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Integration of Loads and Electric Storage Systems into Advanced Flexibility Schemes for LV Networks

Skalierbarkeits-Analyse von PV-, Speicher-, Wärmepumpen und Elektroauto-Zukunftsszenarien in den Niederspannungsnetzen Salzburgs und Oberösterreichs

IEWT 2019, TU Wien, 15.02.2019

Roman Schwalbe, Johannes Kathan, Markus Radauer, Ewald Traxler

Objectives

1. **Analyse the impact of high penetrations of PV, EV, home storage systems… on the low voltage grids**
2. **Analyse the impact of nationwide coverage of voltage control strategies (**P(U), Q(U), cosPhi, leafs controls**) on the low voltage grids**
3. **Estimate necessary additional upcoming grid transformer and line reinforcement** in the low voltage grid
4. **Provide a flexible framework for analysis and comparison of different technical solutions**
5. **Transition from assessment of few case studies to a higher grid population** to obtain significant results that are applicable nationwide

Technical realisation

1. **Calculation of specific situations via specific power flows** - no time series simulation
2. **Symmetrical power flow calculation with voltage slack at the medium voltage side (10 or 30 kV) of the secondary substation's transformer**
3. **Calculate worst-case scenarios** "high-load-no-infeed" and "low-load-full-infeed"
4. **Use transformer loading drag pointer measurements** from each secondary substation to scale all loads in the grid according to their yearly energy consumption
5. **Distinguish between customer and distribution system operator equipment** when analysing equipment loading and grid voltages

Grid reinforcement Methodology

1. **Load flow calculation without any grid reinforcements** and assessment whether defined voltage boundary conditions or line loading are violated
2. **Transformer overloading** is solved by replacing the transformer with a larger transformer as long until no more overloading is present
3. **Line overloading** is solved by is either reinforcement or replacement with a defined replacement scheme. This process is repeated until there is no more line overloading in the grid.
4. **Voltage problems** are solved by replacing or reinforcing lines starting from the substation towards the point where the voltage problem arose initially. This is done until no voltage band violation occurs anymore. Thus reinforcement has not necessarily carried out to the point where the voltage problem occurred initially.

Overview of the dataset

Value	Salzburg Netz GmbH	Netz Oberösterreich
Total number of LV grids in the dataset	6220	8394
Total number of grids for calculation	3355	6385
Percentage of grids for calculation of total number of grids	54%	76%
Number of PV systems already installed and part of the calculation (2014)	4575	7992
Total power of PV already installed (2014)	44 MW_p	86 MW_p
PV power considered in the calculation (2014)	34,46 MW_p	72,81 MW_p
Number of other generation units considered in the calculation (2014)	123	328
Total power of other generation considered in the calculation (2014)	1,42 MW_p	6.25 MW_p
Total length of lines regarded in the calculations (km)	8.361	18.932

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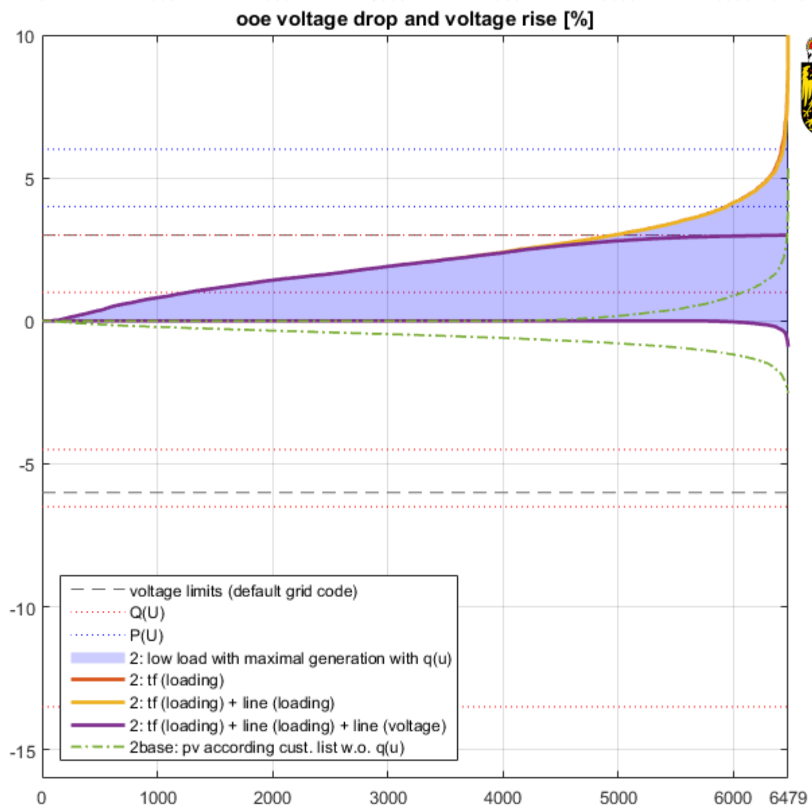
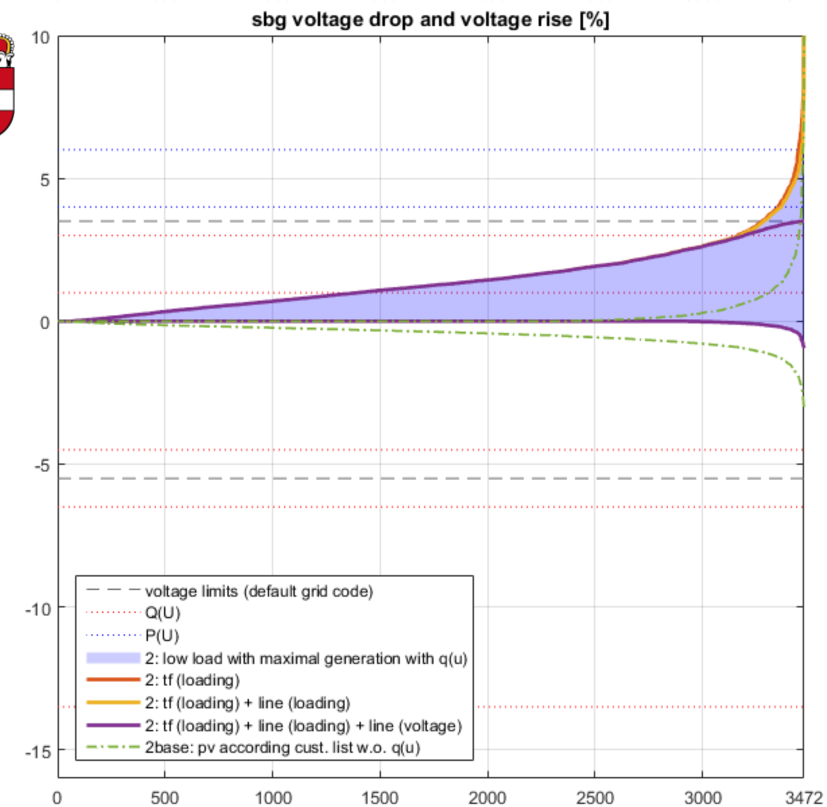
PV generation scenario 2030

Aspect	SNG	NetzOOE	Description
Scaling of generation	0.85		Base simultaneity of PV regarding compensation effects over medium voltage grids
Reactive Power Control	Q(U)		Q(U) is chosen as the standard reactive power control function due to lower network losses compared with a constant cos φ
Active Power Control	No		To assess the grid reinforcement requirements P(U) is not activated. There is a separate scenario which assess an additional P(U) implementation
Total Installed Capacity SNG	1.120 MW_p	1.400 MW_p	Total power of PV installed in the supply area
Expected Capacity NE5 and above	145 MW_p	182 MW_p	Large scale PV generation not regarded in this analysis as installed in higher grid levels
Expected Capacity NE6	134 MW_p	168 MW_p	Based on the given distribution of PV systems about 12% of the cumulated PV power is directly connected to NE6
Expected Capacity NE7	840 MW_p	1.050 MW_p	Based on the given distribution of PV systems about 75% of the cumulated PV power is directly connected to NE7
PV system size household	2 kWp		Based on the distribution of households and other customers in the defined supply area
PV system size industrial	35,5 kWp		Based on the distribution of industrial customers in NE7 and other customers in the defined supply area

