SIMULATION TOOL FOR TECHNO-ECONOMIC ANALYSIS OF HYBRID AC/DC LOW VOLTAGE DISTRIBUTION GRIDS

Nina Fuchs[1], Gerhard Jambrich[2], Helfried Brunner[2]

[1]Electrification & Automation, Siemens AG, Vienna, Austria
nina.fuchs@siemens.com

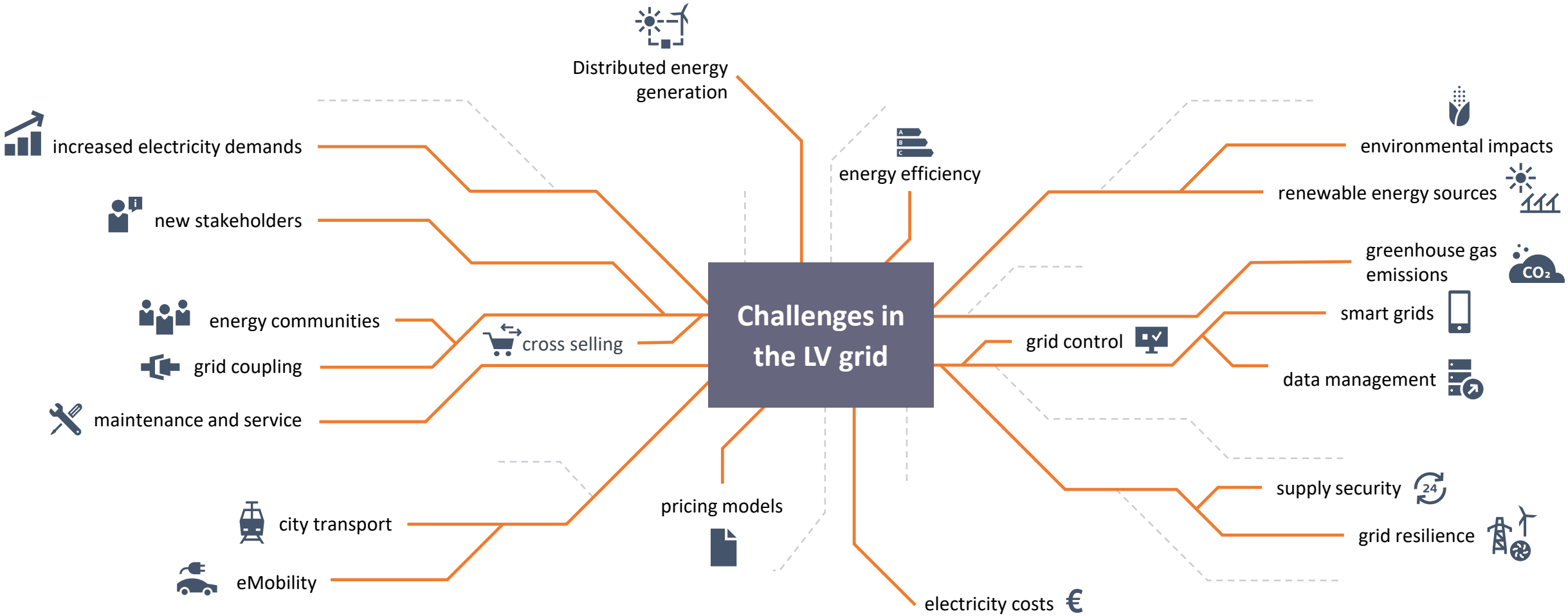
[2]Electric Energy Systems, AIT Austrian Institute of Technology GmbH, Vienna, Austria
gerhard.jambrich@ait.ac.at

