



# *The role of inverters in stable grid operation*

**Alfredo Ernesto Oneto**  
6 Jun 2023, Burgdorf

1. Motivation
2. Distribution grid models
3. Swiss distribution grids
4. Conclusion and opportunities



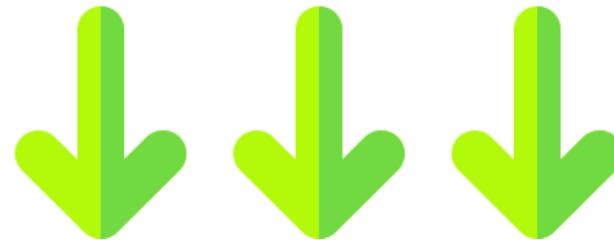
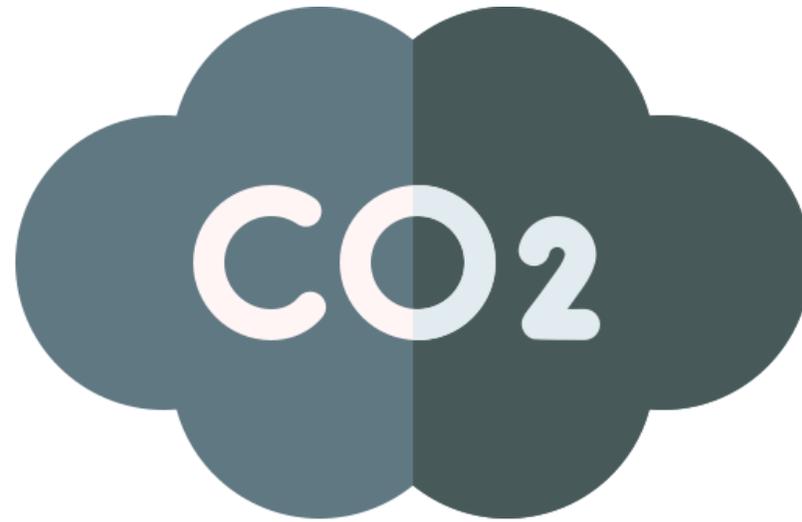
# 1. Motivation

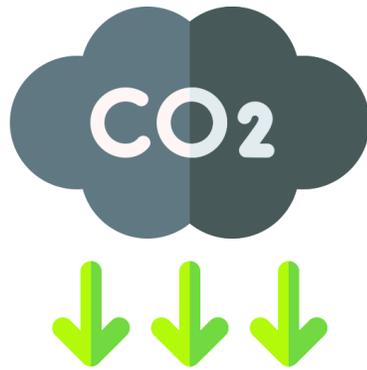
## 2. Distribution grid models

## 3. Swiss distribution grids

## 4. Conclusion and opportunities





An icon of a white heat pump unit with two thermometers on either side, one blue and one red. Wavy lines above the unit indicate heat. Arrows point into and out of the unit.

Heat pumps

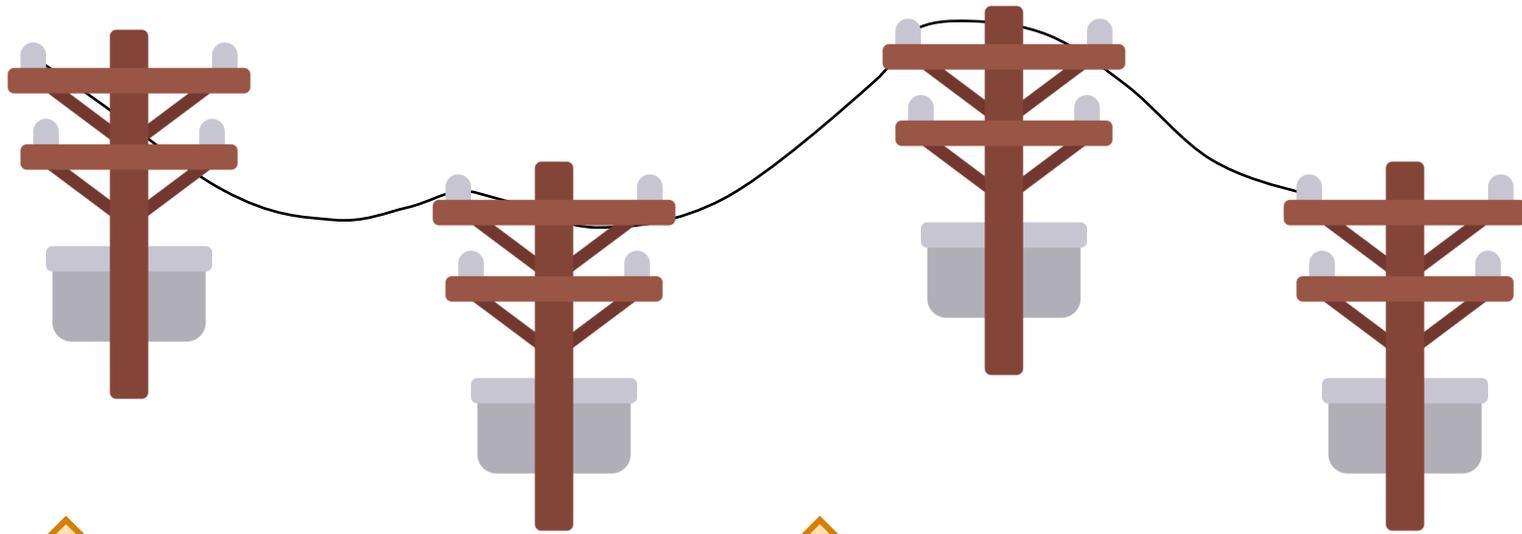
**ETH** zürich Reliability and Risk Engineering