Calculation results – low-load-full-generation





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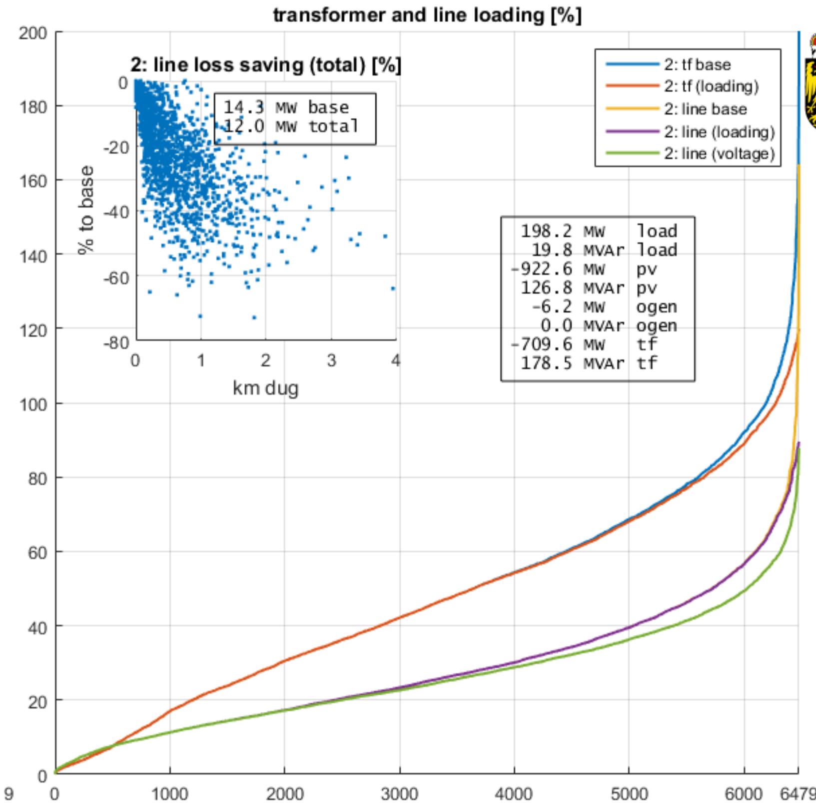

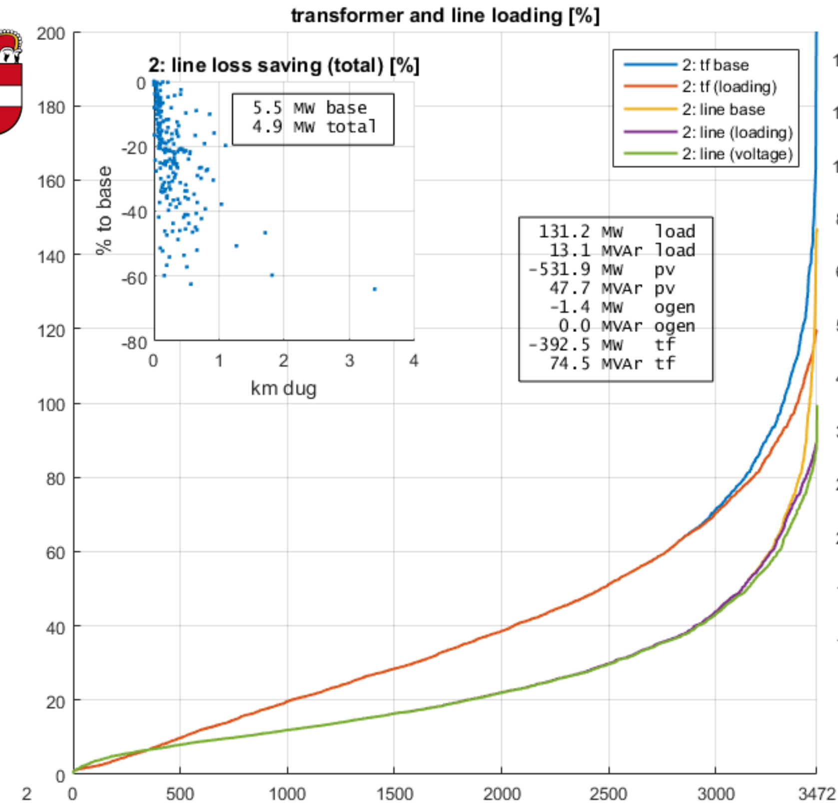

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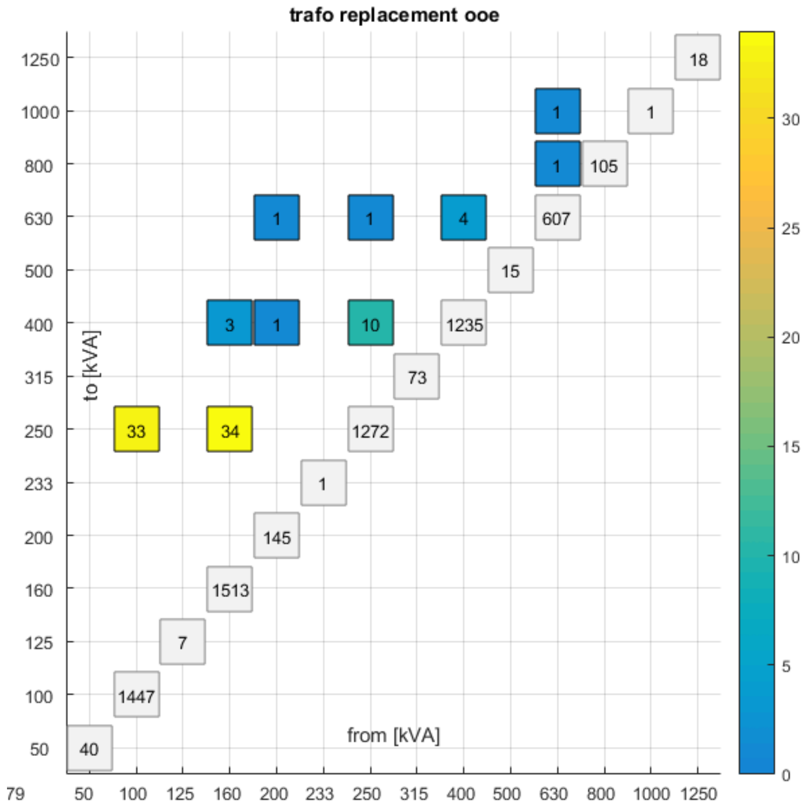