CIRED 2021 Best Young Academic Paper Award Winner

Outline

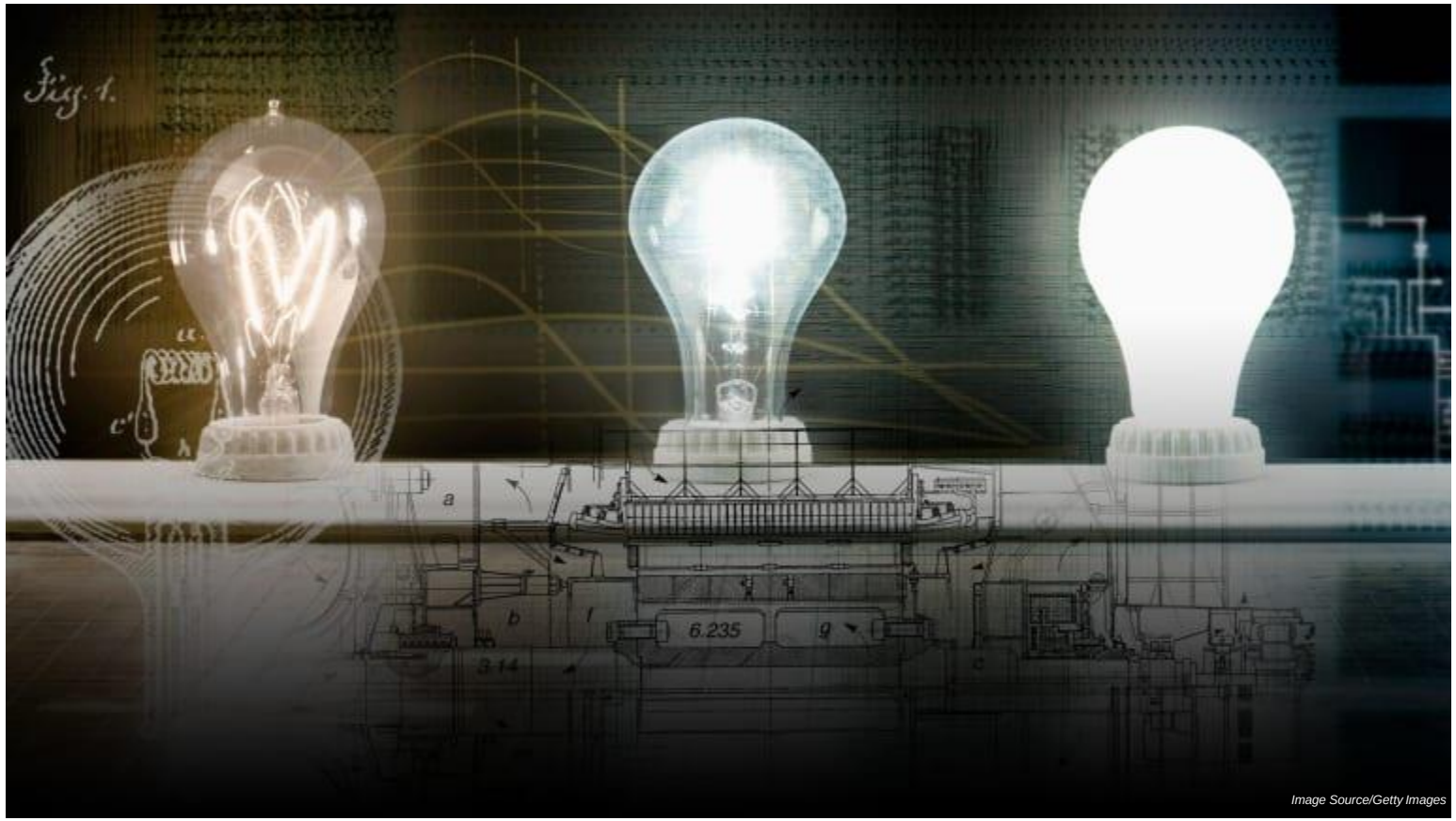
- Motivation
- Scenarios for LV AC/DC Hybrid Grids
- Synthetic Test Grid
- Tool Preview
- Selected Simulations
- Load Flow Simulation Results
- Economic Analysis Results
- Outlook

