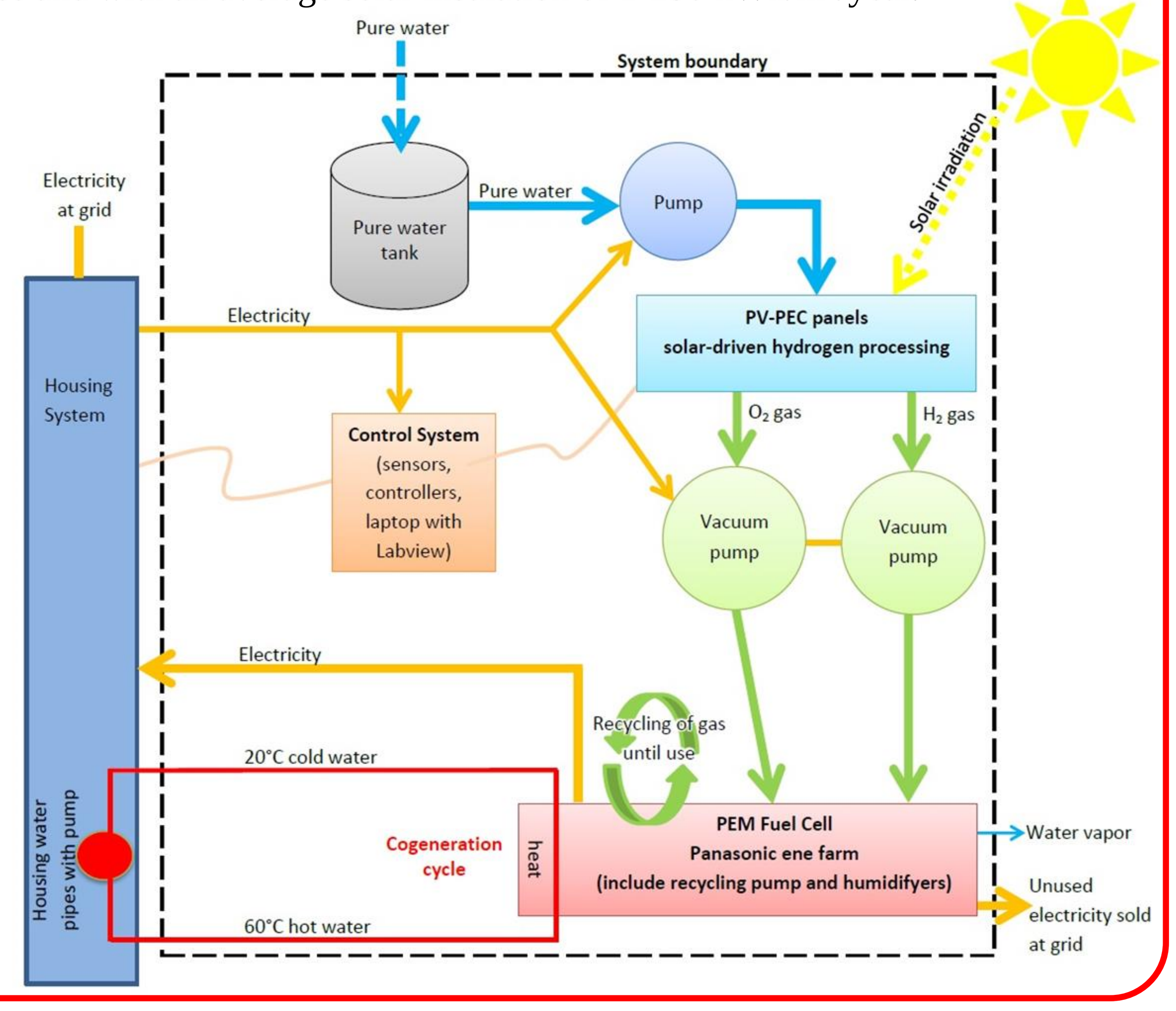
Description of the system:

The PV-PEC panels converts solar irradiation to hydrogen and oxygen. Then, these gases are used in a PEM Fuel Cell to generate electricity and heat which will be used in a cogeneration cycle. We based our study on a household with 60m^2 panels surface and with an average solar insulation of 1’250 kWh/m^2/year.