An icon of a red and blue electric car with a charging cable and a green checkmark in a circle above it.

Electric vehicles

An icon of three blue solar panels on a green base, with a yellow sun above them.

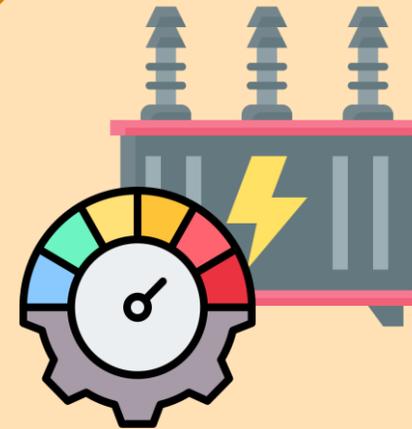
PV systems



Voltage deviations

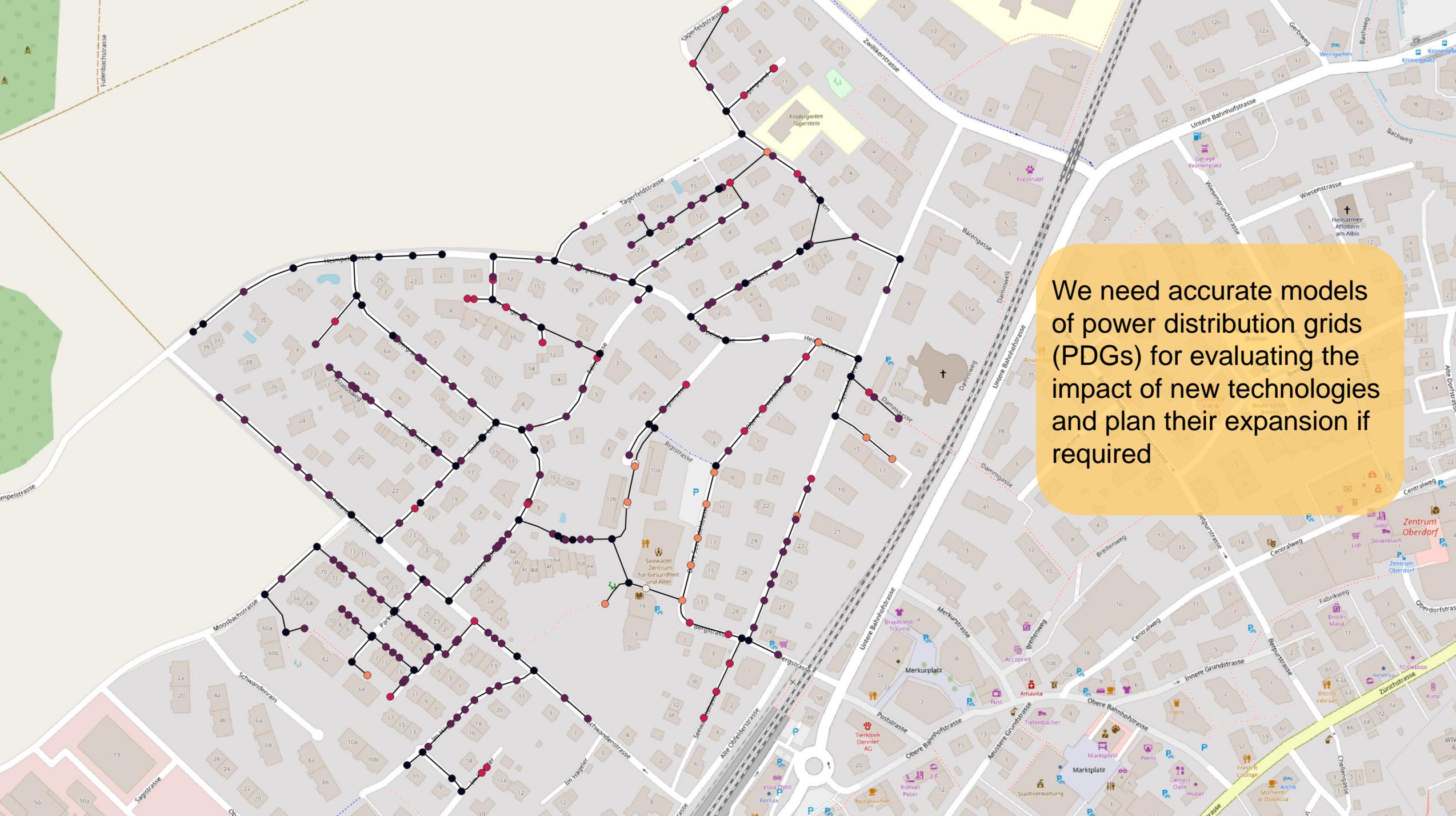


Reverse power flows



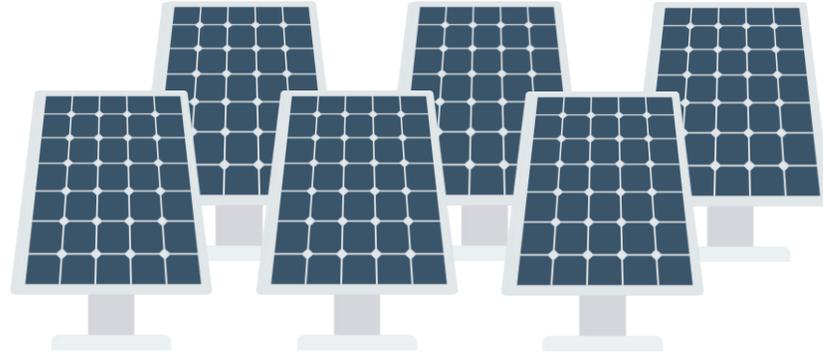
Transformers overload





We need accurate models of power distribution grids (PDGs) for evaluating the impact of new technologies and plan their expansion if required





