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# Multi-Terminal Hybrid Microgrid for emerging applications

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## INTRODUCTION

Power distribution systems are evolving toward low-inertia, RES-based architectures with increasing use of DC technologies. Multi-terminal hybrid DC microgrids are essential for developing advanced control, protection, and power quality solutions to enable efficient, reliable, and scalable DC networks for the clean energy transition.

## FRAMEWORK

This work showcases a hybrid (AC+DC) microgrid test infrastructure (FlexiMLAB) consisting of three laboratories, which are interconnected using 2 DC distribution lines. The setup is seen by the legacy AC distribution network as a load only, i.e. operates as a self-consumption node (no power generation into the grid). The experimental setup illustrates the multi-terminal hybrid DC microgrid interconnecting the laboratory rooms (EB 105, EG 111, and EI 106) using the DC links rated at 350V. Each lab room has connected local PV generation, storage batteries, and conversion units, all operating via DC-DC converters with a 350 V voltage setpoint. A key feature of the system is the availability of multiple voltage levels, provided through a set of DC/DC converters that step the 350 V bus down to 48 V, 110 V, and 220 V. The energy transfer within the microgrid is monitored using an advanced network of high-resolution AC and DC meters, installed at every critical interface point.

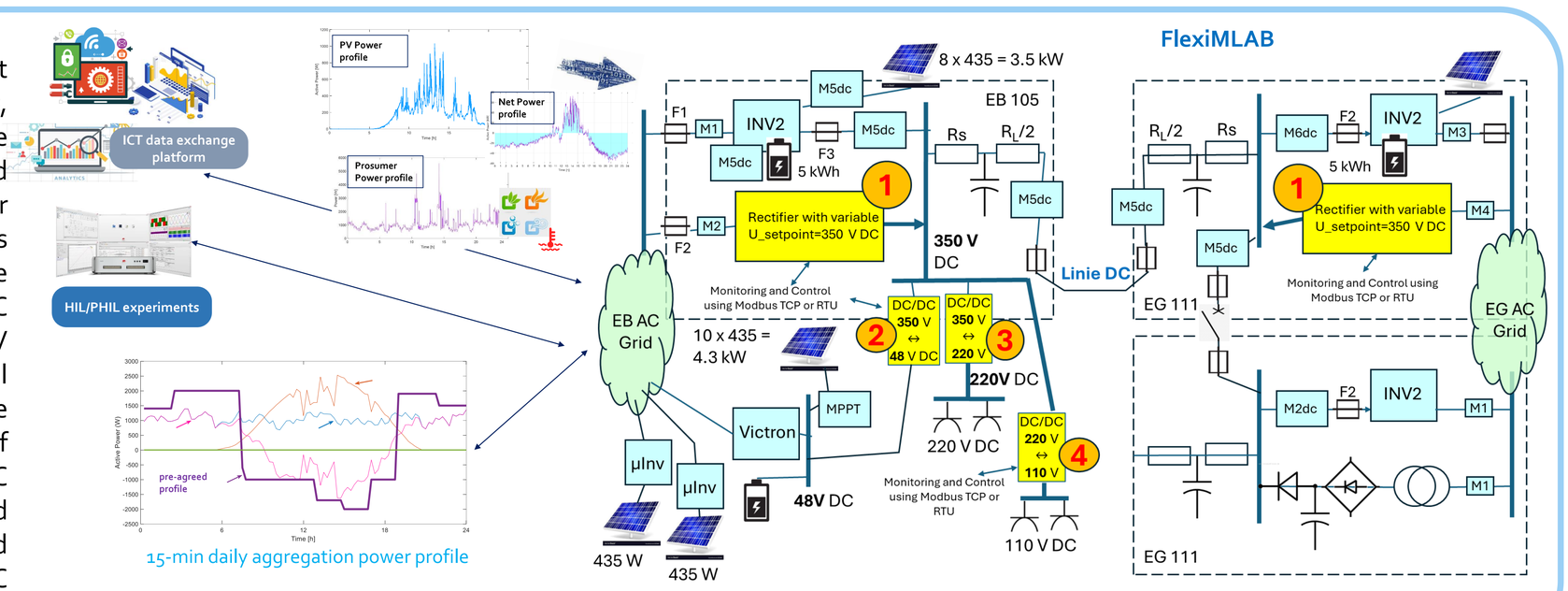
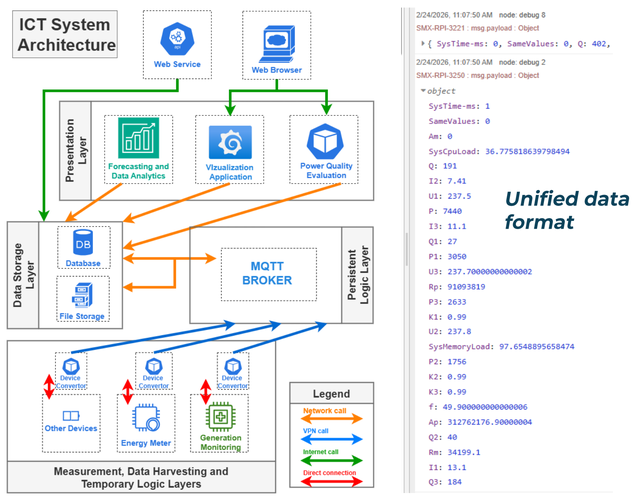



