Development of a model for power grids based on the cellular approach for an optimum integration of electric charging infrastructure

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Agenda

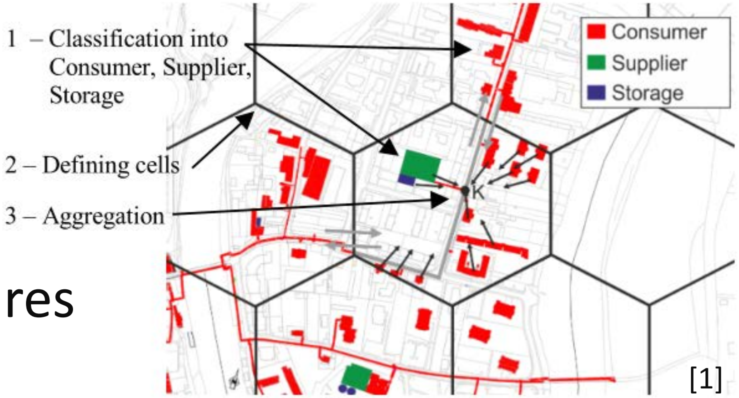
- Why is the development of a model necessary?
- The cellular approach
- Development of a model for the power grid
- Accuracy of the active power
- Implementation of charging stations into the grid model
- Preliminary results

Why is the development of a model necessary?

- Simplification of the complex grid structure
- Reduction of the calculation time by using time resolved annual load profiles
  - Practical application: Calculation of 4 special weeks
  - Model (for example reduction from 350 busbars to 50): Calculation time with annual load profiles 1 to 3 hours
- Application Areas
  - Localisation of optimum installation sites for renewable energy plants or charging stations
  - Analyses of the interaction between energy demand of households, industry, electric vehicles and the production of renewable energy
  - Identification of areas that are susceptible for grid instability
  - Determining the degree of self-sufficiency

The cellular approach

- Power, heat and gas grids
- = flexible analysis method
- Simplification of complex grid structures
- Compromises between accuracy and calculation time

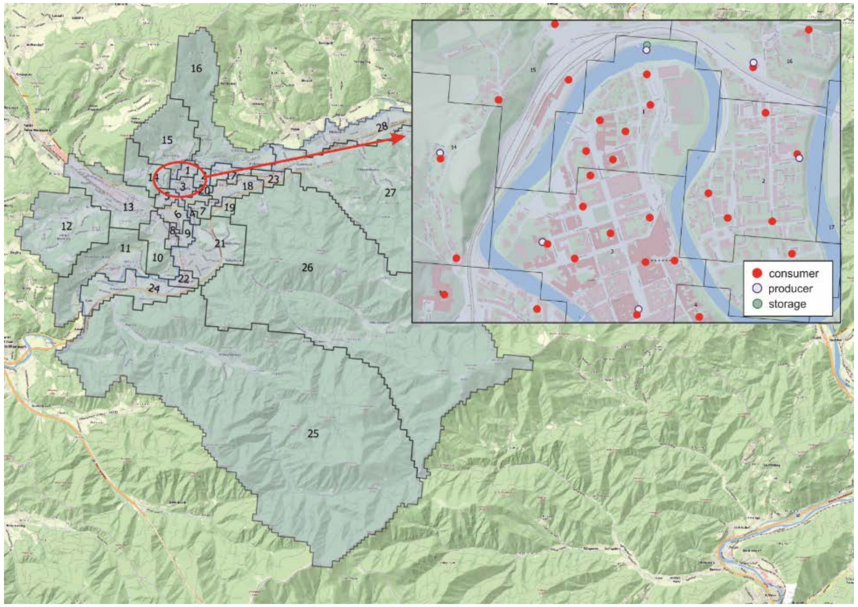


[1]

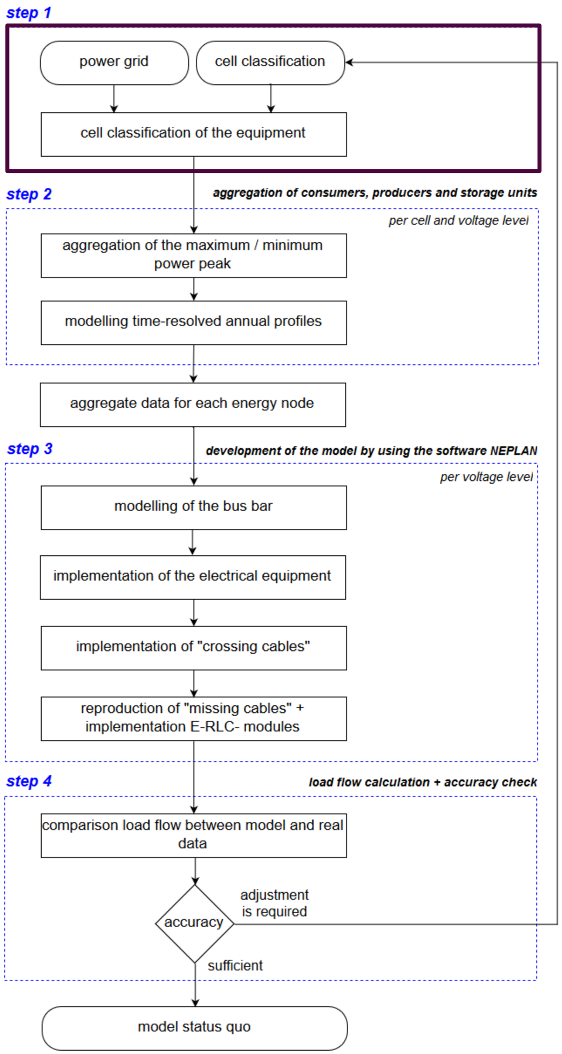
1. Classification into Consumer, Supplier and Storage
2. Defining cells
3. Aggregation: time resolved data in one energy node → Incomplete data → use of standard load profiles to aggregate load profiles without substantial loss in accuracy
4. Connection of the energy nodes according to the existing grid infrastructure