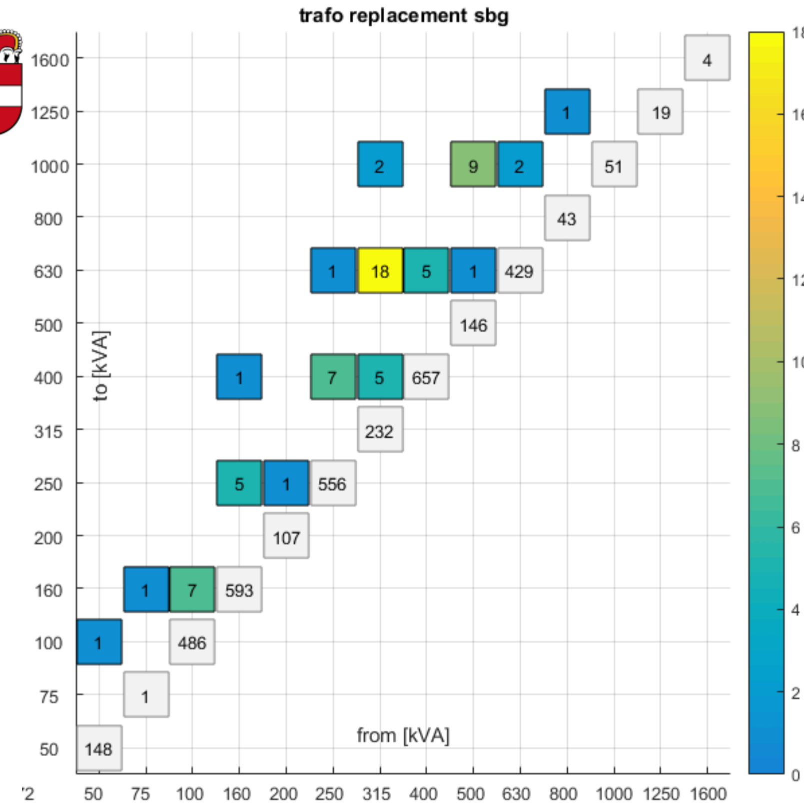

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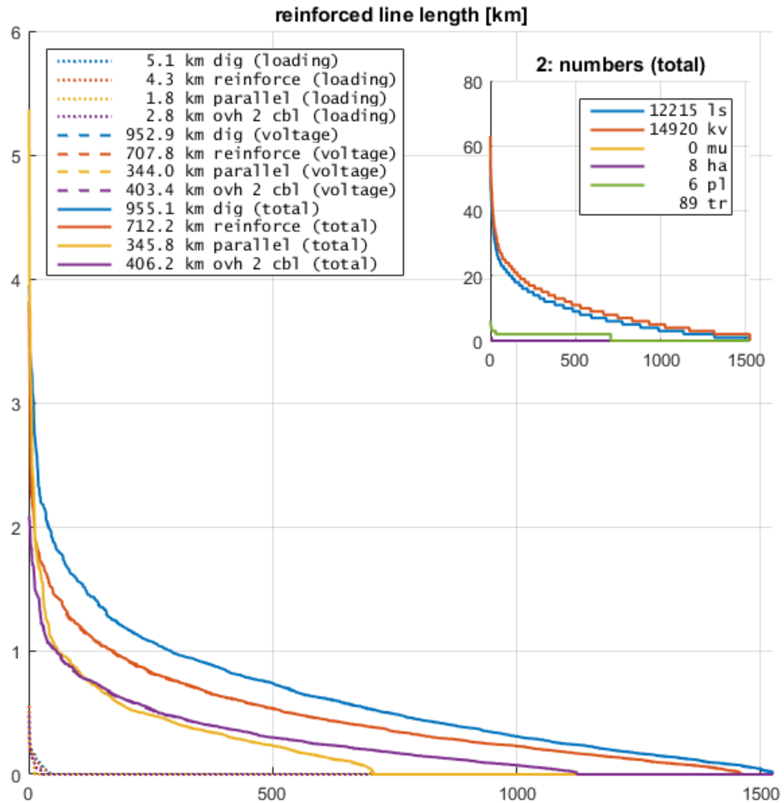
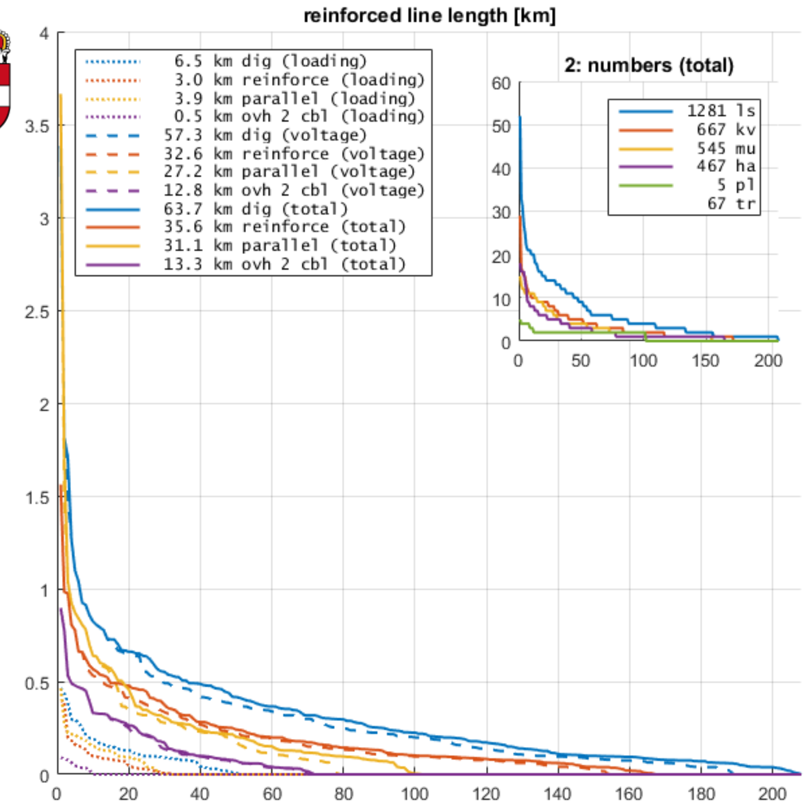
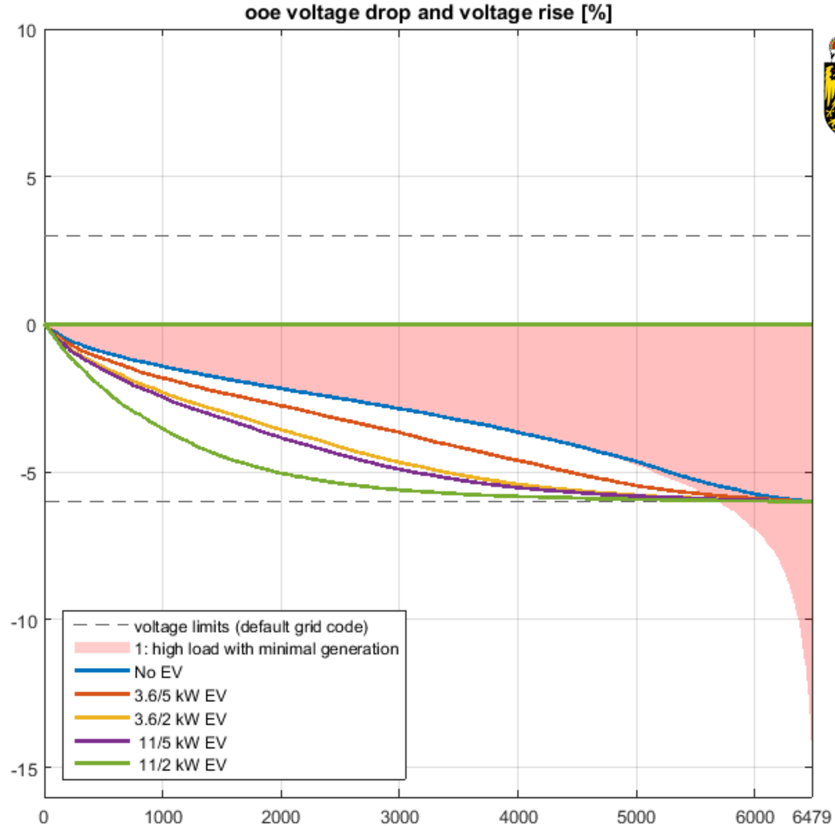


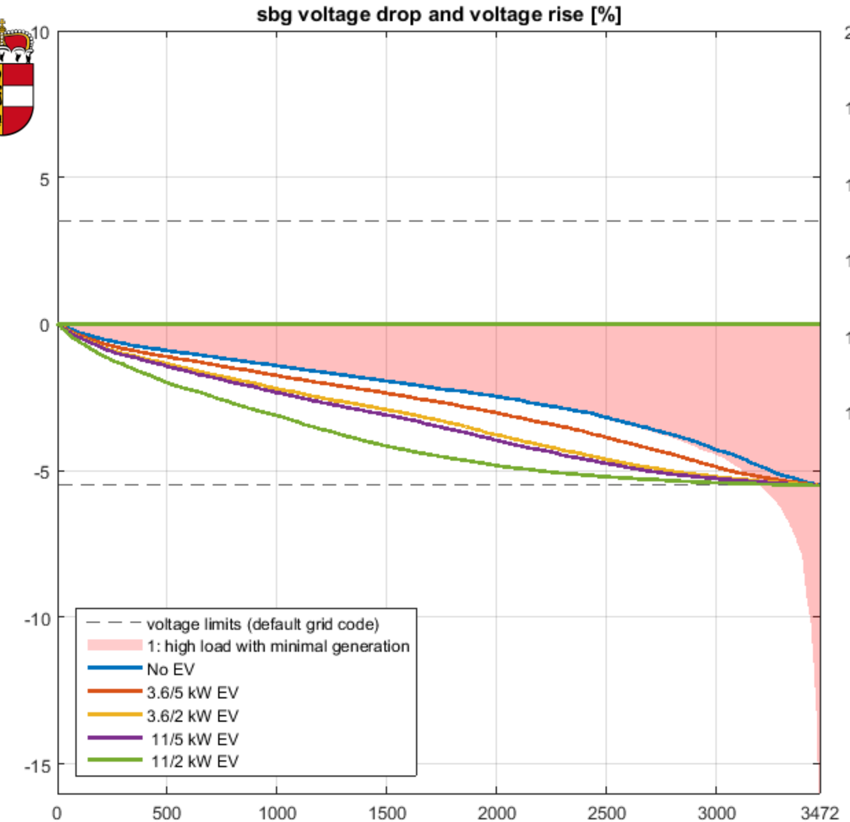


Electric vehicle scenario 2030

Aspect	Value/Unit	Description
Simultaneity	0.20 / 0.25 / 0.33 / 0.50 / 1.00	Increasing simultaneity due to market driven charging strategies
Active Power Control	P(U)	An under voltage protection starting at -6% of the nominal voltage to reduce active charging power to 6A at -10%. Reduction to zero starts at -10% of the nominal voltage
Charging Power (kW)	3.7kW / 11kW	Different charging power levels based on common charging levels
Total number of EVs SNG	200.7 k	One EV per household (H0 profile) and agricultural customer (Lx profile) according to customer list
Total number of EVs NetzOÖ	352.9 k	