Motivation


Distributed energy generation
energy efficiency
environmental impacts
renewable energy sources
greenhouse gas emissions
smart grids
data management
supply security
grid resilience
electricity costs
pricing models
city transport
eMobility
maintenance and service
grid coupling
energy communities
cross selling
grid control
increased electricity demands
new stakeholders
Challenges in the LV grid

Motivation

Let’s take a step back…

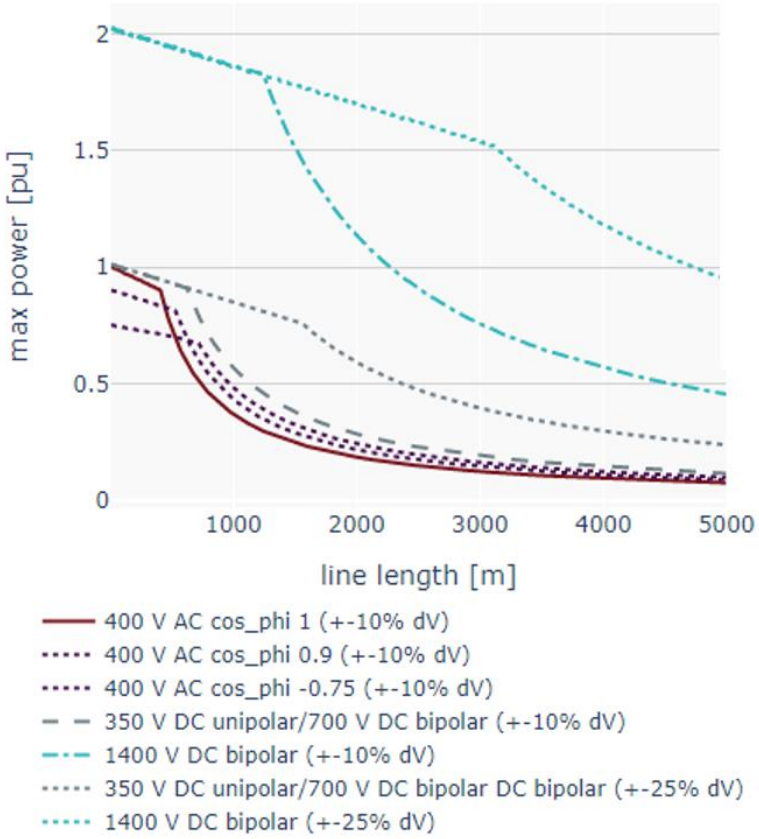


Why direct current?

→ Improve overall **efficiency**.

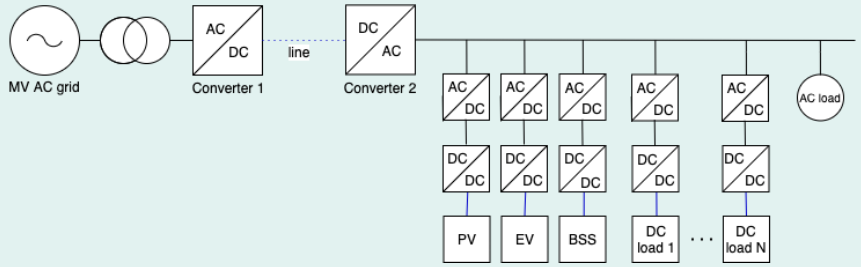
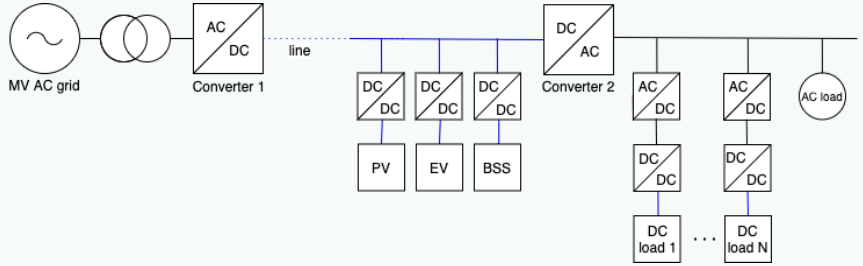
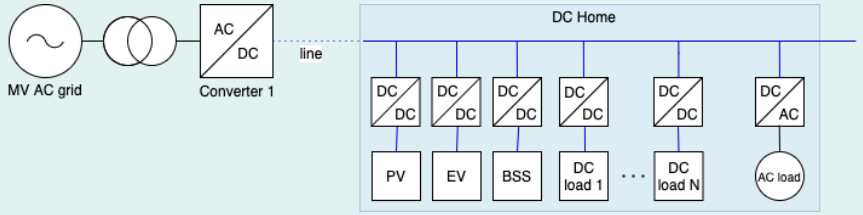
→ Increase **power transmission capacity**.