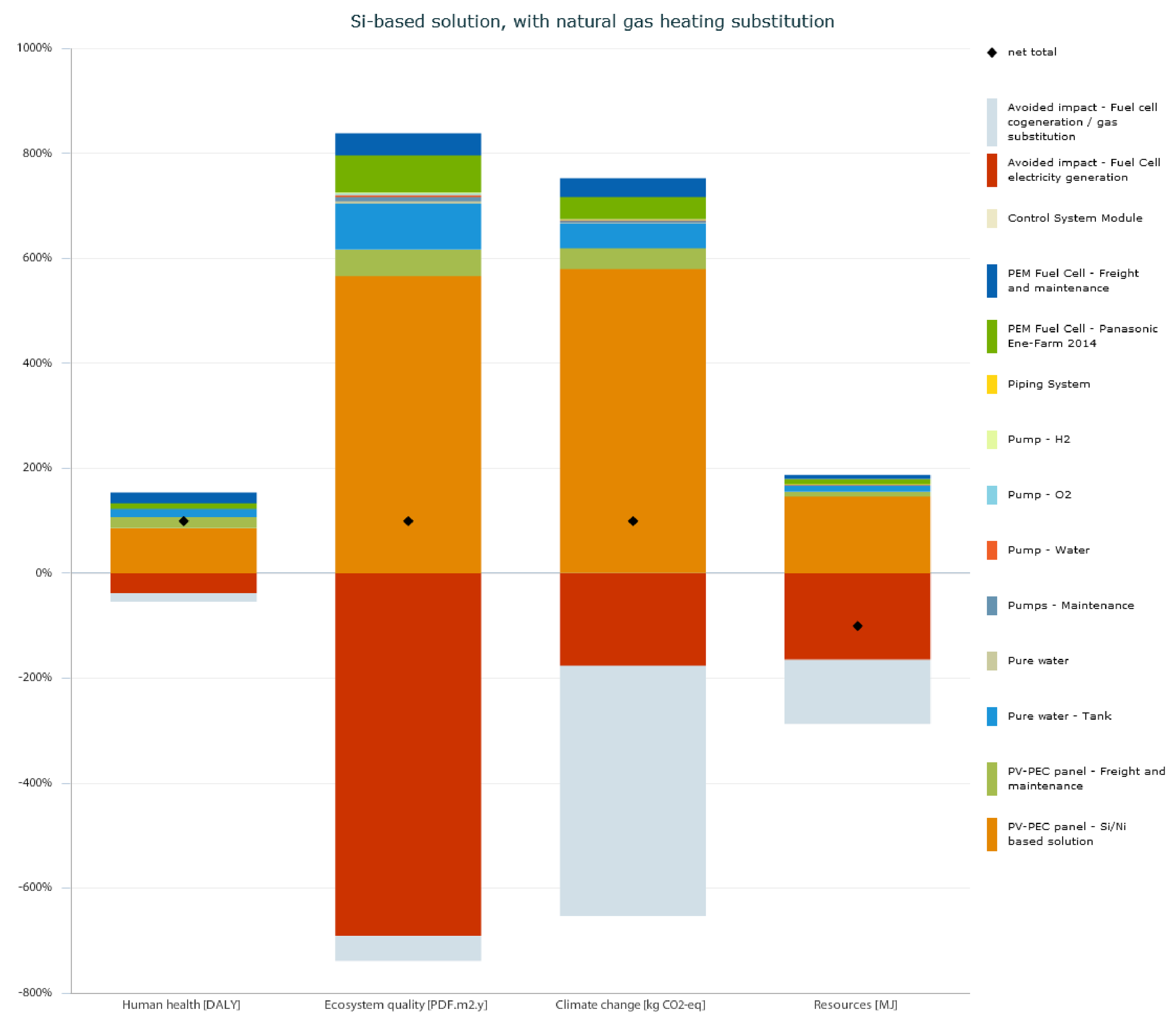
Two PEC alternatives have been developped:

Si-based solution: c-Si PV module with Ni-based catalysts, which represents a cheap type of panel, with 9.8% efficiency.

Ga-based solution: GaAs/GaInP PV module with platinum catalysts, which represents a more expensive type of panel, with 16,4% efficiency.

