

# SIRFN POWER SYSTEM TESTING DEVELOPMENT OF BENCHMARK SYSTEM FOR CHARGING CONTROL INVESTIGATION

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## Motivation

To address the emerging threat of climate change, consumers must transition to sustainable transportation. The electrification of the transport sector through e-mobility poses new challenges and uncertainties for grid operators as shown in Figure 1. Without efficient prior measures, grid development problems will inevitably arise, causing a need for costly grid expansions. To ensure a technically and economically successful transition to electric vehicles, grid operators need modern, digital tools that enable the investigation of a variety of future scenarios. At present, these tools only exist in a simulation environment, where multiple assumptions are made to obtain feasible results. This poses a high risk, as operators must design and maintain distribution grids in advance and based on clear-cut scenarios.

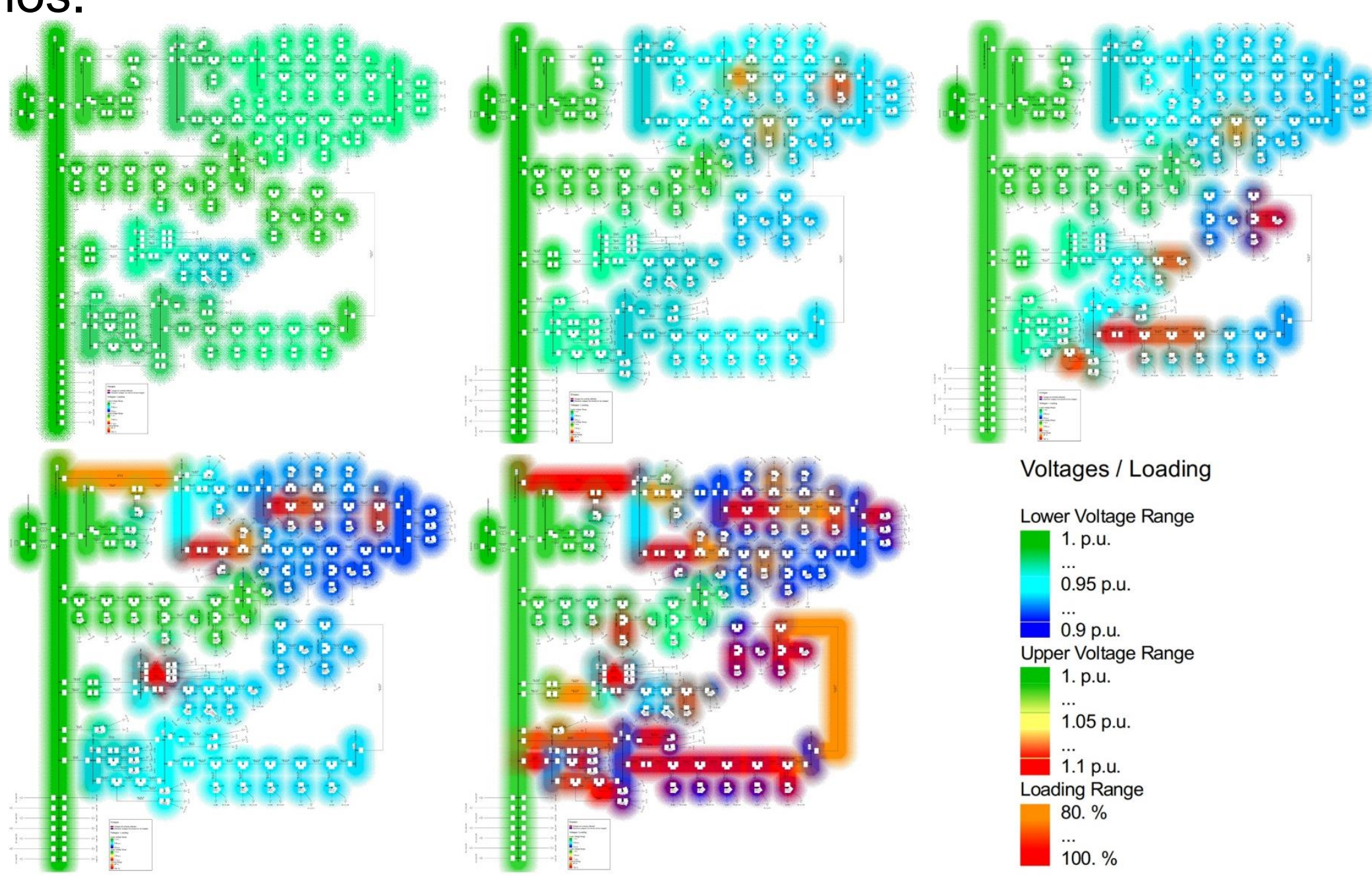


Figure 1 - Existing LV distribution grids with different EV penetration levels with a charging station share of 0%, 8%, 10%, 12% and 20% (top left to bottom right) [1]

## State-of-the-Art

Existing test systems lack data/information about real grid behaviour with increased shares of PV systems, EV charging patterns and 3rd party control actions. Most of the works so far deal with 1 – 15min load/generation patterns, which may not always reflect real issues, that should be considered within robust control strategies (unbalance/variability of loads, variability of PV feed-in, communication/measurement loss, asynchronous measurements). To fill this gap, the proposed tool, as depicted in Figure 2, combines PV, EVSE with a higher resolution of 1 – 10 sec, to provide a fundamental basis for further LV grid control strategy investigation.