Output power  
uncertainties

Frequency  
fluctuations

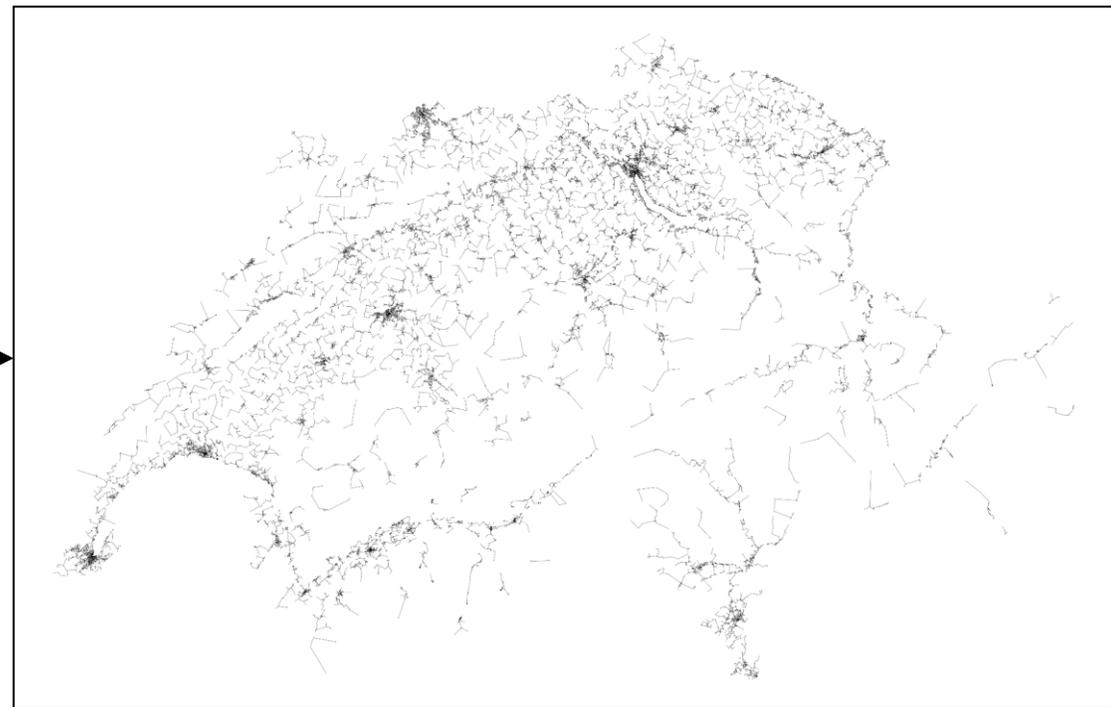