Development of a model for the power grid (1)

1. Cell classification of the electrical equipment

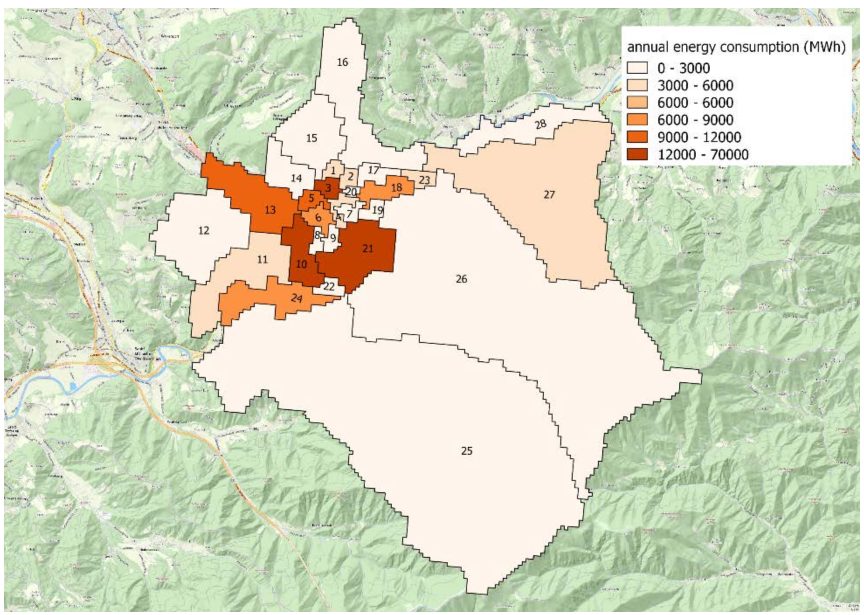


Cell classification of Leoben

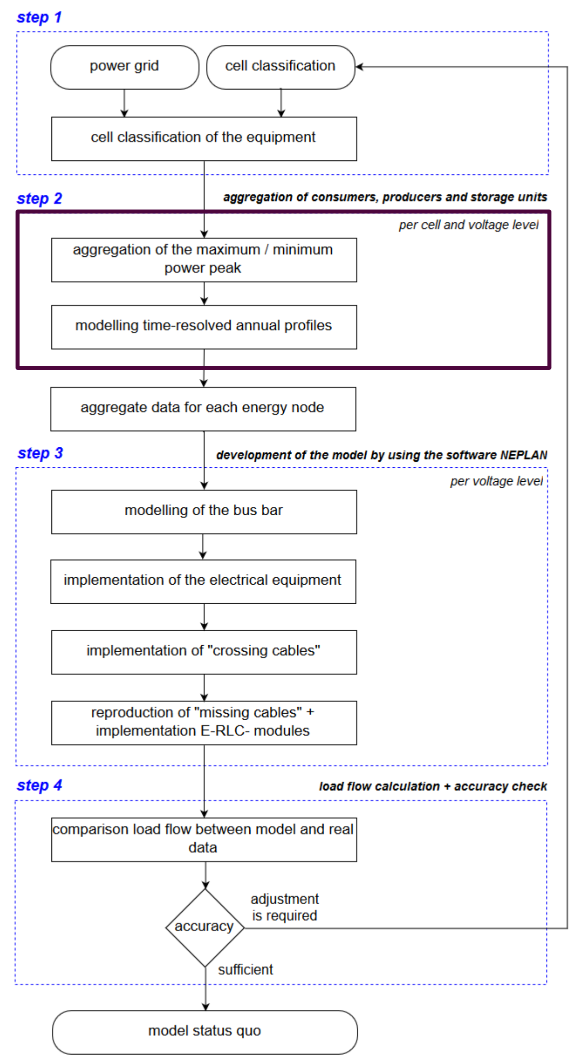


Development of a model for the power grid (2)