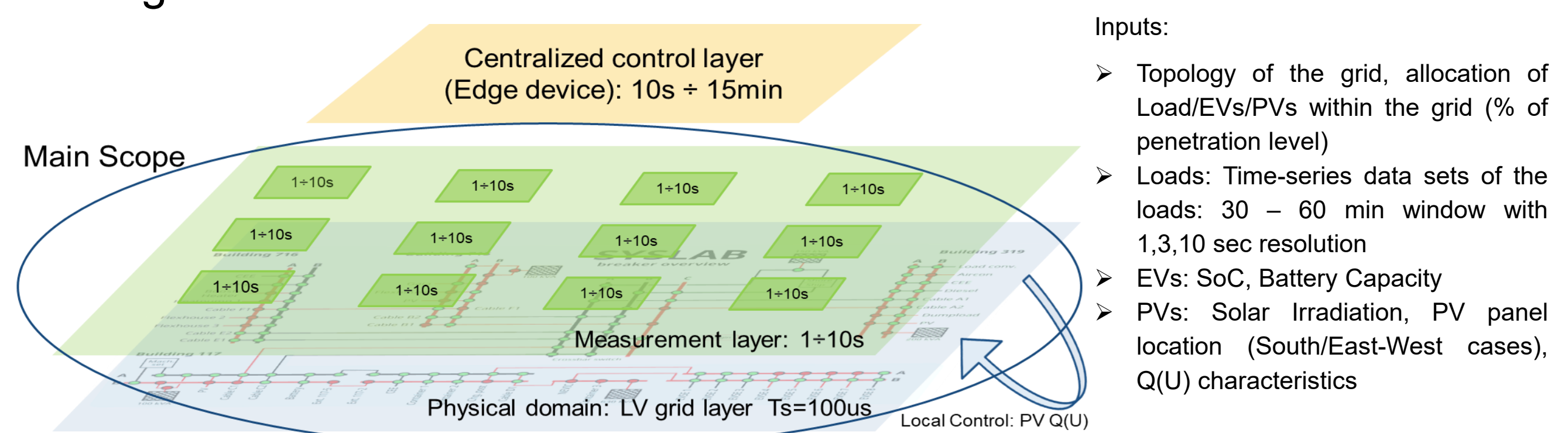


Figure 2- Benchmark system concept

## Benchmark system concept and preliminary results

Work is done in collaboration between SIRFN [2] and ERIGrid 2.0 [3] in establishing a methodology and tools for a further benchmark system. The main objective of the collaboration is to verify and validate reference systems based on SYSLAB-defined topologies [4], as shown in figure 3, with the Simulink environment-based models of LV grid topologies with a high share of EVSE, and PVs to execute it in a real-time environment via digital Real-Time Simulation (RTS) equipment. The main scope is to mimic physical grid behaviour in an RTS environment to allow investigation of real scenarios and accelerate long-term validation processes of various EV charging control algorithms, independent of unexpected exterior obstacles that may hinder field tests.

## References

- [1] C. Allenspach, R. Högger, A. Obusevs, P. Korba, H. Reist, "Implementation of Quasi-Static Time Series Simulations for Analysis of the Impact of Electric Vehicles on the Grid" 2019 IEEE 60th RTUON
- [2] SIRFN: Smart Grid International Research Facility Network. <https://www.iea-isgan.org/>
- [3] ERIGrid 2.0: European Research Infrastructure supporting Smart Grid and Smart Energy Systems Research, Technology Development, Validation and Roll Out – Second Edition. <https://erigrd2.eu>
- [4] SYSLAB - Energy System Integration Lab. <https://www.elektro.dtu.dk/>