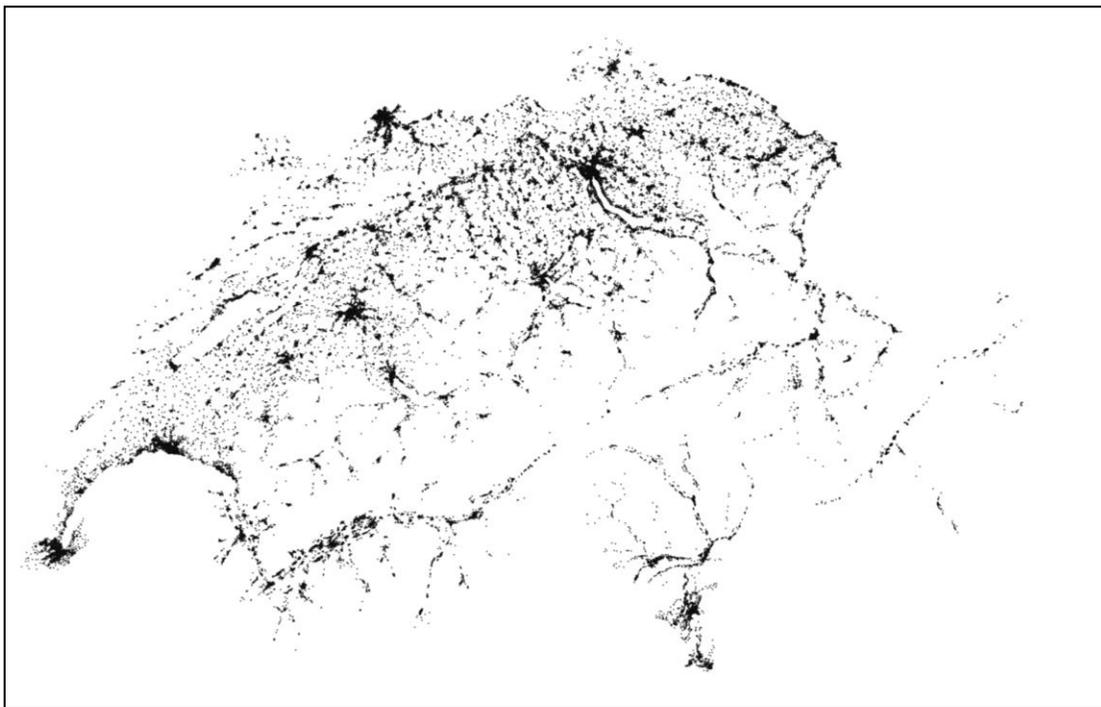
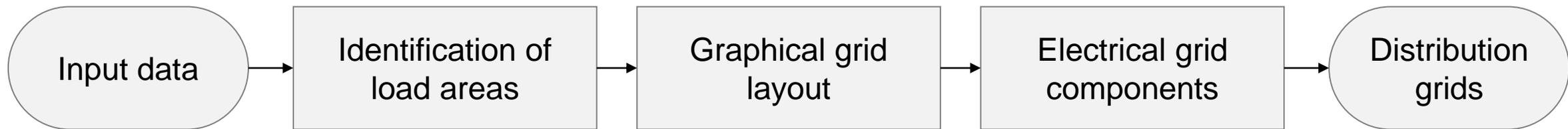