→ Minimize **reinforcement investments**.

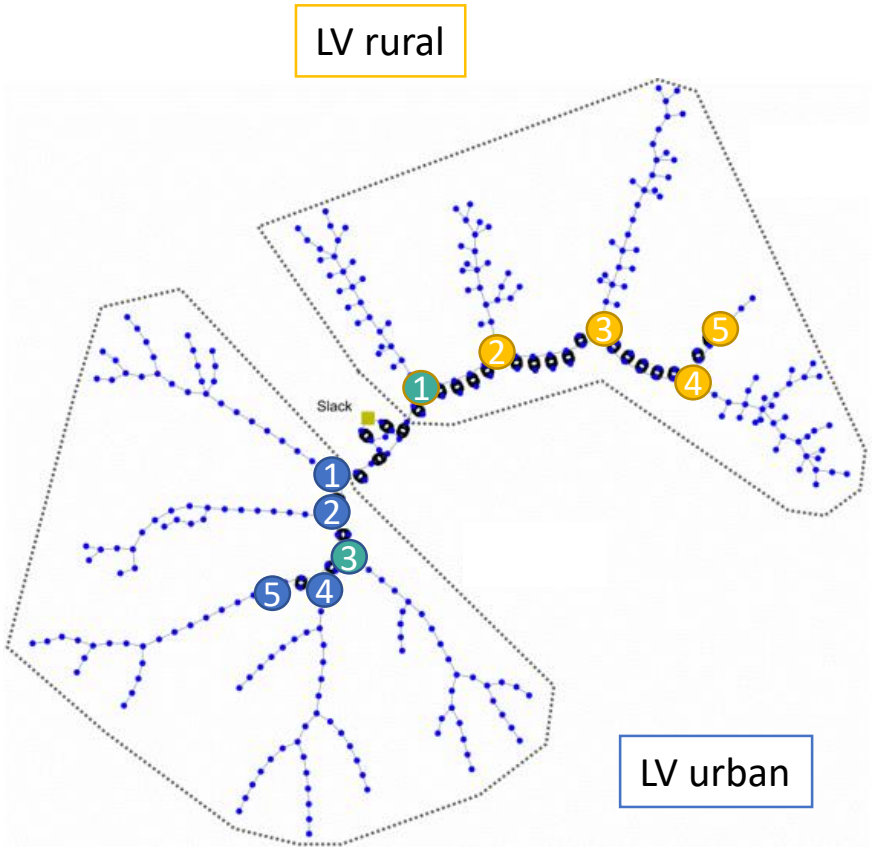


Maximum transmission power vs line length; cable type XAY2Y 4x150; max 1400 V_{DC} bipolar; p.u. of max. power at 1m line length operated at 400 V_{AC}, cos(φ) = 1.

