Infrastructure EELab/Lemcko:

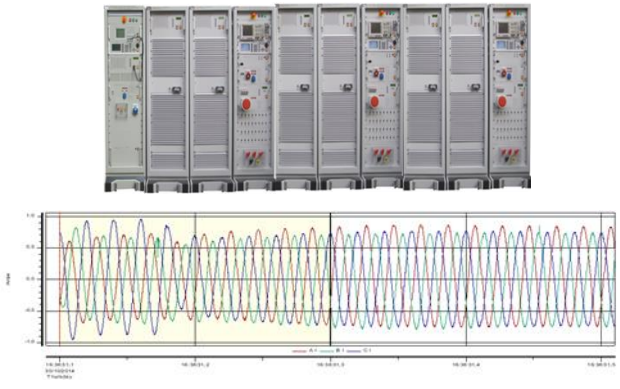
The available research infrastructure within EELab/Lemcko has started with the construction of a test field for photovoltaic installations with different PV technologies (such as thin film, monocrystalline, polycrystalline solar panels etc.), financed within the EFRO call 2007. The aim of this project was to compare different PV systems with each other in terms of efficiency and yield under different climatic conditions including its impact on the public LV distribution network.

[PHOTO 1] : PV-tracker

[PHOTO 2] : PV Test-field

The Hercules foundation s was an excellent opportunity to further expand our vision on distributed generation. The proposed investment made it possible to analyse the grid behaviour with both the existing voltage distortions on the network and the self-defined different types of imbalances and over voltages. Thanks to the four quadrant operation of the system (240kVA), the study could be extended to the impact of renewable sources on the distribution grid. This project was granted by the Hercules foundation in 2009. After implementation of this programmable power source, connections ware made to the PV test field in order to analyse the behaviour of RES on the grid and vice versa. On that moment, it was still not possible to conduct studies on the impact of renewable energy sources on a realistic distribution network.

Later on, the test infrastructure has been extended with an effective distribution network (installed by Eandis – former Fluvius) following the state-of-the-art techniques. The latter consists of an underground cable (approx. 680m – EXAVB 4x150mm² Al), which is connected to 3 different connection points and has been developed to such an extent that it can easily physically configure diverse grid configurations (radial, antenna or ring network) as well as different topologies (TT and TN). The low-voltage (LV) distribution grid provides 18 connection points for consumers (and/or prosumers) and this for both residential and industrial applications. During the EFRO-project 655 in 2011 the grid was further developed to a realistic grid with-nowadays household equipment. The **grid emulator** was born in 2012!!

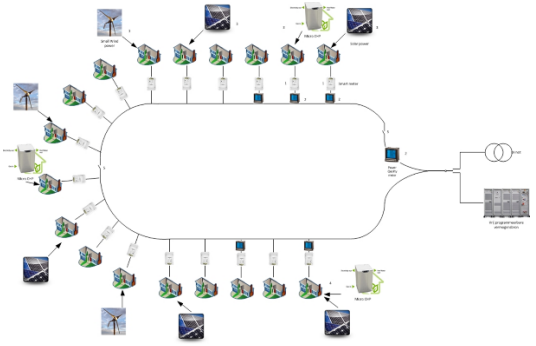


[PHOTO 3] : Freely programmable power source

[PHOTO 4] : LV-test-field

Since 2014 we started with the further research, more related to the self-consumption of renewable energy sources by adding storage to the system. In a first stage local storage systems were analysed from the point of view of energy

balancing. With the further development of measurement systems, the knowledge of load behaviour and the stability of systems both more dynamic approach and study of the aggregated storage was needed. Therefore we submitted a project proposal to the Flemish IWT (institute for Scientific research) for granting our research proposal in the domain of local storage. The project "Decongestion to the distribution grid by decentral storage" – D³O (IWT-TETRA/130187) was granted. This project allowed us to analyse the impact of local storage on the grid in order to increase the self-consumption of end users. During this project the **grid emulator** was extend with local storage units from both line connected and line interactive types of combined PV/storage systems.