2. Aggregation of consumer, producer and storage units

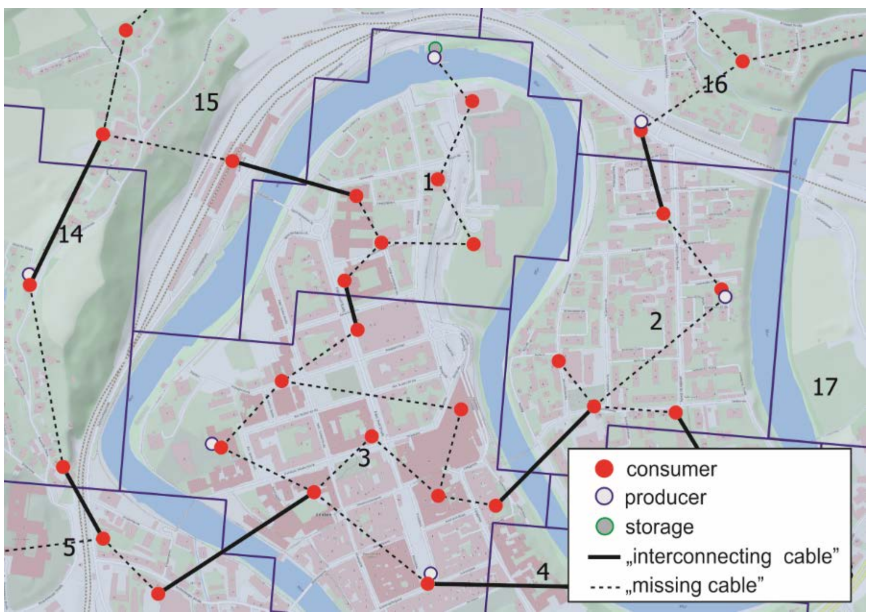


Annual energy consumption (MWh)

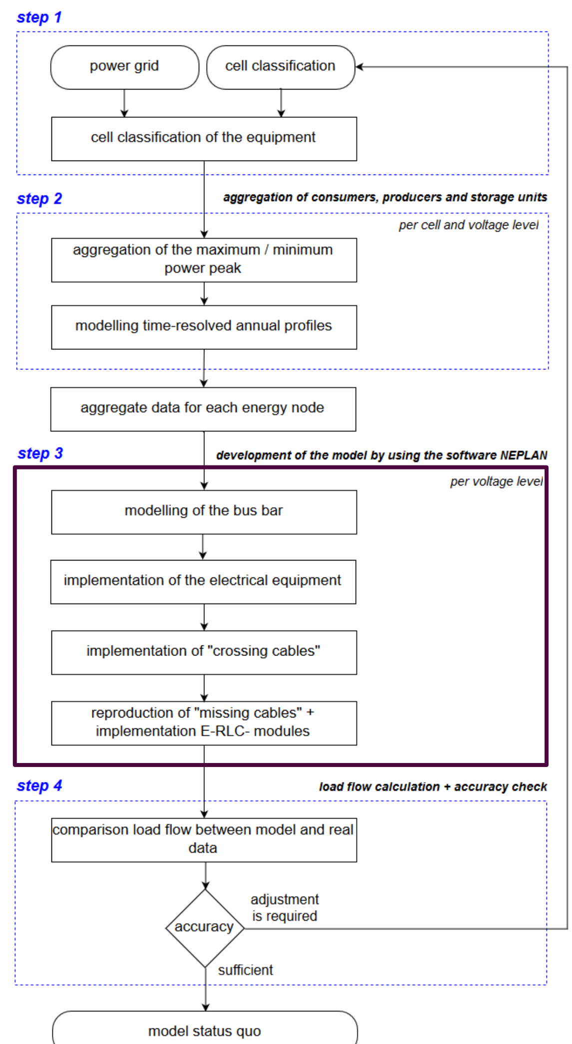


Development of a model for the power grid (3)