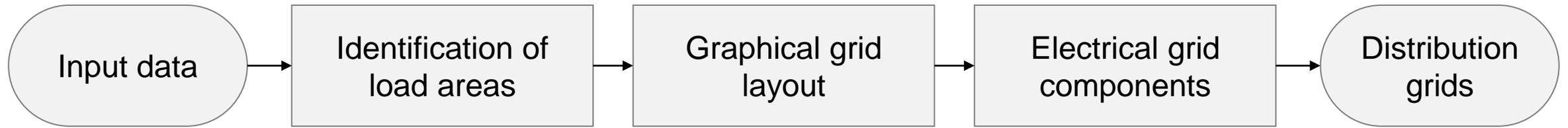
Communication  
challenges

Electricity  
markets  
challenges

1. Motivation
2. **Distribution grid models**
3. Swiss distribution grids
4. Conclusion and opportunities







LV data

LV consumers and  
LV transformers  
types

LV line types

LV grids

Transport  
infrastructure

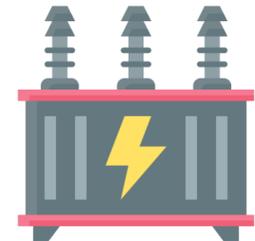
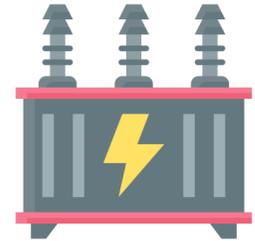
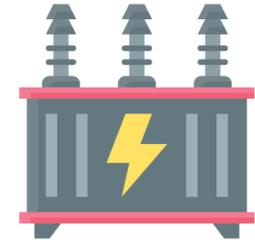
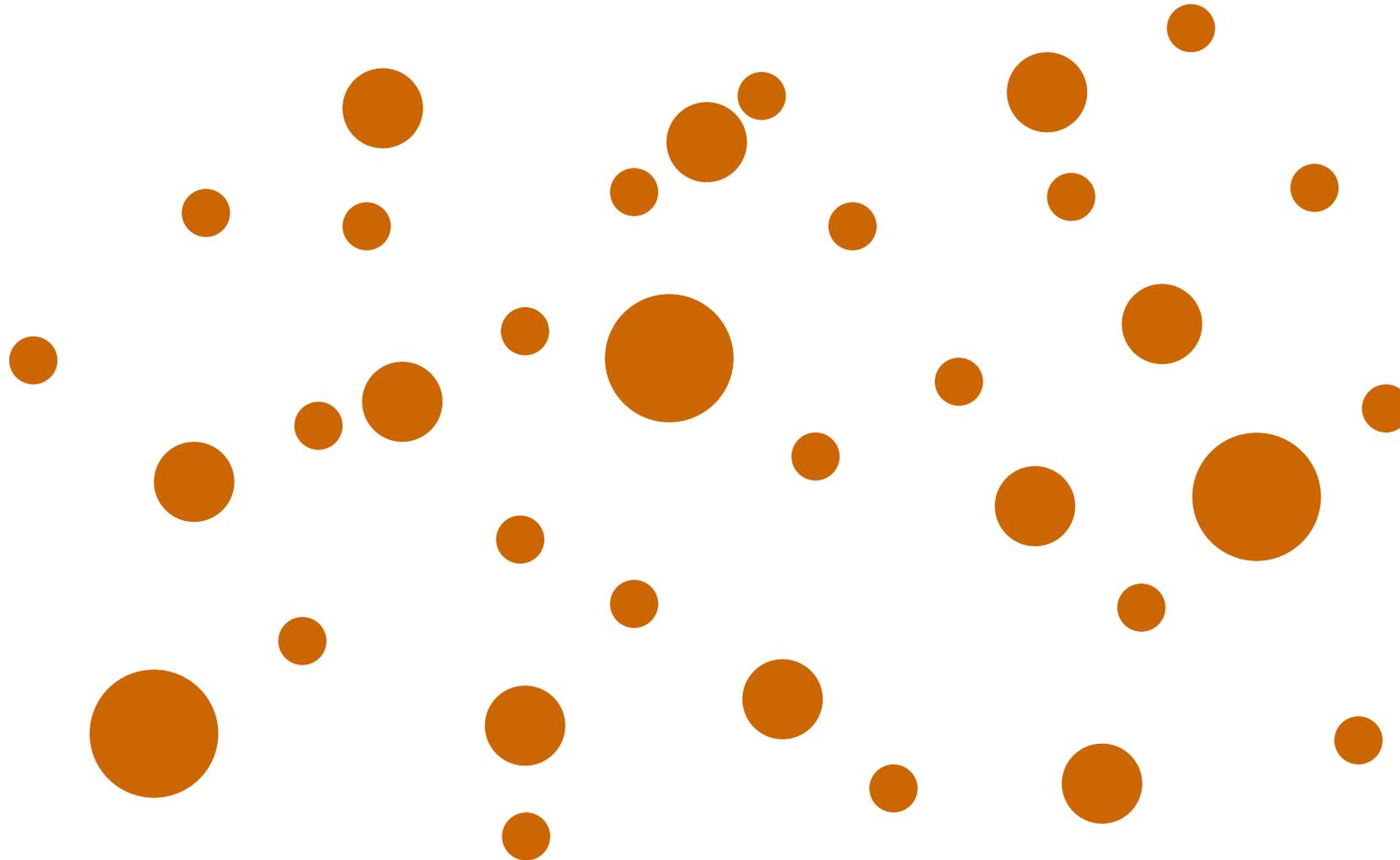
MV data