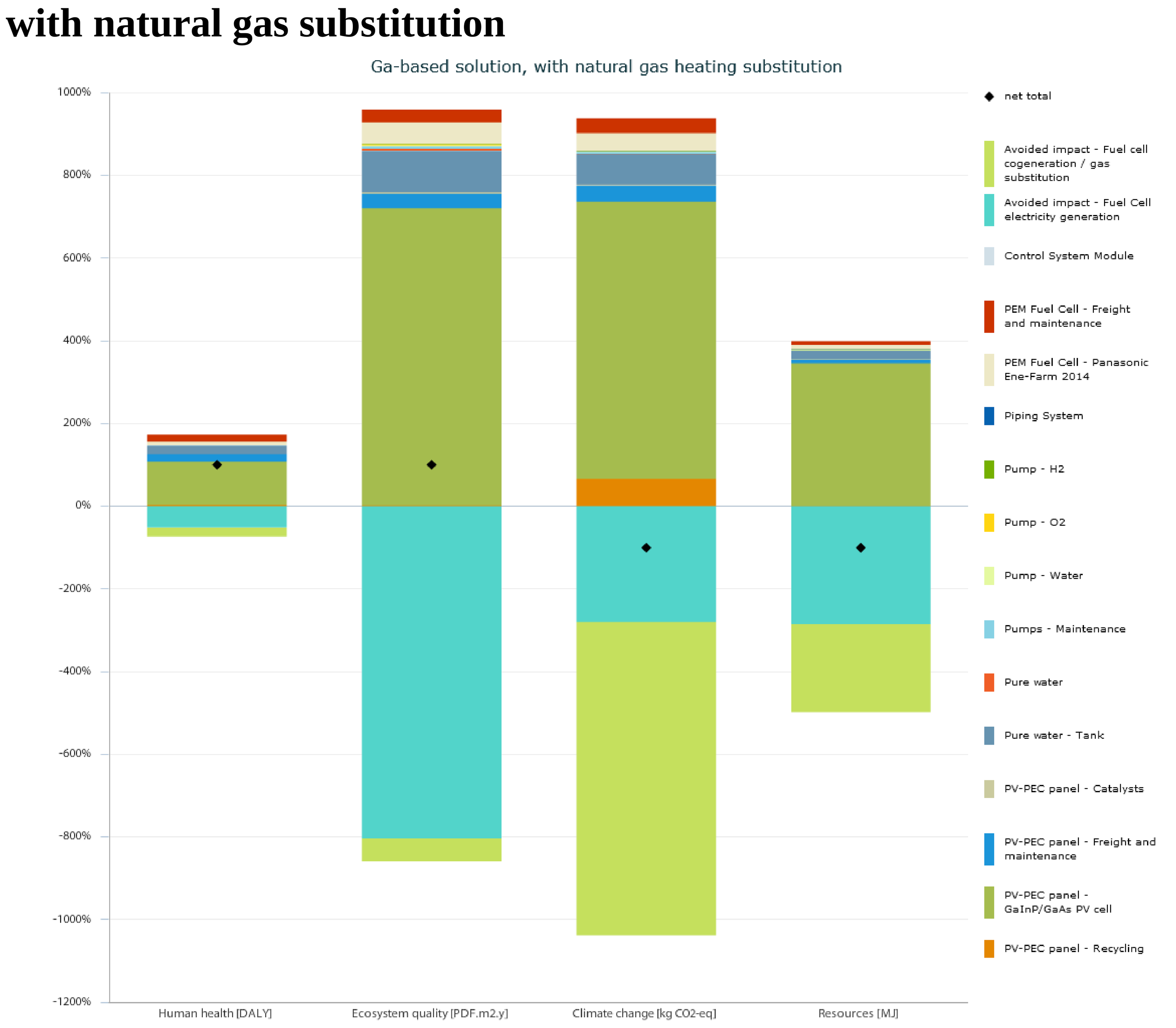


LCA of the two PV-PEC alternatives solutions with natural gas substitution



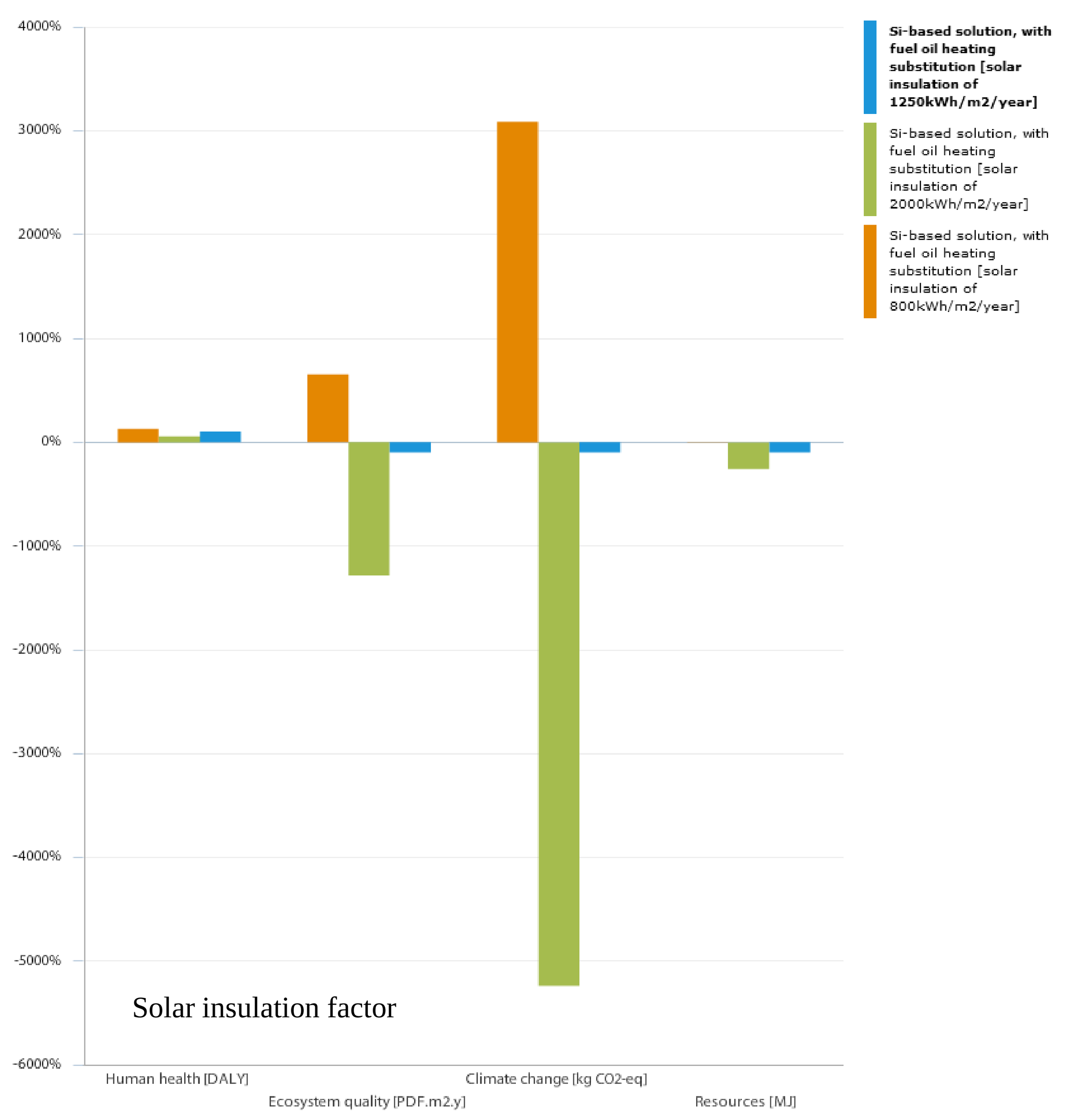
These graphs are showing the net environmental impacts for various indicators. The two solutions are set as an alternative to natural gas heating. For the scaling, we have the total net impact set at 100%, so the indicators are correlated according this scale.