3. Development of the model by using the software NEPLAN

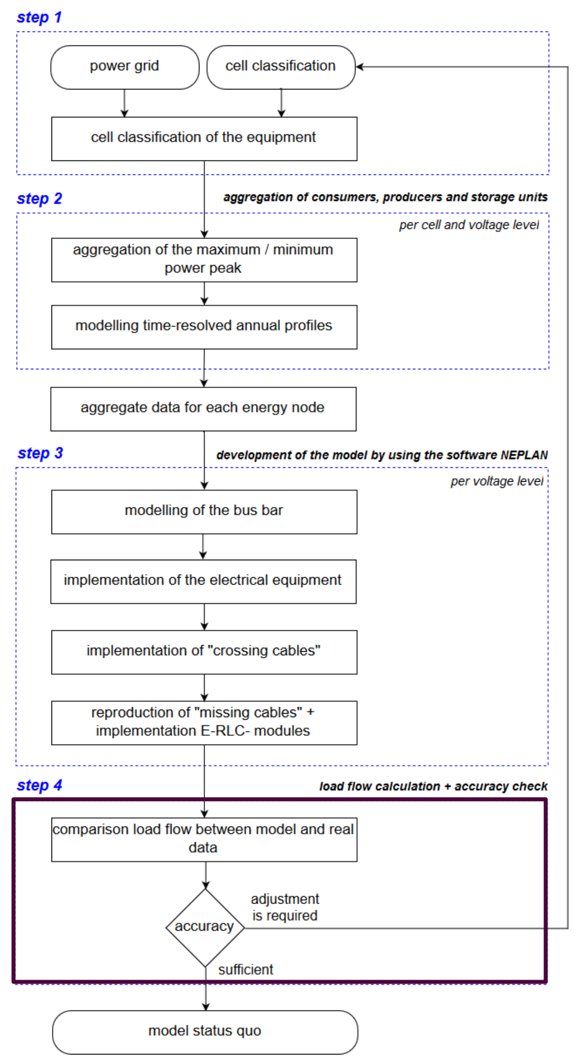


Implementation of cables



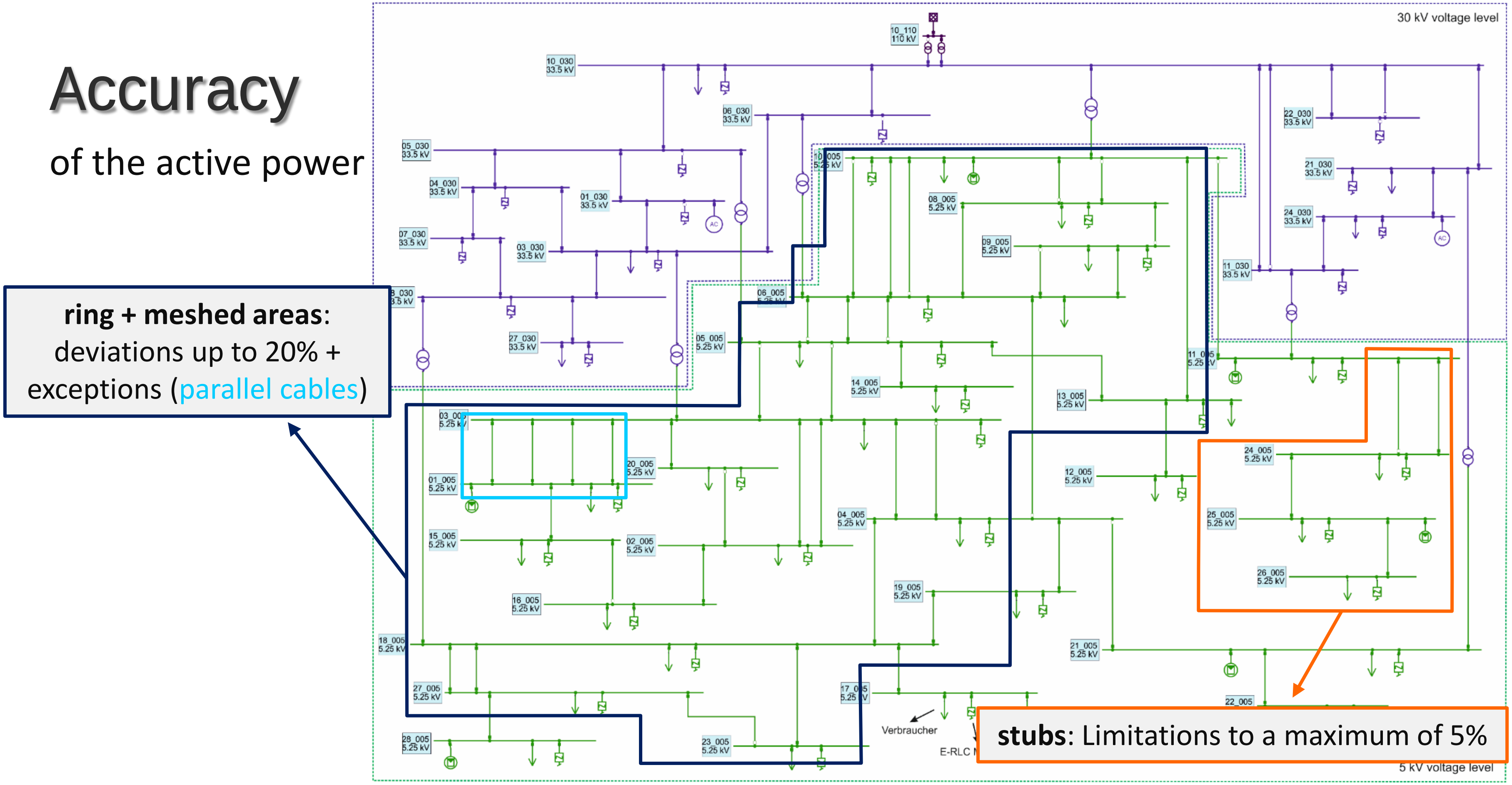
Development of a model for the power grid (4)

4. Load flow calculation and accuracy check
   - Calculation of the highest possible load flow
     - real data
     - model
   - Comparison
     - Accuracy is achieved → model status quo
     - Adjustment is required → cell classification