Calculation results – high-load-no-generation+EV





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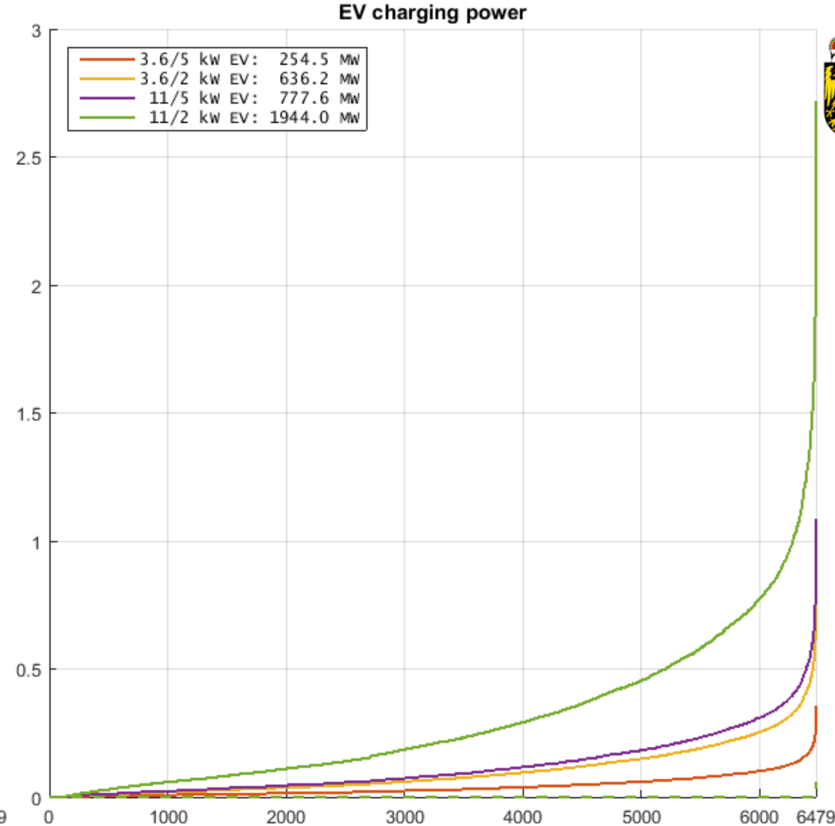

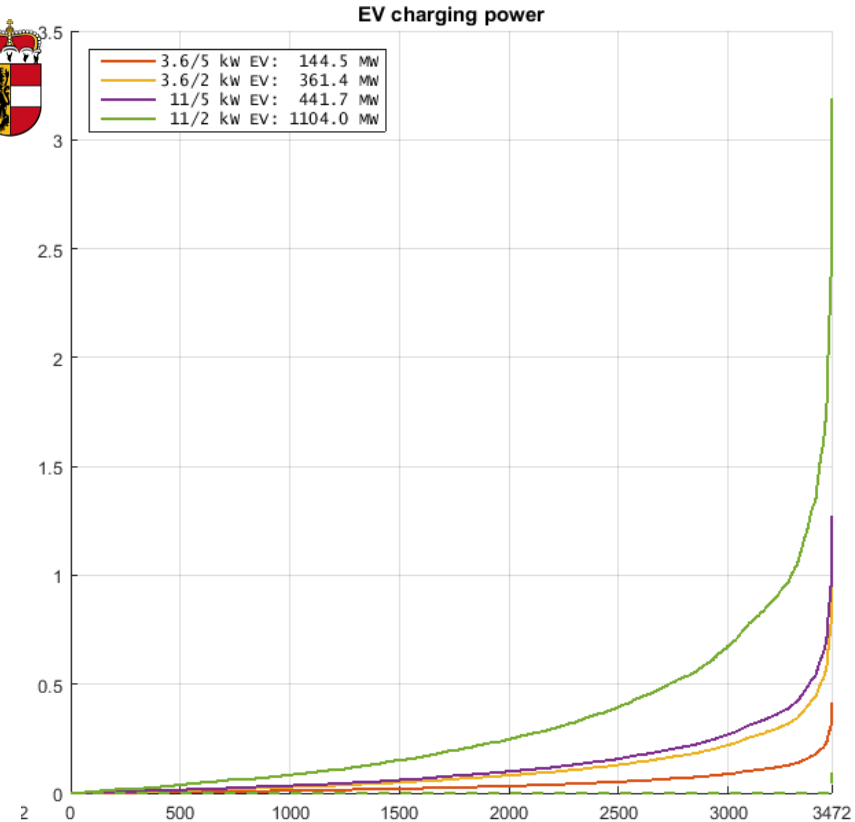

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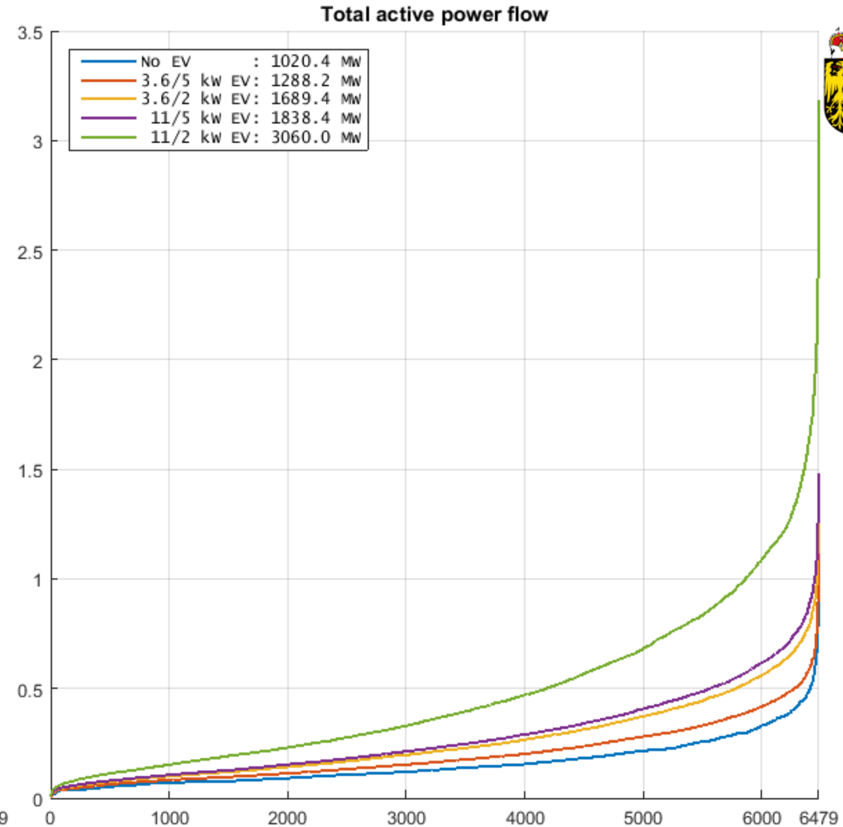