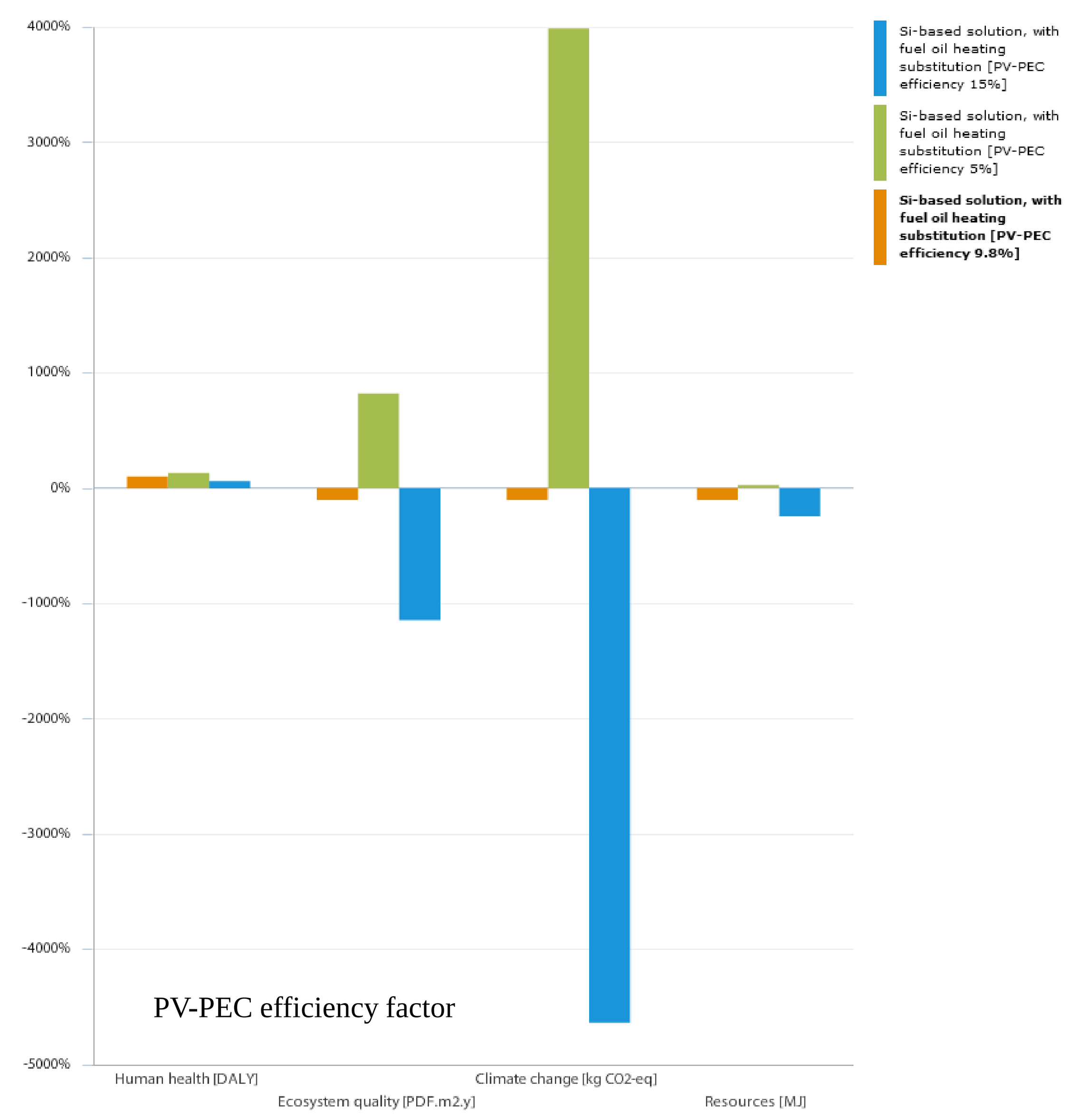
The Si-based solution left has only a reduced impact in term of resources. The Ga-based solution has also a reduced impact for the climate change, so this solution is a little better.

