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Impacts of Distribution Grid Congestion Management on Charging Efficiency of Private Electric Vehicles

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Initial Situation:

- Steady increase in controllable consumption units such as non-public charging infrastructure for electric cars & electric heat pumps will lead to high distribution grid utilization in the future .
- Amendment of the German Energy Act (EnWG) Section 14a as of 1 January 2024 allows the grid-oriented curtailment of controllable consumption units.

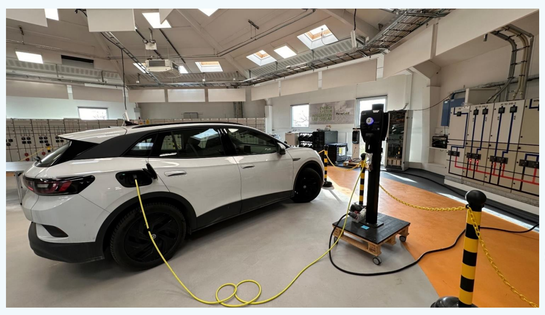
Problem:

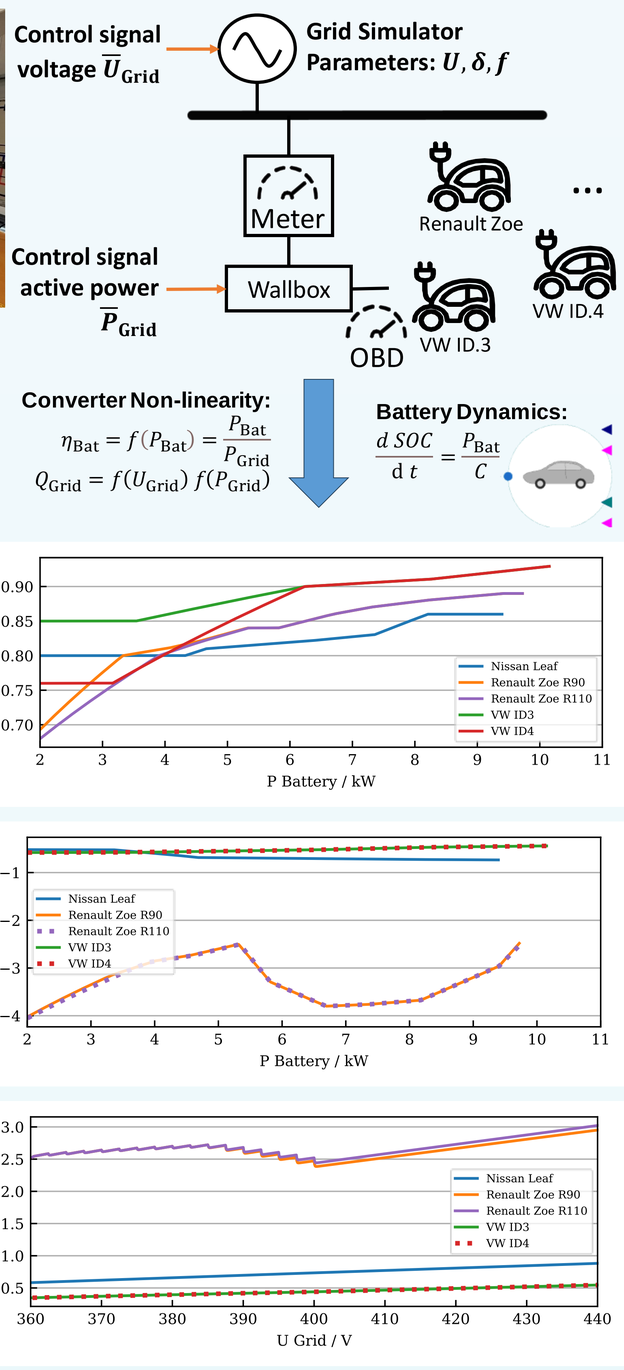
- The behavior of the inverters in terms of power factor and efficiency within the on-board charger of electric cars depends on the grid status, the power consumption and the model and therefore differs for different electric cars.
- The resulting effects on the frequency and level of grid bottlenecks and system efficiency have not yet been researched.

Goal:

- Development and validation of models for the charging infrastructure of electric vehicles based on measurements taken at the SYSLAB of the Technical University of Denmark (DTU) as part of the ERIGrid 2.0 Project.
- Analyzing the efficiency drawbacks and grid effects of congestion management based on Section 14a EnWG.

Experimental Results and Modelling

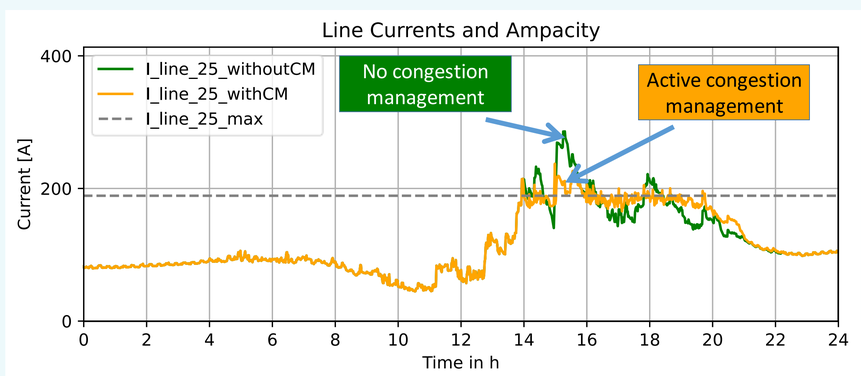




- Measurement of the battery dynamics and converter non-linearities in DTU´s SYSLAB, as part of the ERIGrid Lab Access program.
- Results were compiled into a Modelica model for dynamic timeseries simulation.
- Converter AC/DC efficiency and power factor are dependent on the battery power.
- Converter power factor is additionally dependent on the grid connection voltage.

Curative Grid Congestion Management

- Evaluation of the measurement results show that
  - the efficiency of the on-board-charger decreases with decreasing active power consumption, i.e. charging speed,
  - the reactive power consumption is capacitive and increases with decreasing active power consumption and
  - the effect of the grid voltage on the efficiency is low, but has an effect on the reactive power consumption.
- Effects on the grid situation are investigated with a future energy system scenario containing a high share of electric vehicles
- The total energy demand for the charging process gets increased by about 250 kWh per car per year, depending on the grid situation.
- Due to higher loads the line losses will increase also leading to higher cost for the grid operator.



Results