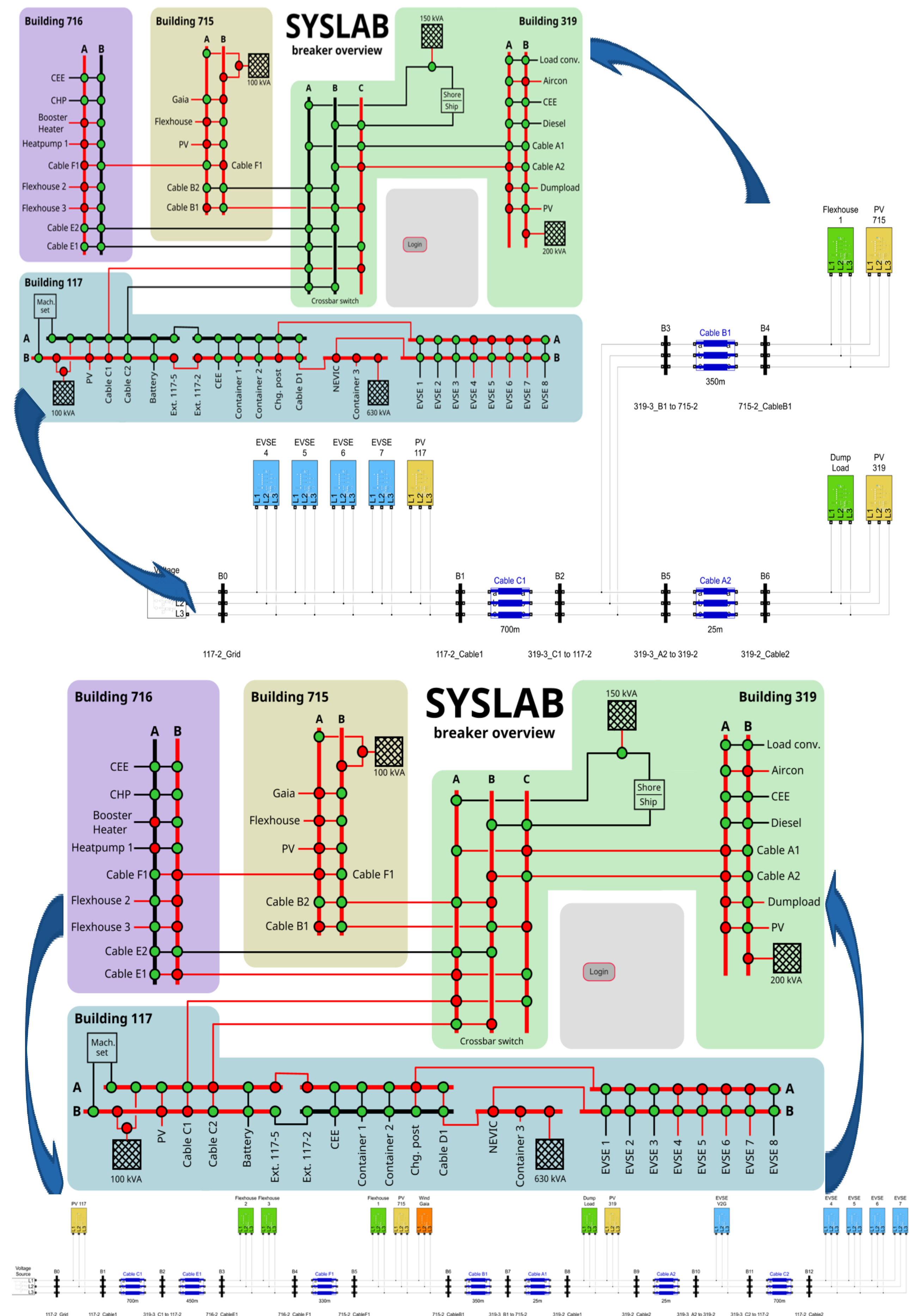


Figure 3 - Verification and validation of urban (top) and rural (bottom) topology systems

Table 1. Summary of validation results for three investigated topologies

	Case 1 <sup>1</sup>		Case 2 <sup>1</sup>		Case 3 <sup>1</sup>	
Implementation "C" <sup>2</sup>	RMSE U [V] <sup>3</sup>	RMSE I [A] <sup>3</sup>	RMSE U [V] <sup>3</sup>	RMSE I [A] <sup>3</sup>	RMSE U [V] <sup>3</sup>	RMSE I [A] <sup>3</sup>
Medium line topology	1.641	1.928	2.017	1.695	2.329	1.337
Urban topology	3.868	0.289	3.697	1.294	3.602	1.656
Rural topology	4.704	1.088	8.329	1.788	7.553	2.881

<sup>1</sup> Different load/generation combinations during tests

<sup>2</sup> Define grid voltage as an external grid with V<sub>nom</sub> = 400V & use setpoints of the dumpload

<sup>3</sup> Worst Case: max value of all busbar errors

Based on validated reference systems, a benchmark system is being developed within SIRFN community, combining worldwide know-how of digitalisation, mobility, and energy transformation in a power system testing 'risk-free' environment.

## Conclusion

The validated LV grid reference system fits the RMSE requirements in regard to voltage and current set as RMSE V<5V, RMSE I<5Amps. Further investigations regarding active and reactive power model discrepancies need to be conducted in order to increase confidence in using the digital twin. The digital twin benchmark system aims to reach an optimal balance between simplicity (and thus the computational effort required) and accuracy. Further tuning of the model is still possible, especially with regard to the cable line parameters and the outlier detection.

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