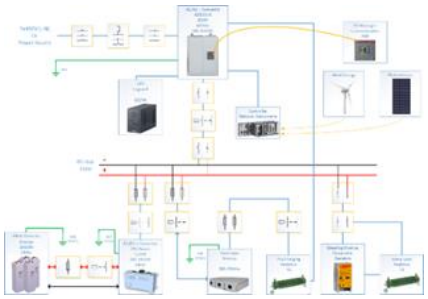


[PHOTO 5] : Extended test field with RES

[PHOTO 6] : Schematic View

The technological developments and results of the D³O project initiated the research group to develop a complementary research in the domain of storage systems. Indeed, since the behaviour of a residential end user can differ a lot with the consumption profile of a company in both profile and dynamic behaviour, a new research proposal with title "Solutions for increased self-consumption and self-sufficiency in SMEs" –"KMO" was submitted to VLAIO (the Flemish Institution for Innovation and Entrepreneurship) and granted (HBC 2016.0107) During this project new insights were created who lead us to a first design concept of a local dynamic storage system, who allows to analyse dynamic behaviour on storage including the influence of hybrid storage technologies Since 2017 a first concept was operational.

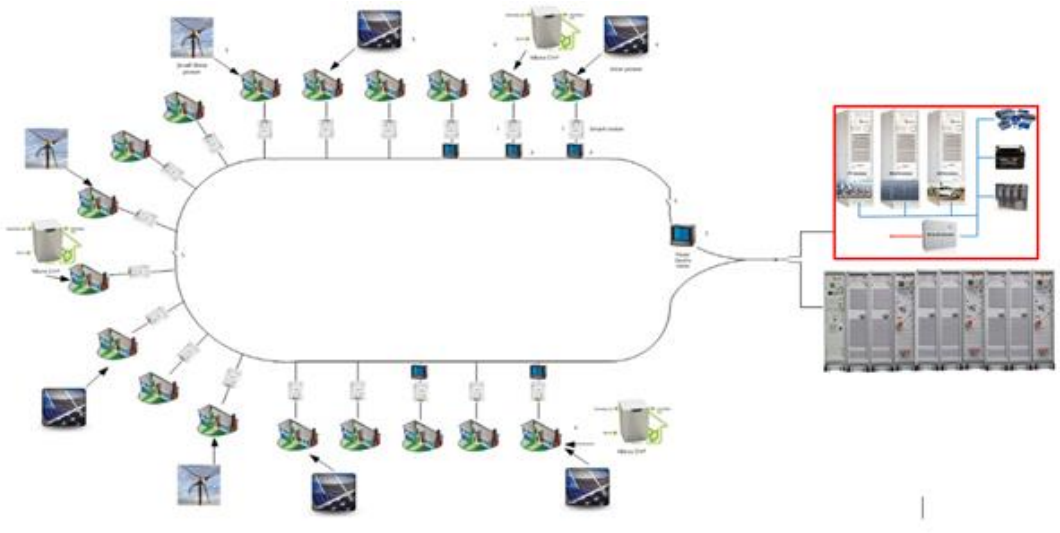
[PHOTO 7] : Test field for hybrid storage



[PHOTO 8] : Schematic View

Again, the insights obtained during the KMO research period has lead us to a new issue, related to the need of better interaction between different storage systems. Not only better interaction, but also more flexible solutions required another approach. Furthermore, due to recent research projects, the lab infrastructure was expanded with a DC-grid (where storage technologies like lead-acid and lithium-ion batteries but also supercaps are connected). Consequently these DC link was transformed in a DC grid emulator end resulted in a new emulator/demonstrator for both research and industry analysis.

In order to conduct in depth analysis of the impact of renewable energy systems (RES) and energy storage systems (ESS), see research [1], an emerging need of flexibility occur. In 2017 a new research proposal "Flexible solutions for the LV grid of tomorrow" "FLEXNET"– (HBC 2018.0035) was granted by VLAIO. During the FLEXNET-project both test infrastructures (grid emulator and DC emulator) were combined as a **full integrated grid emulator** (Fig.9). This allows us to study and emulate the behaviour of real load infrastructures, including real PV installations and combined with realistic and different storage systems. This is of major importance for studying future challenges in the electricity grid.



[PHOTO 9] : Schematic overview of fully integrated grid emulator

In February 2020, we submitted a new research proposal in the domain of grid capacity to VLAIO. The aim of this proposal "Control of hosting capacity of LV grids by flexible application of renewable energy, storage and load demand" FLEXICAP (HBC.2020.2104). The aim of this project is to study the possibilities of integration of emerging technologies in the existing grid to prepare it to the grid of the future. Thanks to our high end **fully integrated grid emulator** will be able to expand this system with nowadays technologies and demonstrate and analyse their conduct.

[1] https://www.ugent.be/ea/eemmecs/lemcko/en/research