Accuracy

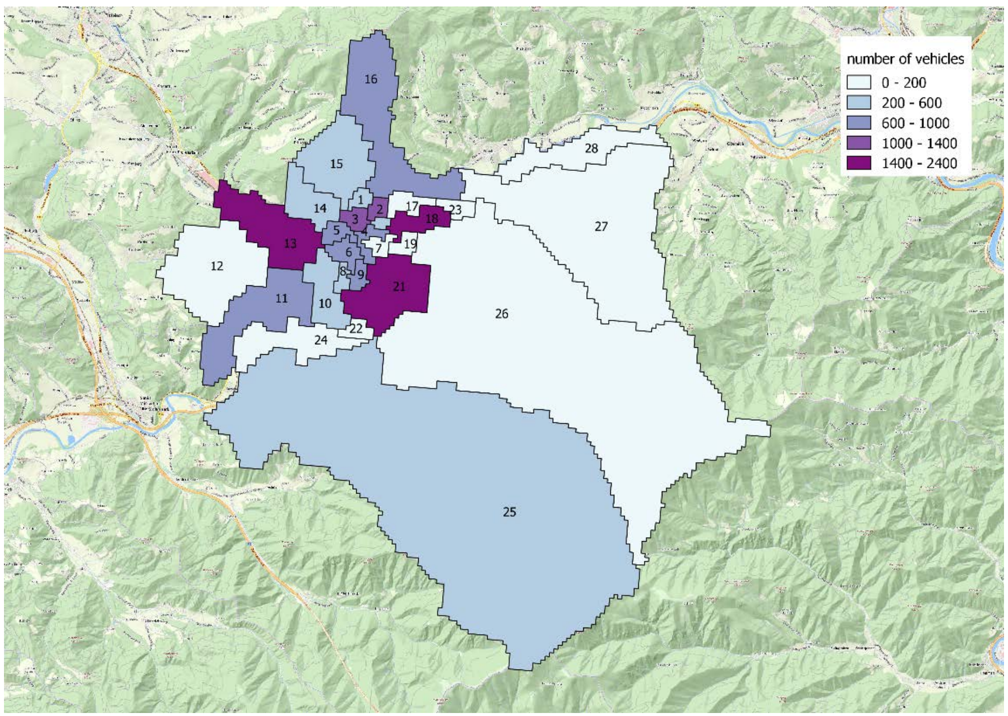
of the active power



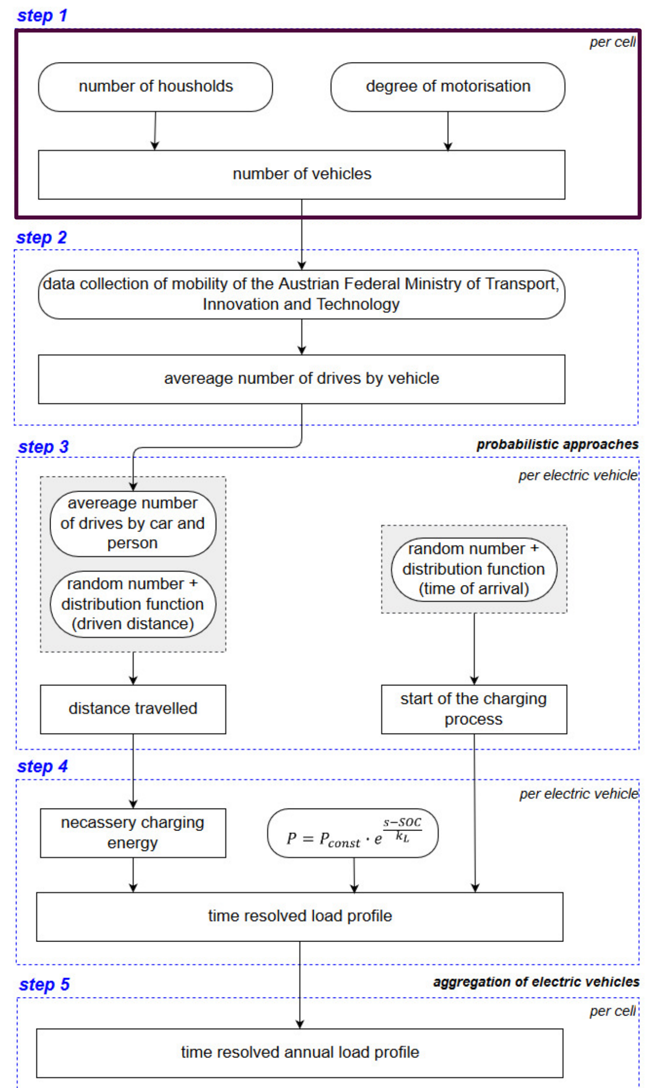
Highest influencing factor: **grid topology** of the currently existing grid
→ different limits of load flow deviations depending on the grid topology

Implementation of charging stations into the grid model (1)

1. Allocation of the vehicles



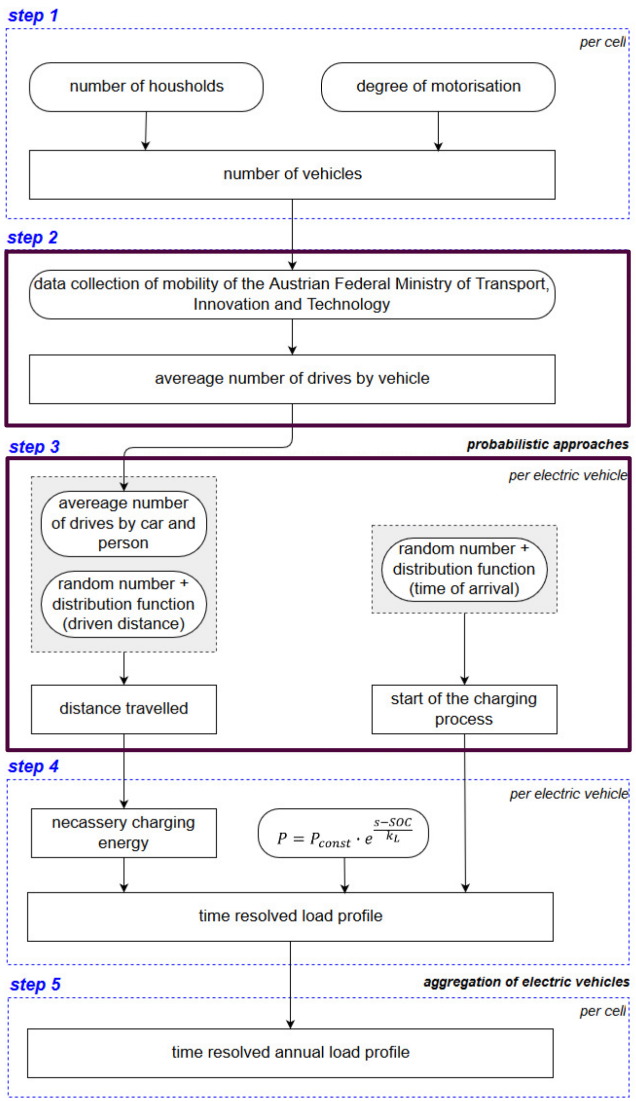
number of vehicles



Implementation of charging stations into the grid model (2)