Scenarios for LV AC/DC Hybrid Grids

scenario	description	schematic diagram
0	lossless conversion to DC	
1a	LVDC lines, AC customers	
1b	LVDC lines, AC customers, PV and EV connected to LVDC grid	
2	LVDC lines, DC customers	

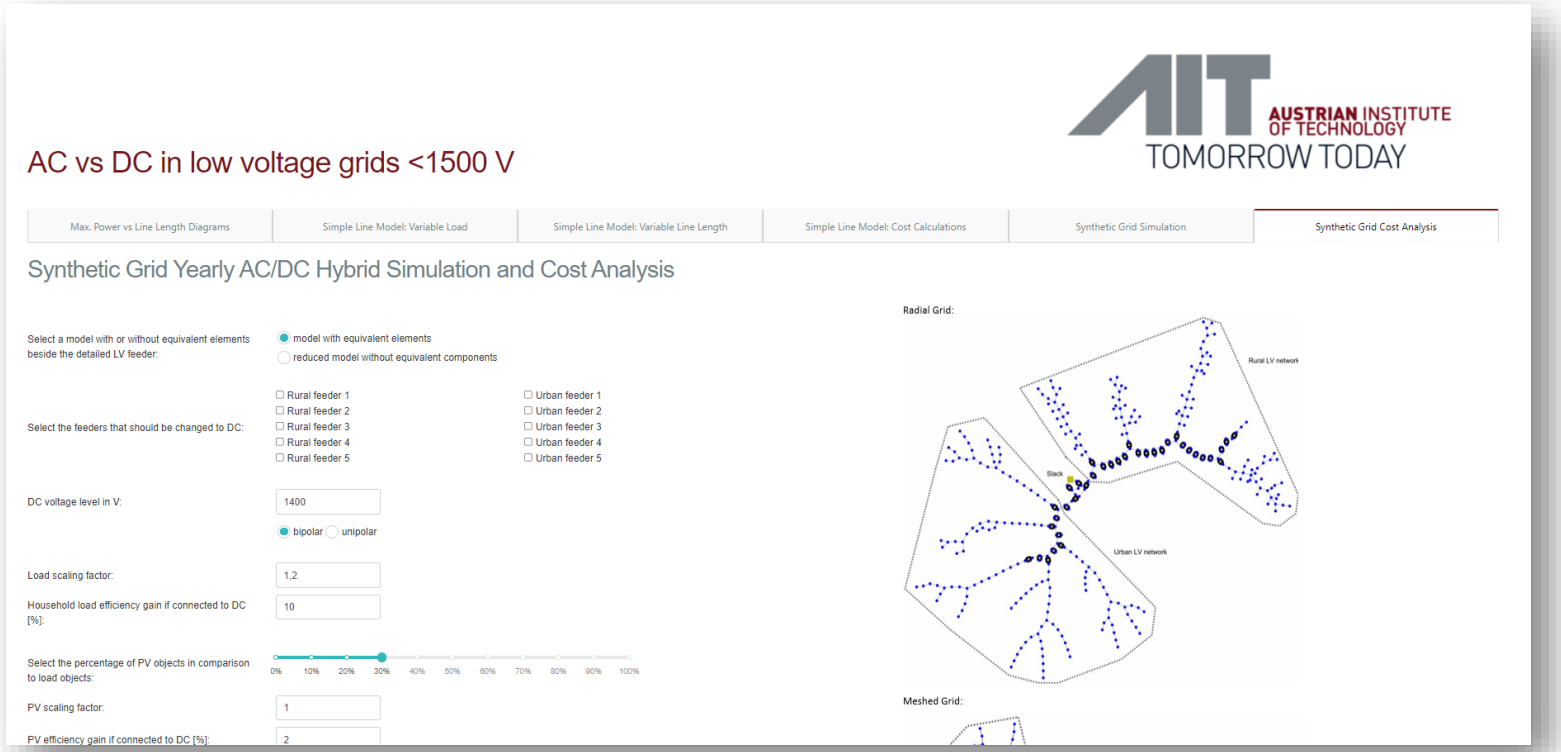
Synthetic Test Grid



Feeder	Length [m]	Nr of lines	Nr of loads
LV rural 1	**1056**	**26**	**16**
LV rural 2	430	22	14
LV rural 3	549	30	17
LV rural 4	610	34	22
LV rural 5	220	2	1