MV consumers,  
MV/LV substations,  
and MV  
transformers types

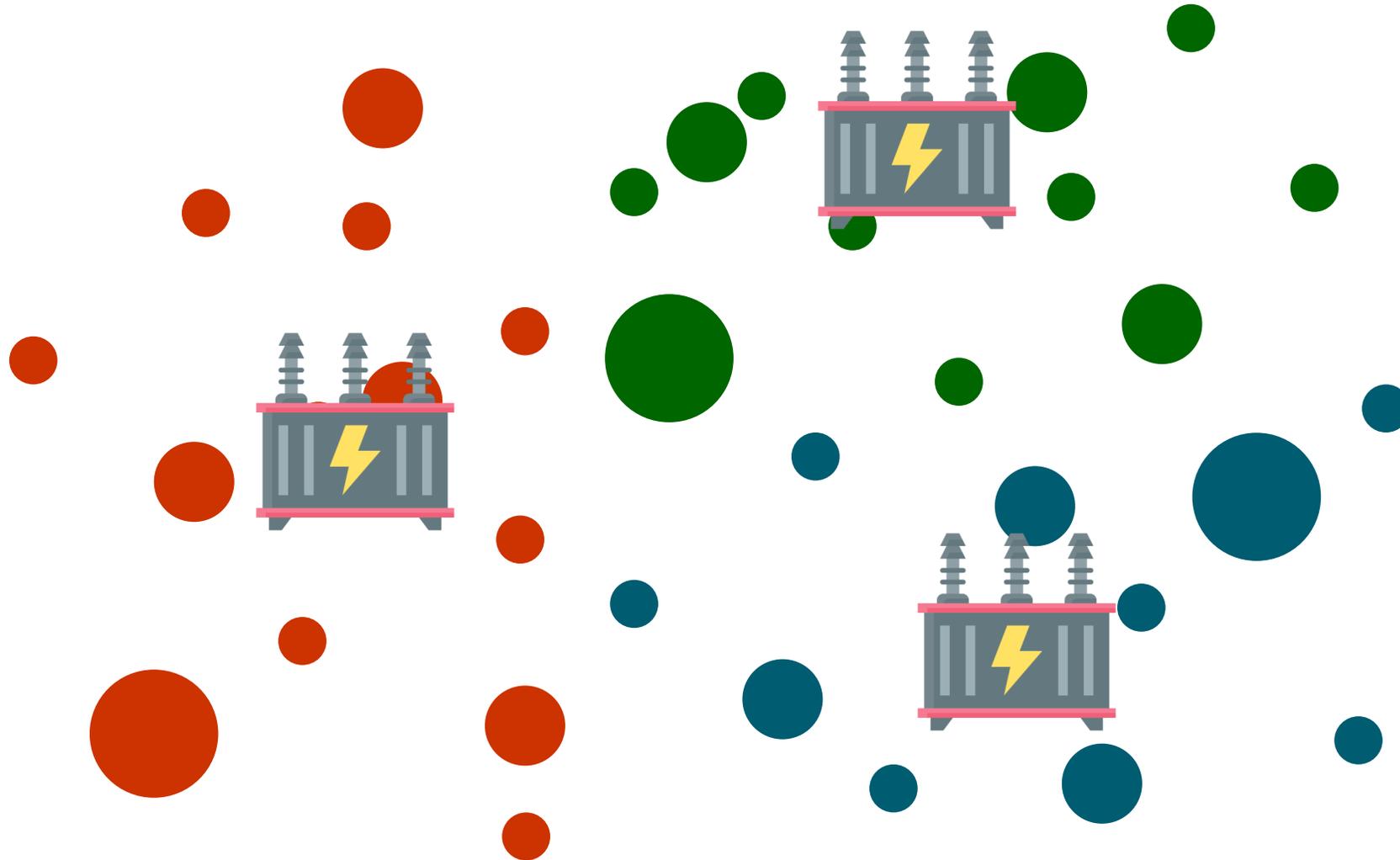
