LABORATOIRE D'ELECTROTECHNIQUE ET D'ELECTRONIQUE DE PUISSANCE DE LILLE

Master project, 2023 – 2024

A comparative life cycle assessment of a hybrid AC/DC microgrid and its AC equivalent in a tertiary building

Supervisor: Benoit Durillon
Co-supevisor: Khaled Almaksour
Contact: benoit.durillon@junia.com

Context

The current climate crisis calls for a drastic reduction in greenhouse gases (GHG) emissions. Greater integration of renewable energy sources (RES) is essential to reduce the GHG emissions from grid electricity. On a building scale, integrated RES (rooftop photovoltaic plant, local wind turbines, …) is a very effective way of implementing those resources.
An increasing number of loads work using direct current (DC) – such as LED lighting, computers, high-power electric vehicle charging stations, etc. – and RES are natural DC sources. In this context, it has been demonstrated that using a DC backbone to connect DC loads to DC sources can increase the global system efficiency. Indeed, the solution of a hybrid AC/DC microgrid (H-MG) (fig.1) is studied with the aim of assessing the pros and cons of such a solution.

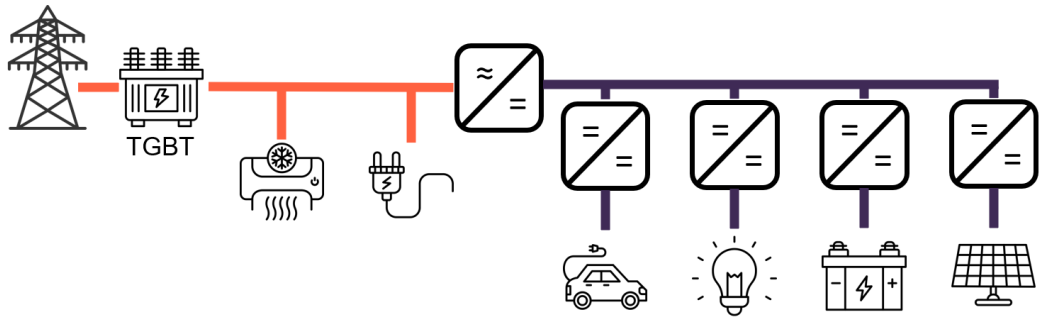

Figure 1 Hybrid AC/DC microgrid example

Using a DC backbone implies many changes in the network architecture, with DC/DC static converters, DC protection equipment, and specific controllers. Current research focuses on the use phase of DC and hybrid AC/DC microgrids, but very few research is conduced about the impacts of their whole life cycle.

Objective

To have a clear view on the environmental impacts of a H-MG, the lifecycle assessment (LCA) methodology will be used. A comparative study between a conventional AC microgrid (AC-MG) and a H-MG will be performed.

The main objective of this study will be to assess the different environmental impacts of both microgrid types to provide scientific data to deciders. Sensitivity analyses will also be needed, to assess the impact of key parameters such as DC voltage, PV area, DC loads, …

The A-MG and H-MG architectures and all the needed technical data about its component will be provided. The objective of the master thesis will be to make an inventory of the in- and out-going flows to assess its environmental impacts.

Work steps

1. A bibliographic project about the LCA of energy systems, electrical networks, semiconductors appliances will be performed;
2. The system borders, functional unit, hypotheses and methodological choices will be defined and discussed , according to the objective of the work;
3. The environmental loads of the different components of both MGs will be inventoried, based on technical data, LCA databases and existing scientific literature;
4. A sensitivity analysis on some key parameters (DC voltage levels, PV capacity, converters' architecture, semiconductors technology, …) will be performed to mitigate the results and provide more robustness to the analysis.

Keyword

Hybrid AC/DC microgrid, AC/DC hybridization, renewable energy sources, environmental impact, lifecycle assessment, lifecycle analysis

References

Tabassom Farzad, Cecilia Sundberg, et Ulla Mörtberg, « Life Cycle Analysis for a DC-microgrid energy system in Fjärås », 2019.

C. Kockel, L. Nolting, R. Goldbeck, C. Wulf, R. W. De Doncker, et A. Praktiknjo, « A scalable life cycle assessment of alternating and direct current microgrids in office buildings », Applied Energy, vol. 305, p. 117878, janv. 2022, doi: 10.1016/j.apenergy.2021.117878.

A. Papageorgiou, A. Ashok, T. Hashemi Farzad, et C. Sundberg, « Climate change impact of integrating a solar microgrid system into the Swedish electricity grid », Applied Energy, vol. 268, p. 114981, juin 2020, doi: 10.1016/j.apenergy.2020.114981.

D. J. Hammerstrom, « AC Versus DC Distribution Systems Did We Get it Right? », in 2007 IEEE Power Engineering Society General Meeting, juin 2007, p. 1 5. doi: 10.1109/PES.2007.386130.

E. Unamuno et J. A. Barrena, « Hybrid ac/dc microgrids—Part I: Review and classification of topologies », Renewable and Sustainable Energy Reviews, vol. 52, p. 1251 1259, déc. 2015, doi: 10.1016/j.rser.2015.07.194.