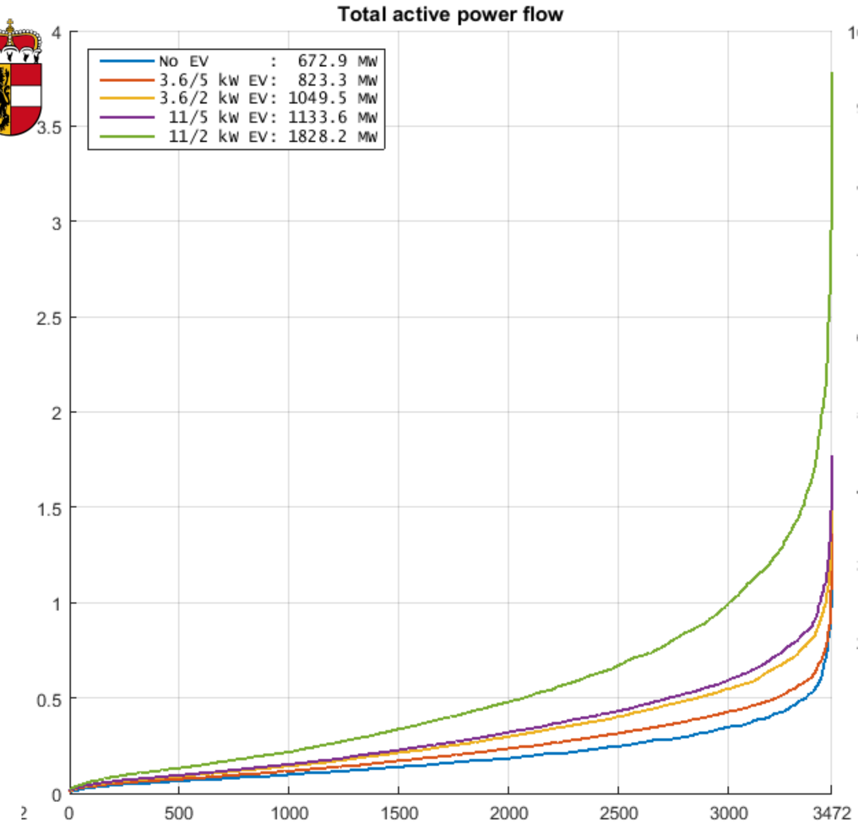

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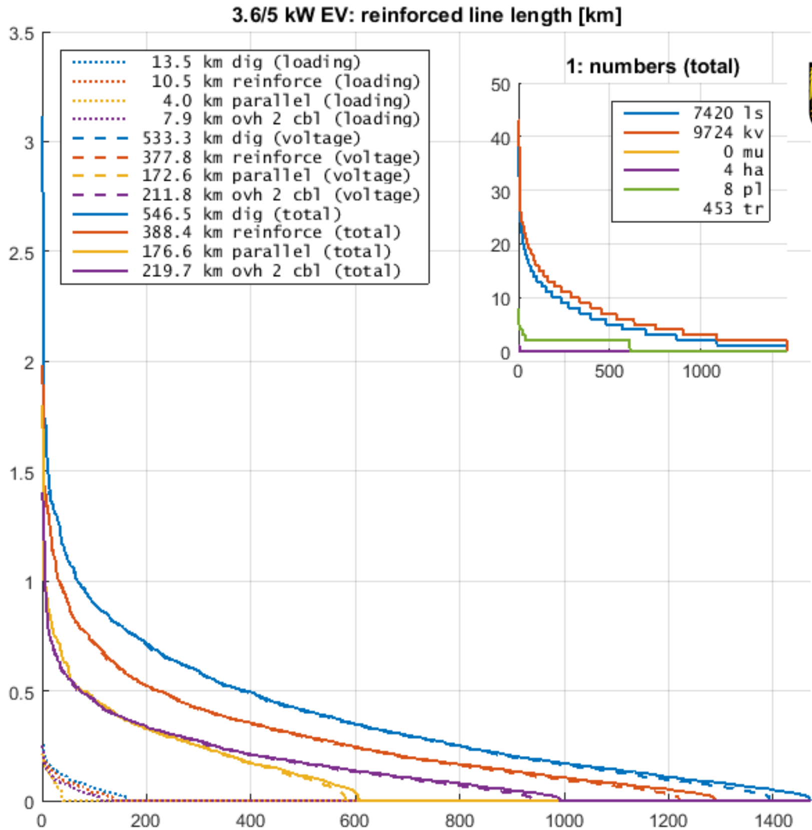

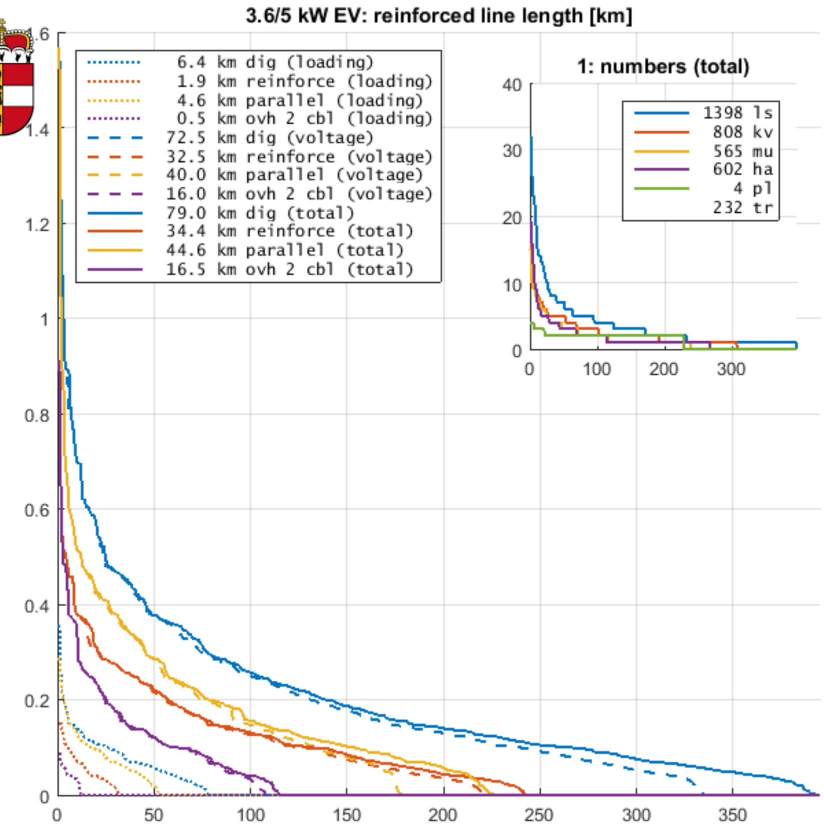

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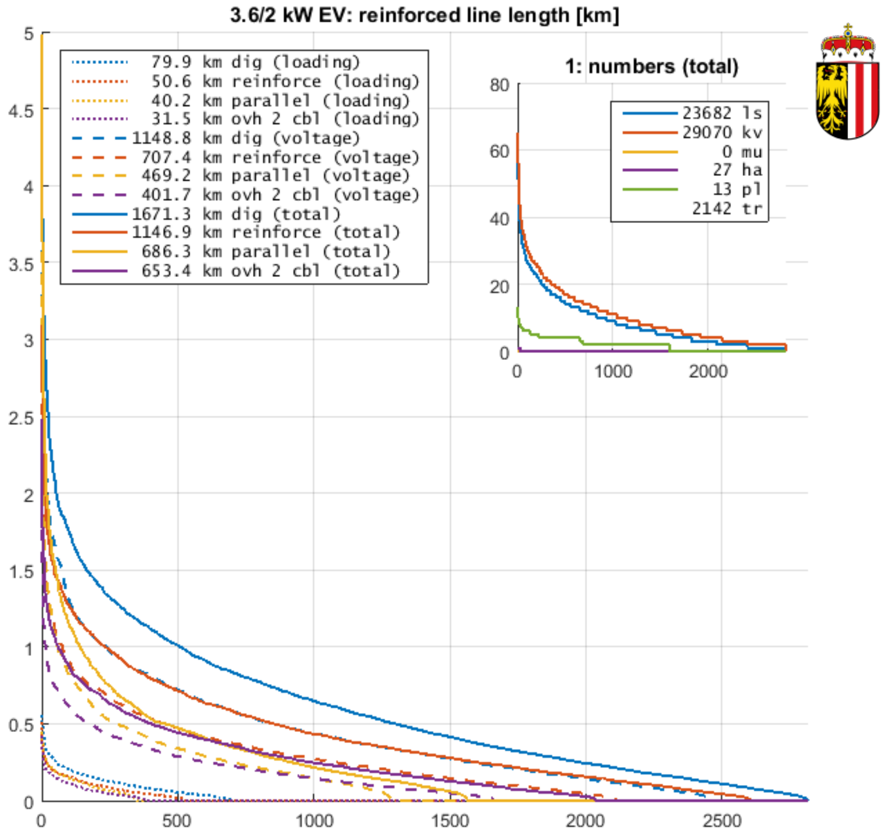