2. Average number of drives by vehicle

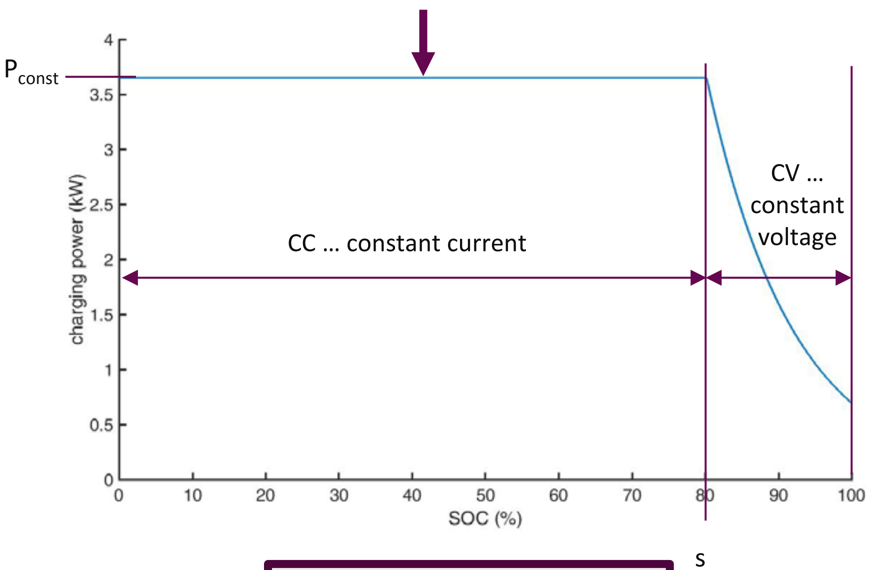
3. Probabilistic approaches
   - Distribution function (driven distance)
     → distance travelled
   - Distribution function (time of arrival)
     → start of the charging process



Implementation of charging stations into the grid model (3)

4. Time resolved load profiles

$$P = P_{const} \cdot e^{\frac{s-SOC}{k_L}}$$ [2]