Feeder	Length [m]	Nr of lines	Nr of loads
LV urban 1	430	28	25
LV urban 2	370	22	19
LV urban 3	360	30	26
LV urban 4	400	34	31
LV urban 5	450	21	19

Techno-Economic Analysis Tool Preview



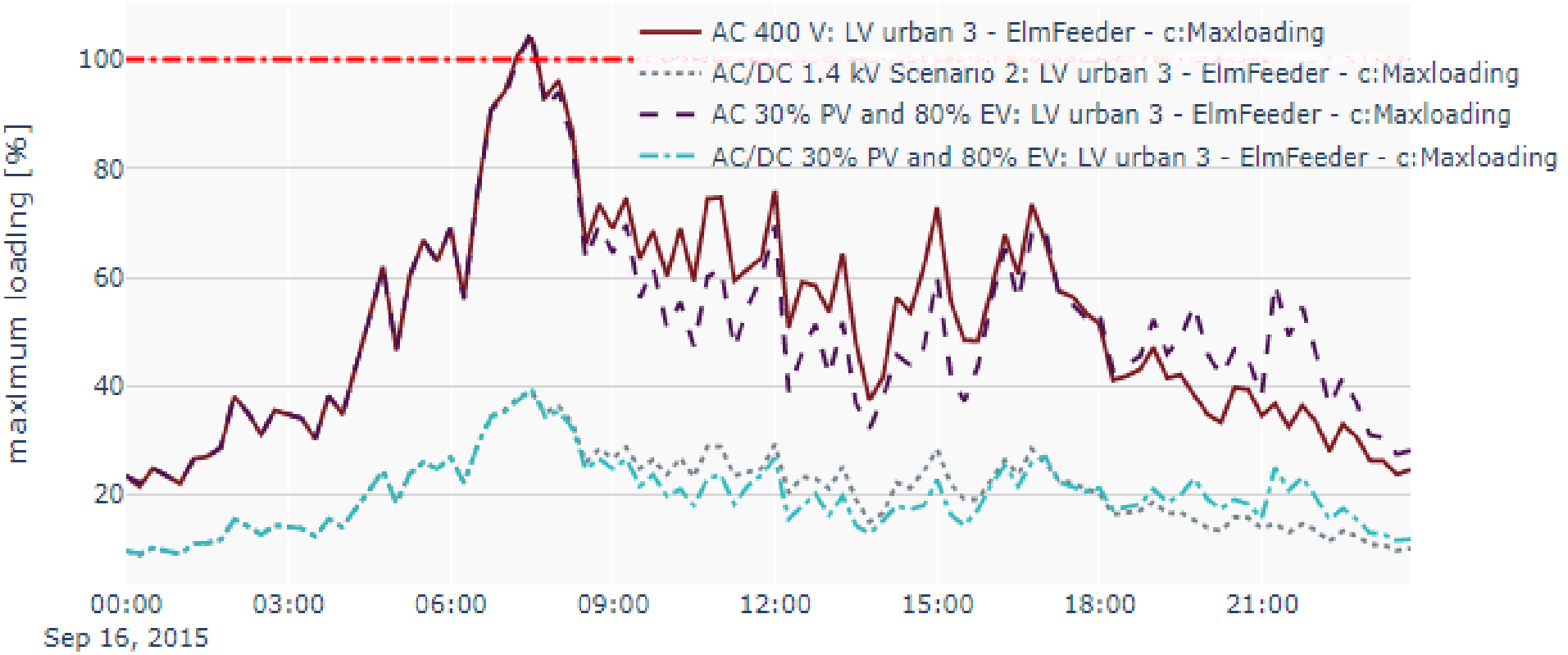
- Automated simulations using Power Factory in the background.
- Browser based user interface.
- Custom selection of simulation model and parameters.
- Yearly and daily simulations.
- Economic analysis using simulation results.
- Presentation of Results and
- Export of Results to CSV and/or PDF reports.