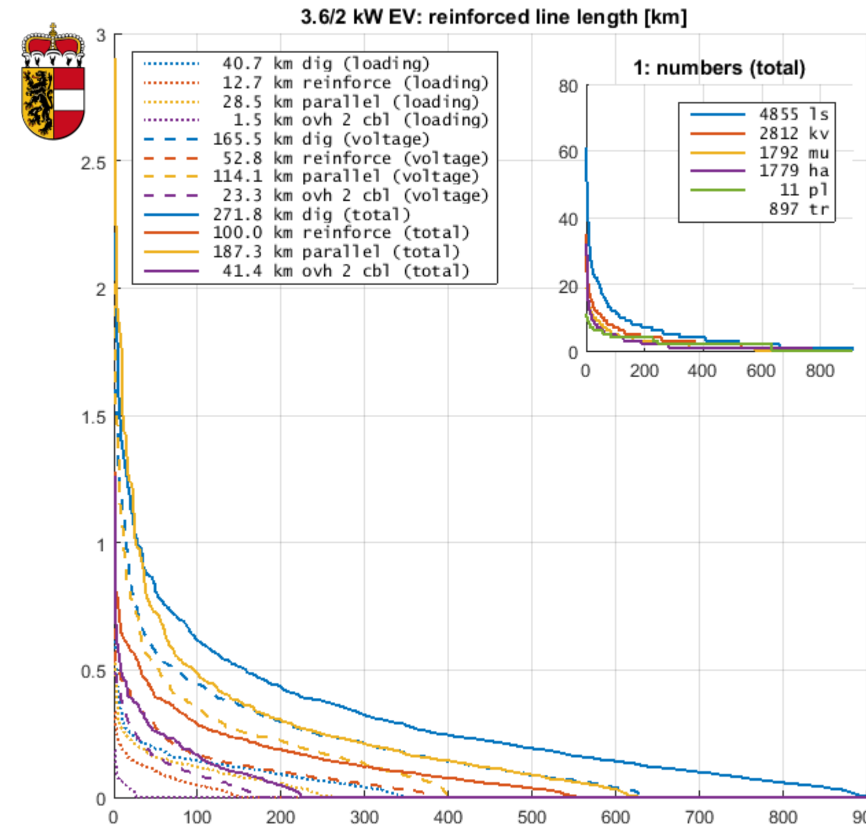

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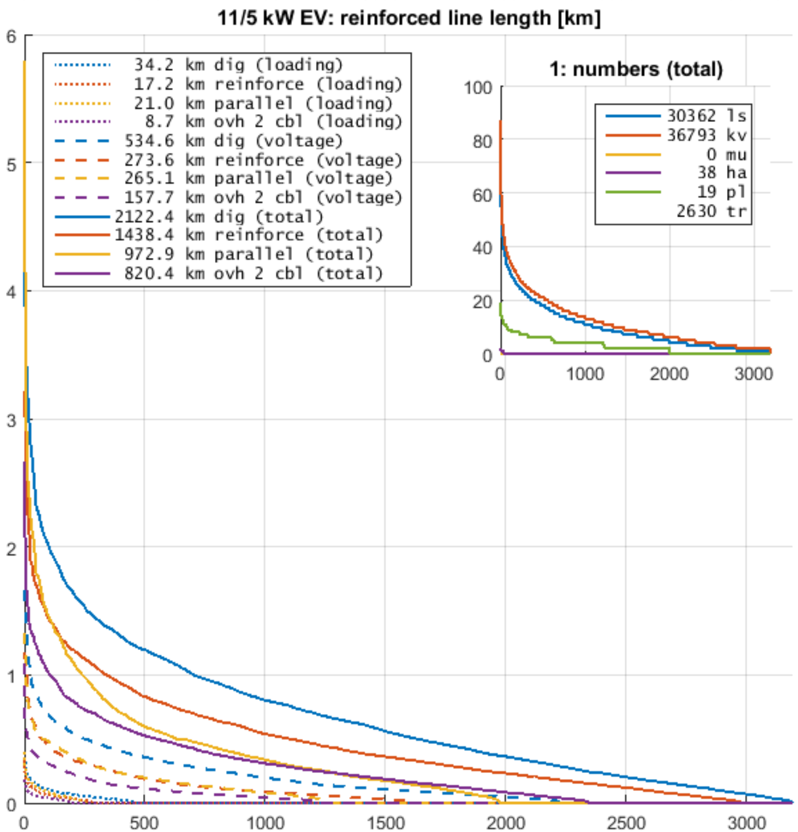

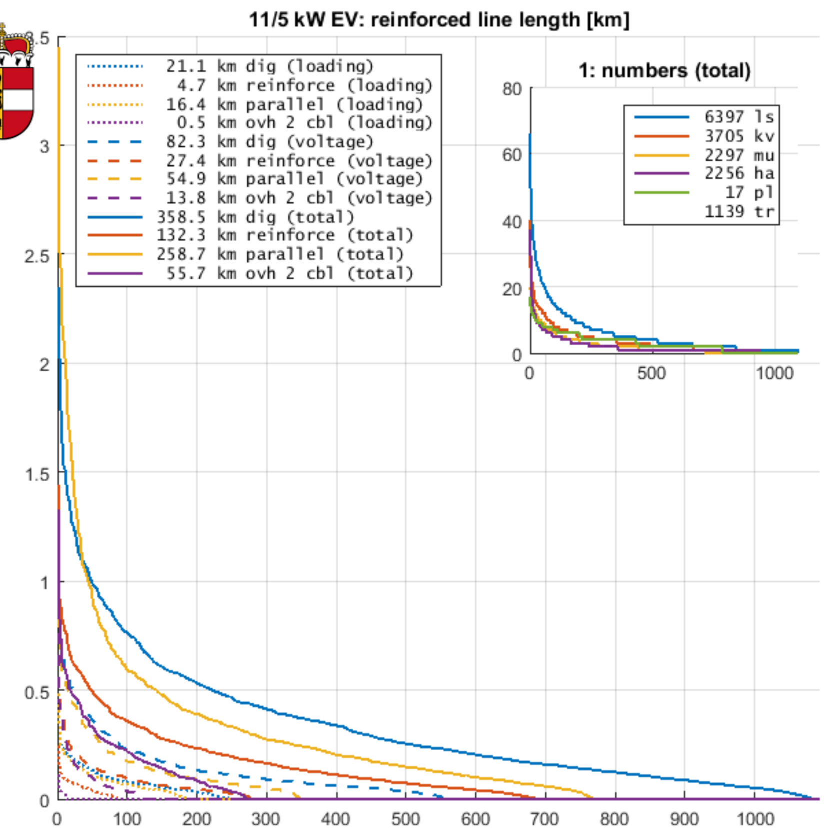

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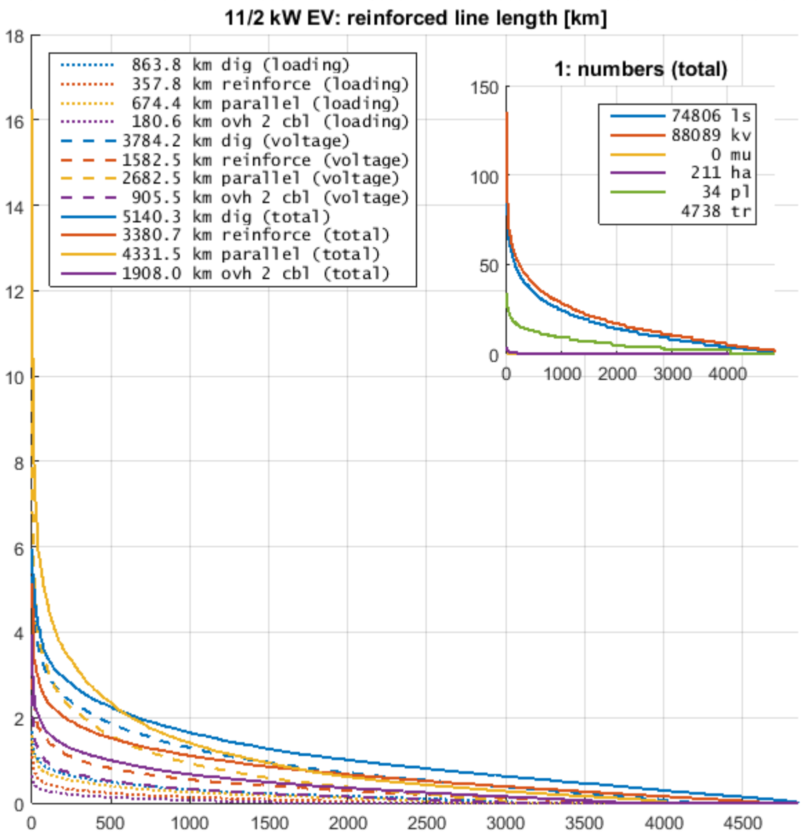