MV line types

MV grids

# Identifying load areas



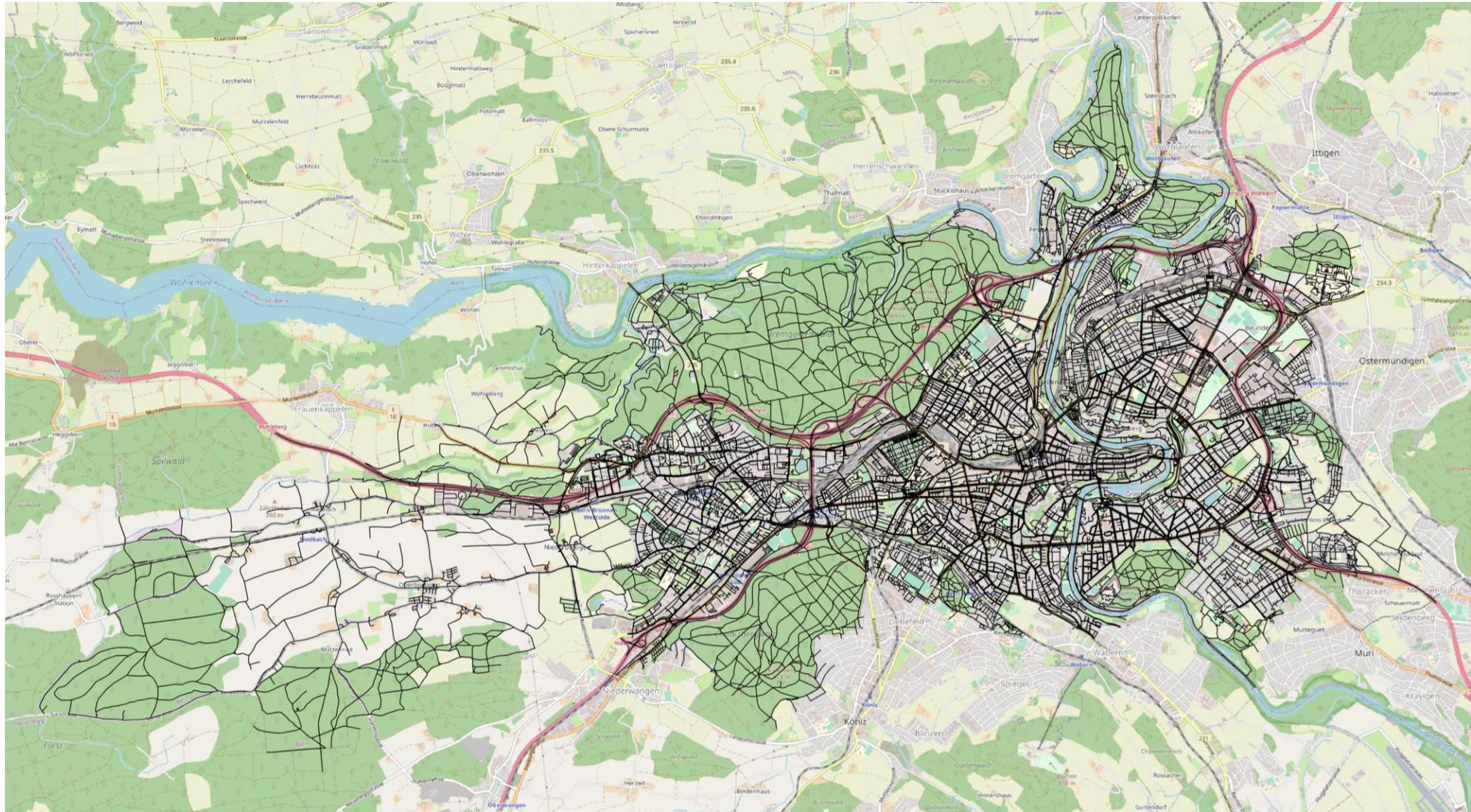
# Identifying load areas