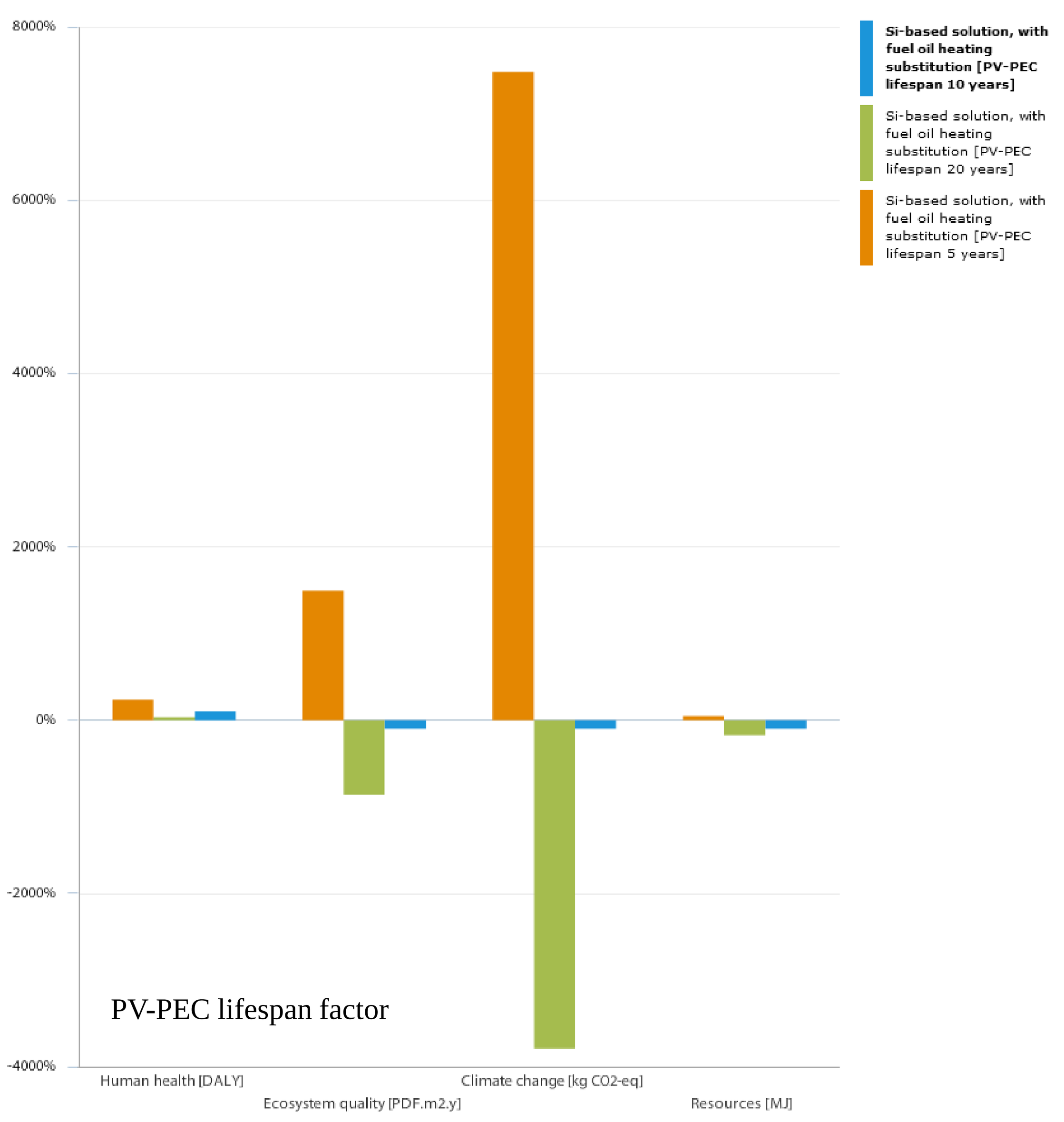


Sensibility Analysis:

To quantify the influence of each main factor, we conduct a sensibility analysis for the Si-based solution, with fuel oil heating substitution.







The sensitivity analysis shows the main factors that can greatly affect the final net environmental impacts. All the comparisons are based on the base case (in bold in the legends) set at 100%, in order to compare easily the factors variations.

Conclusion :

These small-scale hydrogen-based energy production plant can avoid a large amount of impact cause by current sources of energy. Nevertheless the production of these devices also causes non negligeable environmental impact which can make these alternatives useless. Since this technology is still experimental, we can assume that some improvements will be made in the futur. The sensitivity analysis shows that a better solar insulation will consequently reduce climate changes. Also if the efficiency and the lifespan of the PV-PEC panels are increased, the net amount of impact will be reduced.

Acknowledgements:
LICP: Professor Dimitris Kiritsis, PhD Damien Friot, Fatih Karakoyun *LRESE*: Professor Sophia Haussener, Alexandre Cattry, Luca Rinsoz, Maxime Vignon, David Perone

Authors:
Audrey Kessler, Aurélien Peix