1 charging process

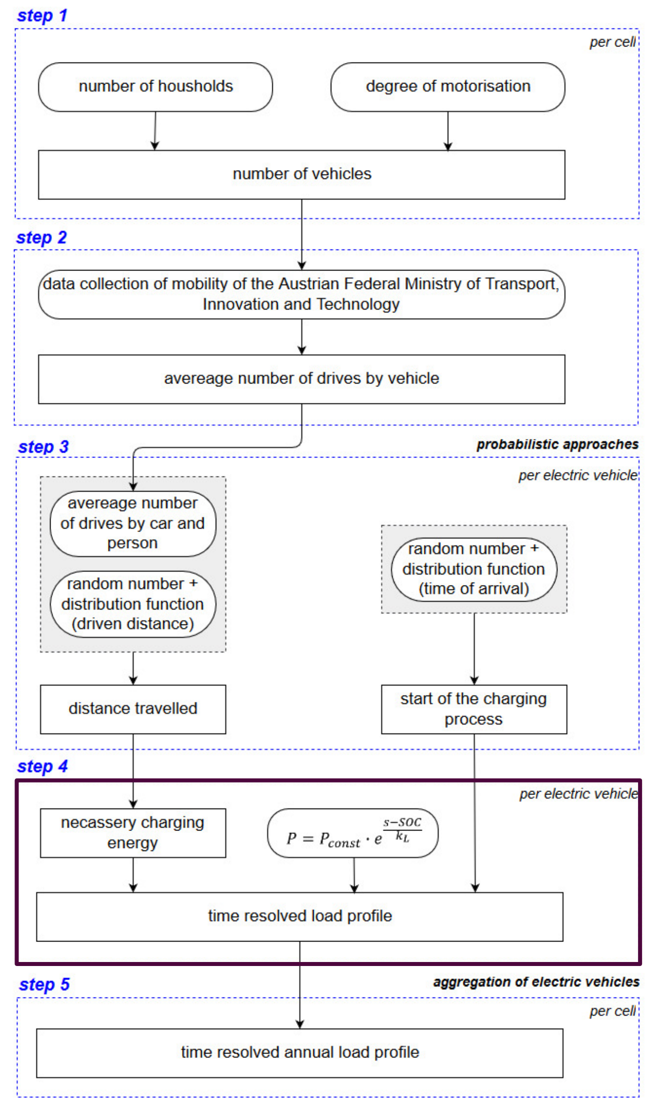
P… charging power

P_{const}… constant power

s… change over point

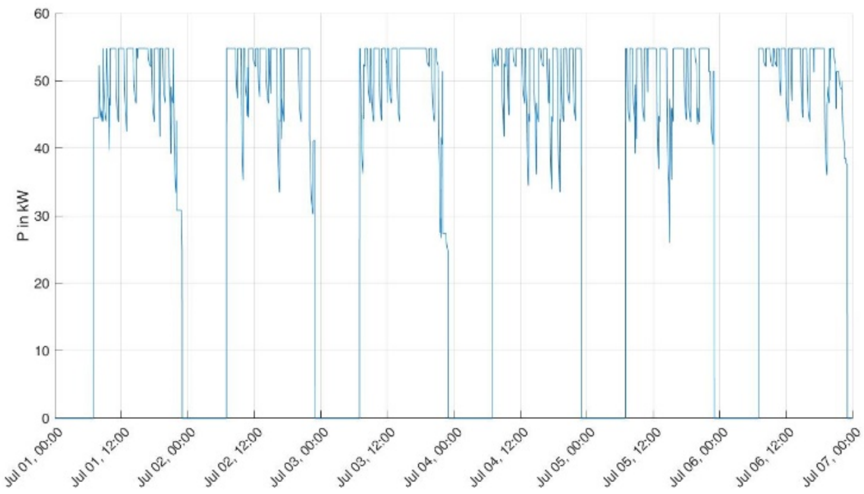
SOC… state of charge

k_L… correction faktor

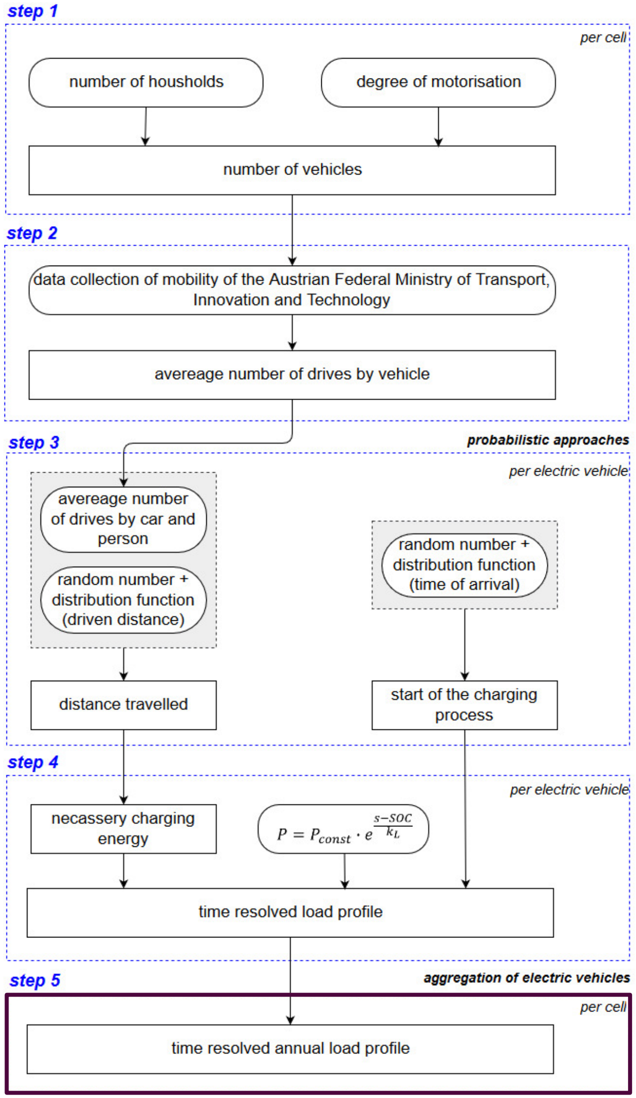


Implementation of charging stations into the grid model (4)