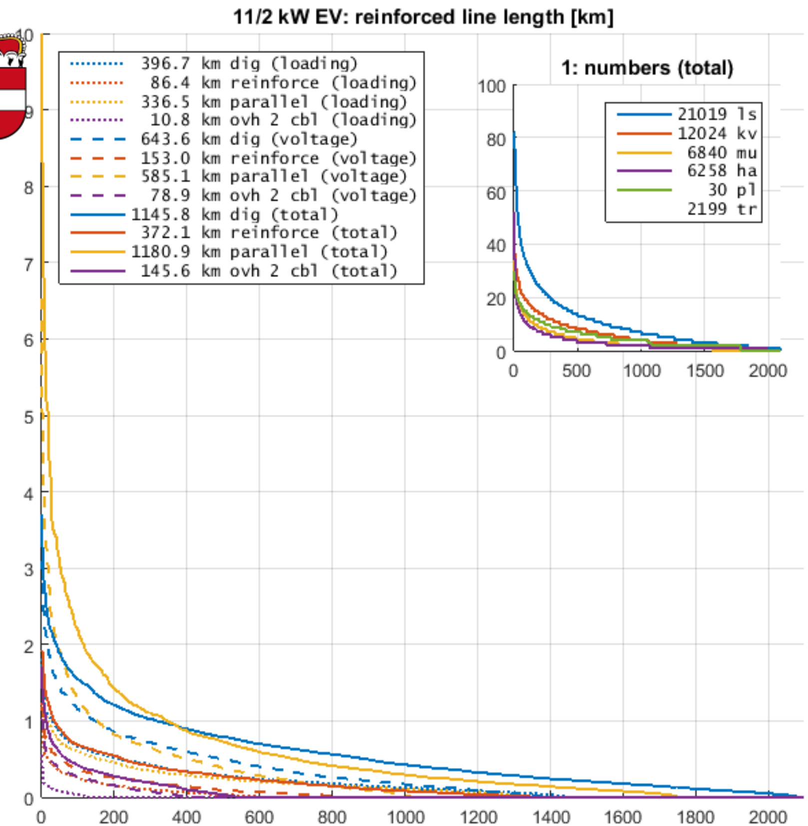

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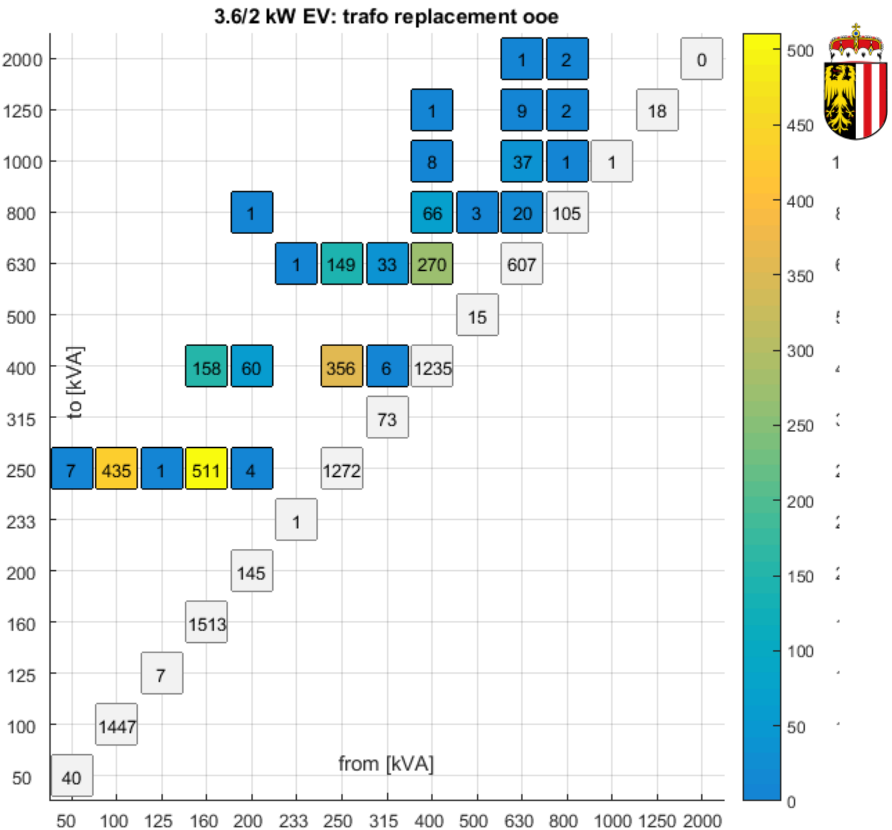

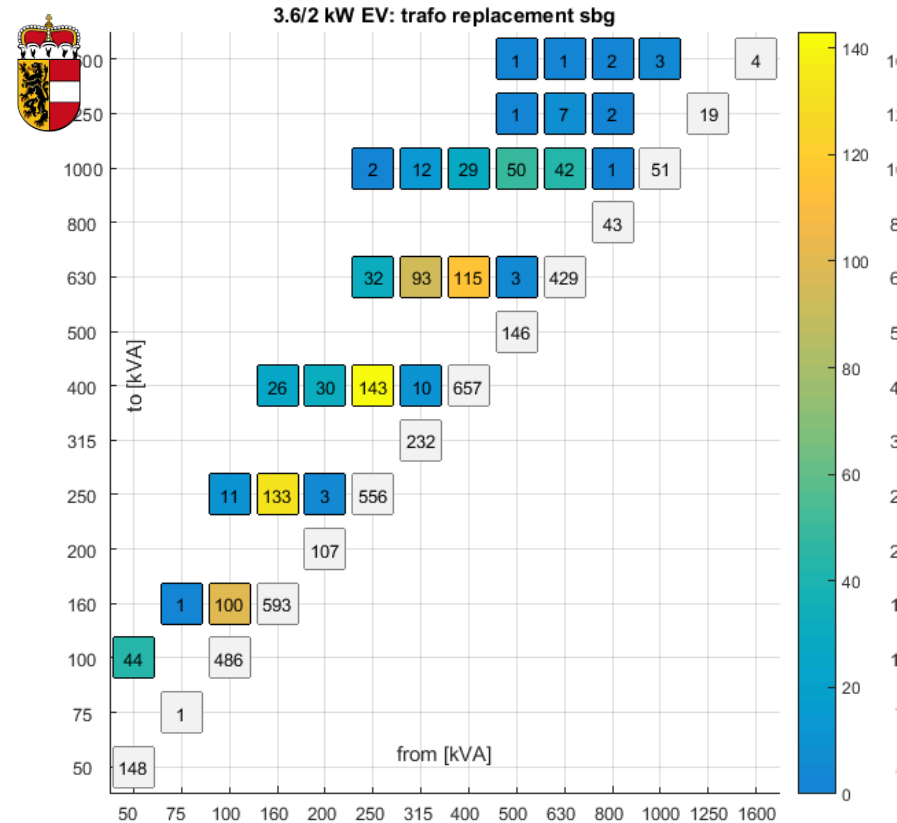

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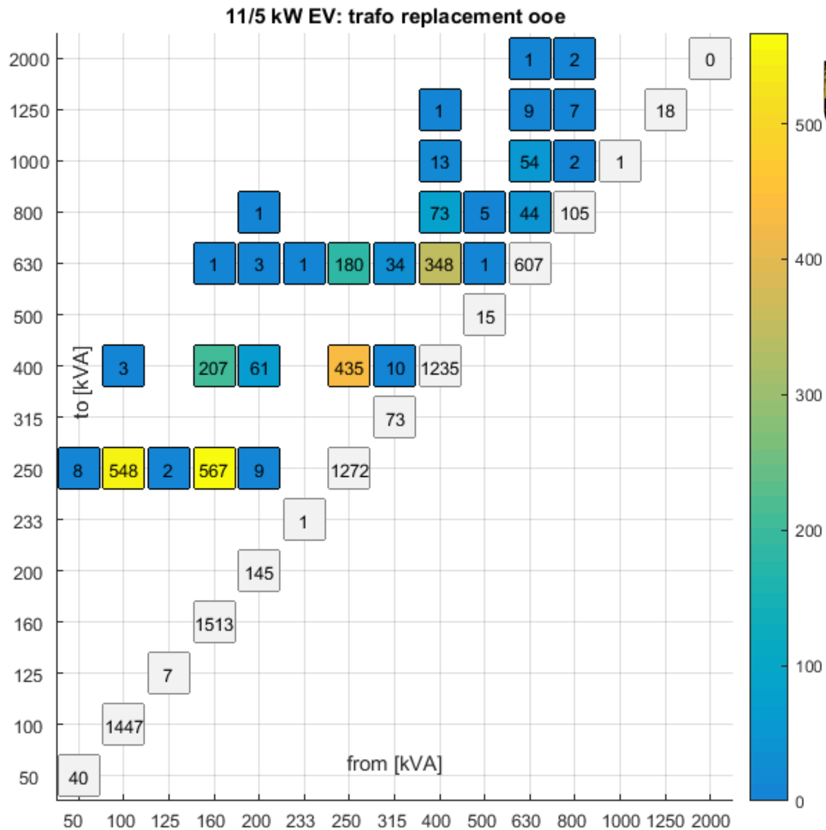