Figure 1. FlexiMLAB microgrid topology and services

# Advancing Emerging Applications with Multi-Terminal Hybrid AC/DC Microgrid Architectures

## ICT Platform for Monitoring and Control



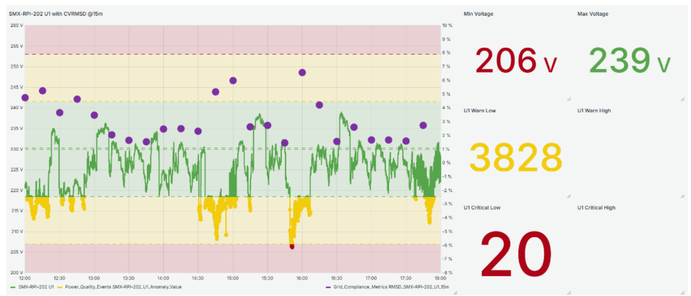


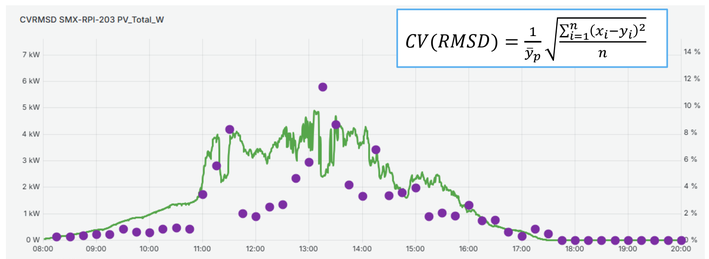


Architecture for the heterogenous information integration in the ICT platform

## Data analytics engine

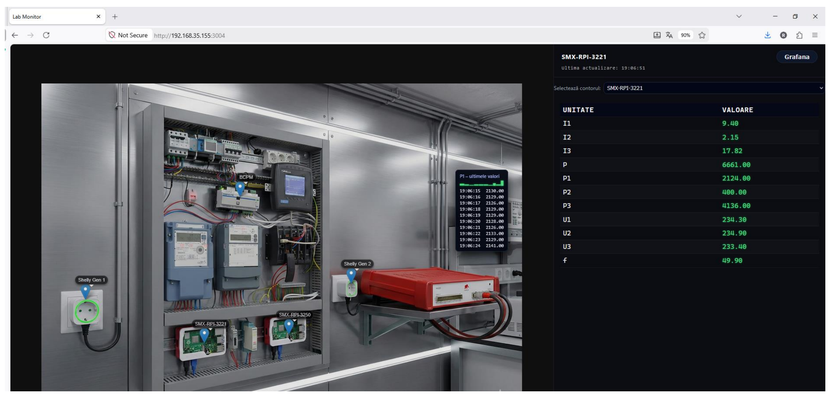
Correlation and data analytics computing




## User interface

User-interface for interaction with the ICT platform (AC side)




## DC side with HIL and PHIL experiments




A real-time monitoring and control of a multi-terminal hybrid microgrid based on integrating advanced power quality measurement, dynamic energy management, and resilient operation for next-generation distributed energy systems – *work in progress*

## PHIL Experiments



Power-Hardware-in-the-Loop (PHIL) experiments using Typhoon HIL are conducted within the FlexiMLAB hybrid AC/DC microgrid to validate advanced protection and control solutions. The Typhoon HIL is interfaced with physical components and an InfluxDB database for realistic, accurate, and flexible testing.

## HINTS FOR FUTURE WORK

- Commissioning & Validation:Testing multi-terminal DC operation (350 V), self-consumption mode, and system stability under dynamic load/generation scenarios.
- ICT Platform Development:Real-time monitoring, data integration from high-resolution meters, and implementation of energy management & control algorithms.
- Advanced Control & Optimization:Coordinated control of DC/DC converters, storage management, and multi-voltage operation (48V–350V).
- Power Quality Analysis:High-resolution assessment of harmonics, voltage stability, and converter interactions in hybrid AC/DC systems.
- Experimental Applications:Validation of DC loads, EV integration, and efficiency gains from reduced conversion stages.

## Acknowledgment

Some of the pictures in this poster have been adjusted using AI tools

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