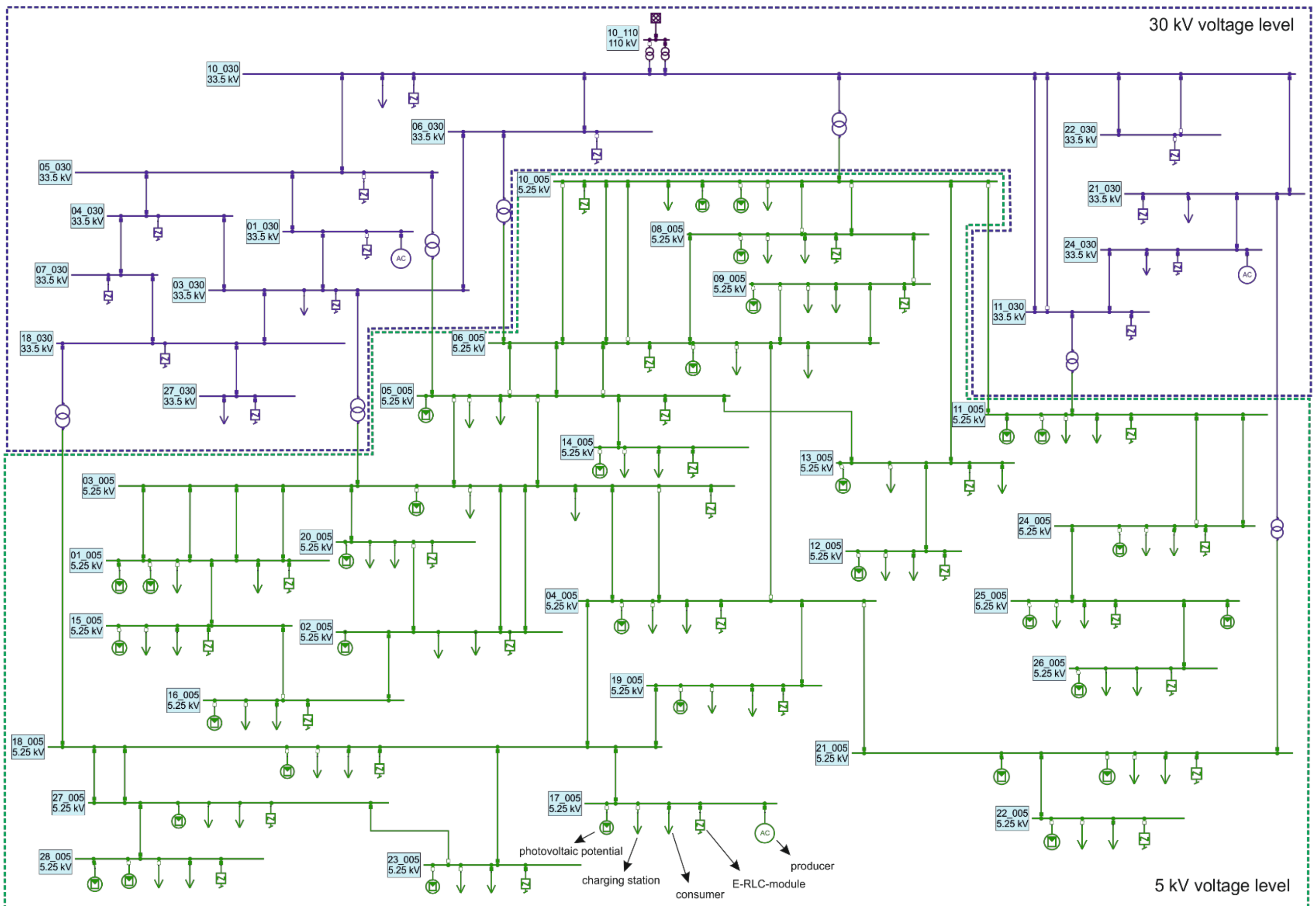
5. Aggregation of electric vehicles



1 week + 16 vehicles



Model for the distribution grid of Leoben



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Preliminary results (1)

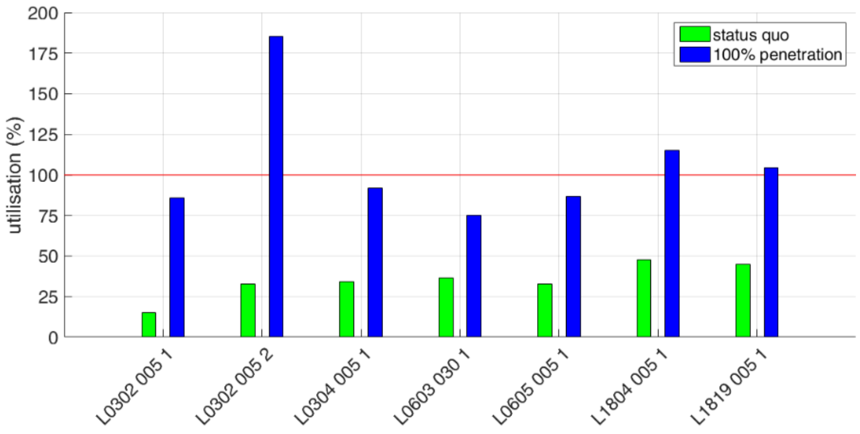
- Consideration of two Scenarios
  - Scenario: status quo
  - Scenario: 100% penetration of electric mobility
    - 1-phase charging with 3.7 kW
  - Time period under consideration: 1 month (744 hours)

- Comparison of these Scenarios
  - An increase in **energy demand** by a factor of 1.5 to 3 times depending on the cell and the number of vehicles within the cell

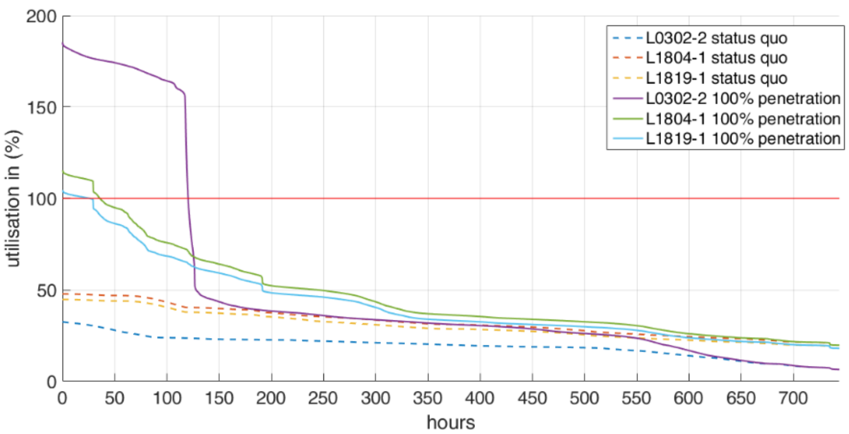
Preliminary results (2)

- Comparison of utilisation cables
  - Utilisation > 75% → 7
  - Utilisation > 100% → 3
  - Duration of the overloads:
    - L0302-2: 130 hours
    - L1804-1 + L1819-1: under 50 hours

Avoiding grid expansion → By demand side measures, storage opportunities,...



Comparison of the maximum utilisation of the cables with an utilisation of more than 75% in the scenario 100% penetration



Frequency of the utilisation of the overloaded cables

Thank you for your attention

References

[1] B. Böckl et al., „Limitations of integrating photovoltaic energy into municipal grids excluding and including storage systems", Solar Integration Workshop, Vienna, 2016

[2] A. Schuster, „Batterie- bzw. Wasserstoffspeicher bei elektrischen Fahrzeugen", Diplomarbeit, Wien, 2008.

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