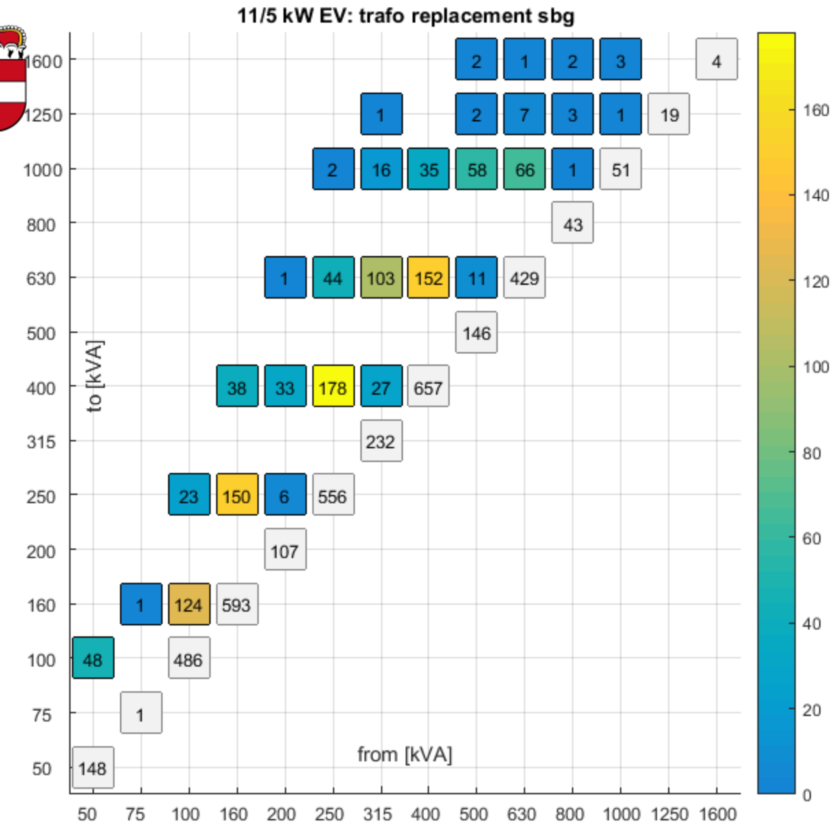

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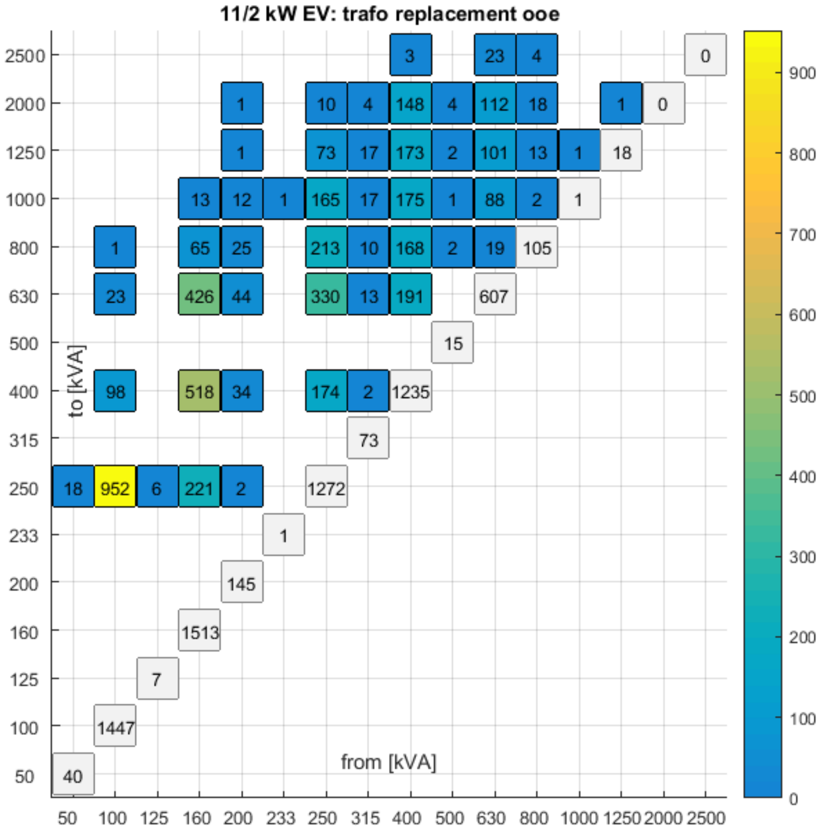

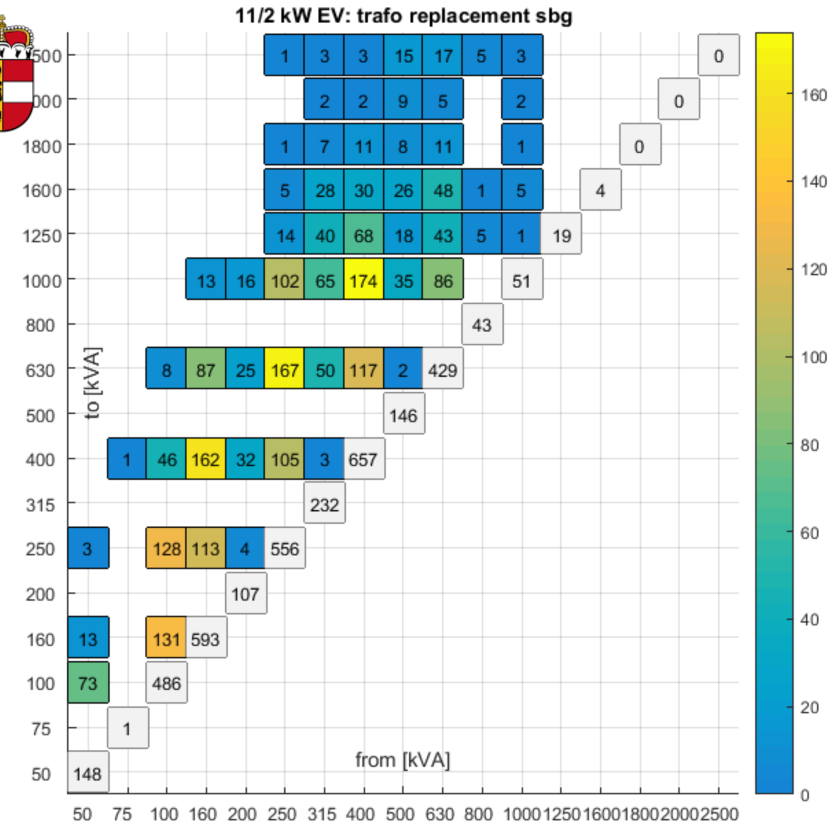

Conclusions

- Partly significant differences between the results of the two provinces
  - Salzburg contains Salzburg Stadt, Upper-Austria doesn‘t contain Linz Stromnetz
  - Salzburg has a higher cabling degree than Upper-Austria
  - Operational strategy and planning approach of both provinces differ slightly
- Some PV and low-power-EV-charging-scenarios in the low voltage grid can be enabled through already ongoing grid reinforcement activities, but total rollout scenarios need massive additional grid reinforcement activities
- To enable high-power-EV-charging with high coincidence, significant additional grid reinforcement has to be done because EV P(U) does not prevent component overloading

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Thank you for your attention!

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