Selected Simulations

- 400 V AC
- 1400 V DC, AC/DC hybrid scenario 2
- 400 V AC, 30% PV penetration, 80% EV penetration
- 1400 V DC, 30% PV penetration, 80% EV penetration, AC/DC hybrid scenario 2

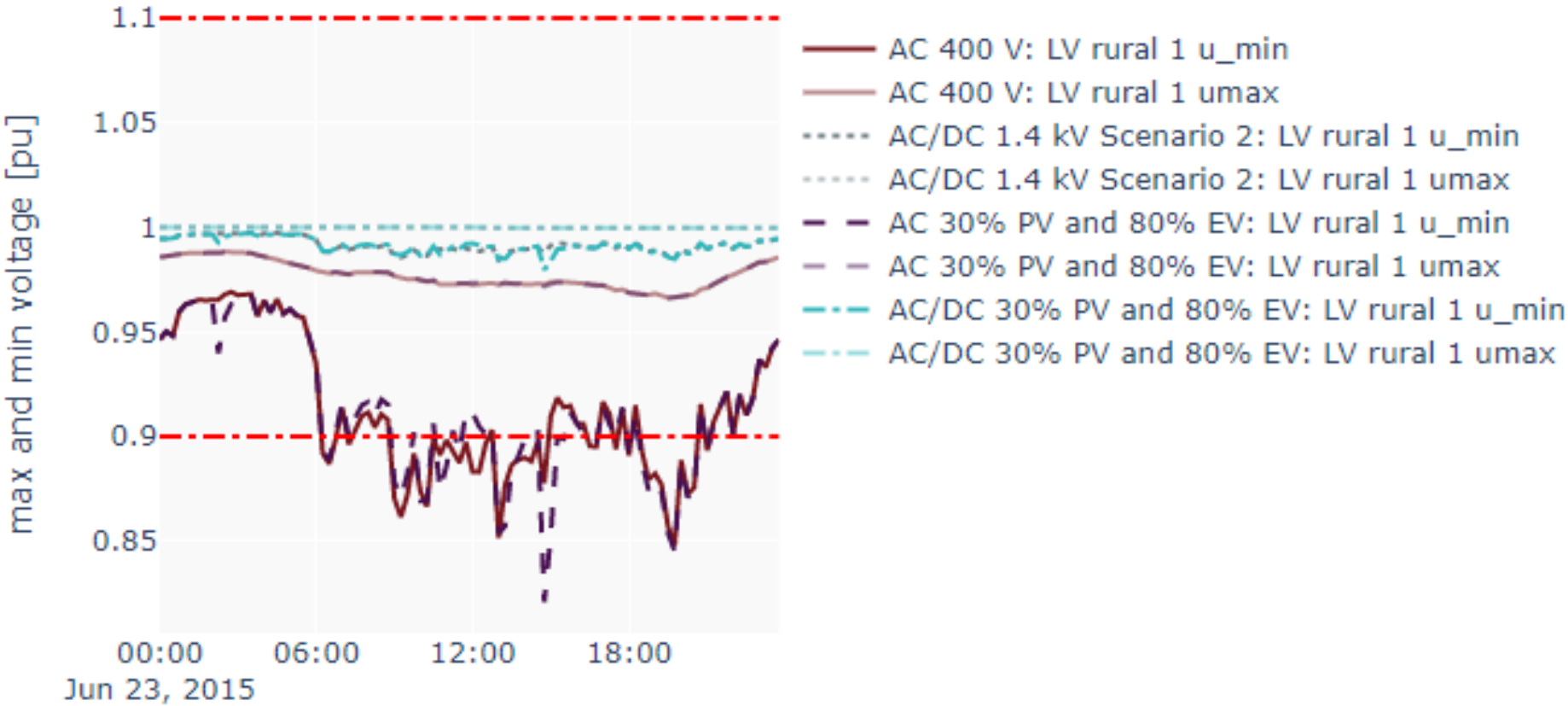
More details on selected parameters can be found in the paper.

Load Flow Analysis – Maximum Loading



*Maximum loading profiles of feeder **LV urban 3** on an autumn day.*

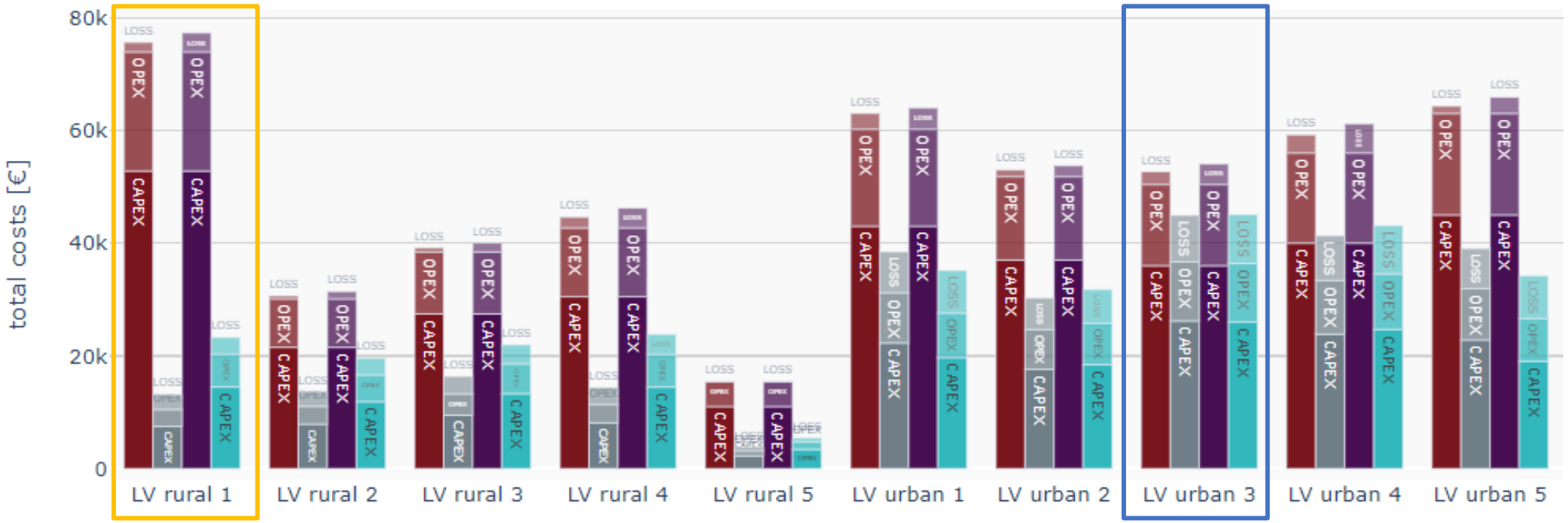
Load Flow Analysis – Voltage Variation



*Voltage profiles of feeder **LV rural 1** on a summer day.*

Economic Analysis

AC/DC Scenario 2 vs. AC reinforcement:



Comparison of TOTEX costs for AC grid reinforcement and conversion to DC for all LV feeders in test grid, TOTEX divided in CAPEX and OPEX (losses costs (LOSS) are indicated separately from the rest of OPEX costs) using calculation parameter from Table 5 in paper and yearly simulation results.

Thank You

AUSTRIAN INSTITUTE OF TECHNOLOGY

Discussion

contact: nina.fuchs@siemens.com