# Determining the grids' layouts

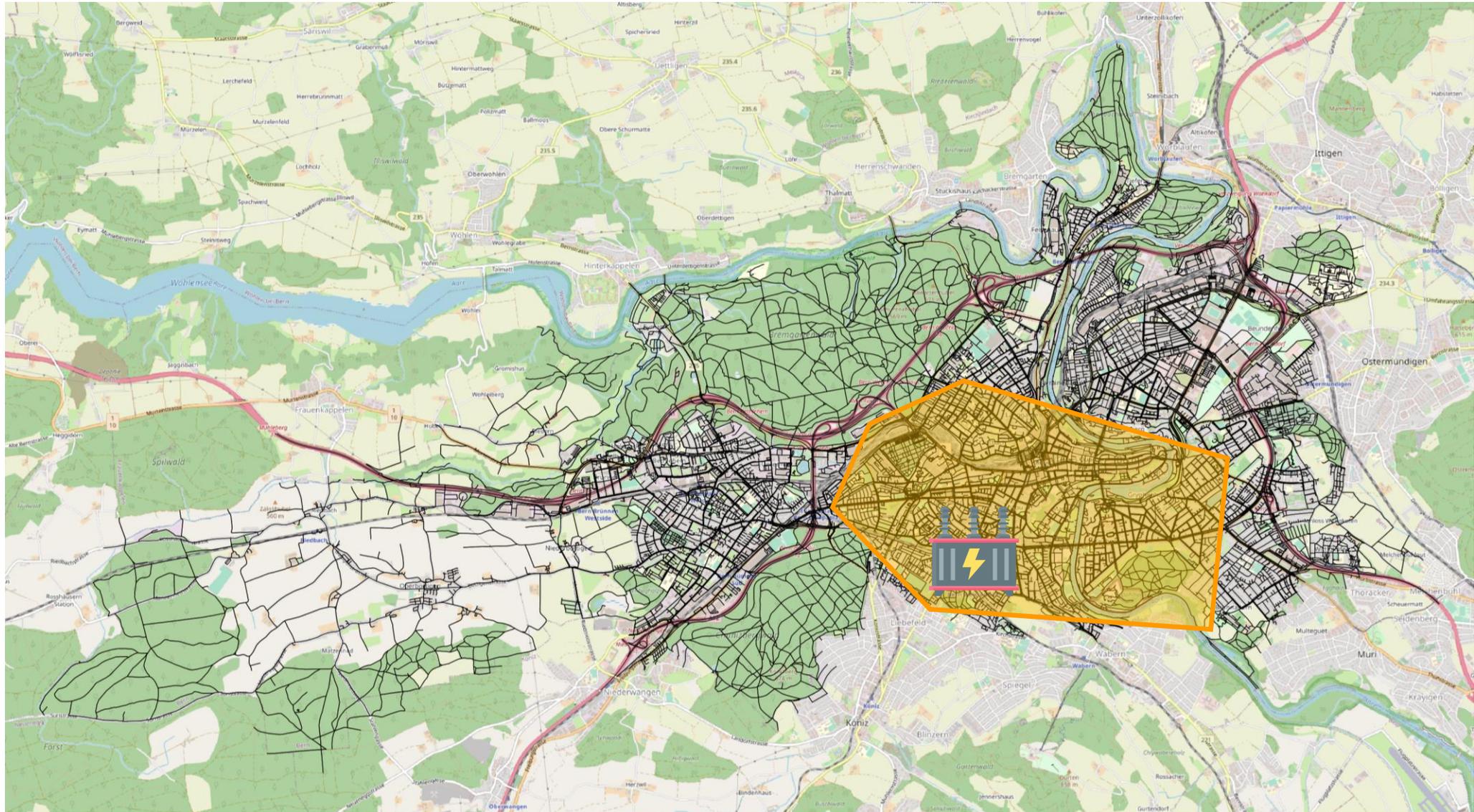


# Determining the grids' layouts

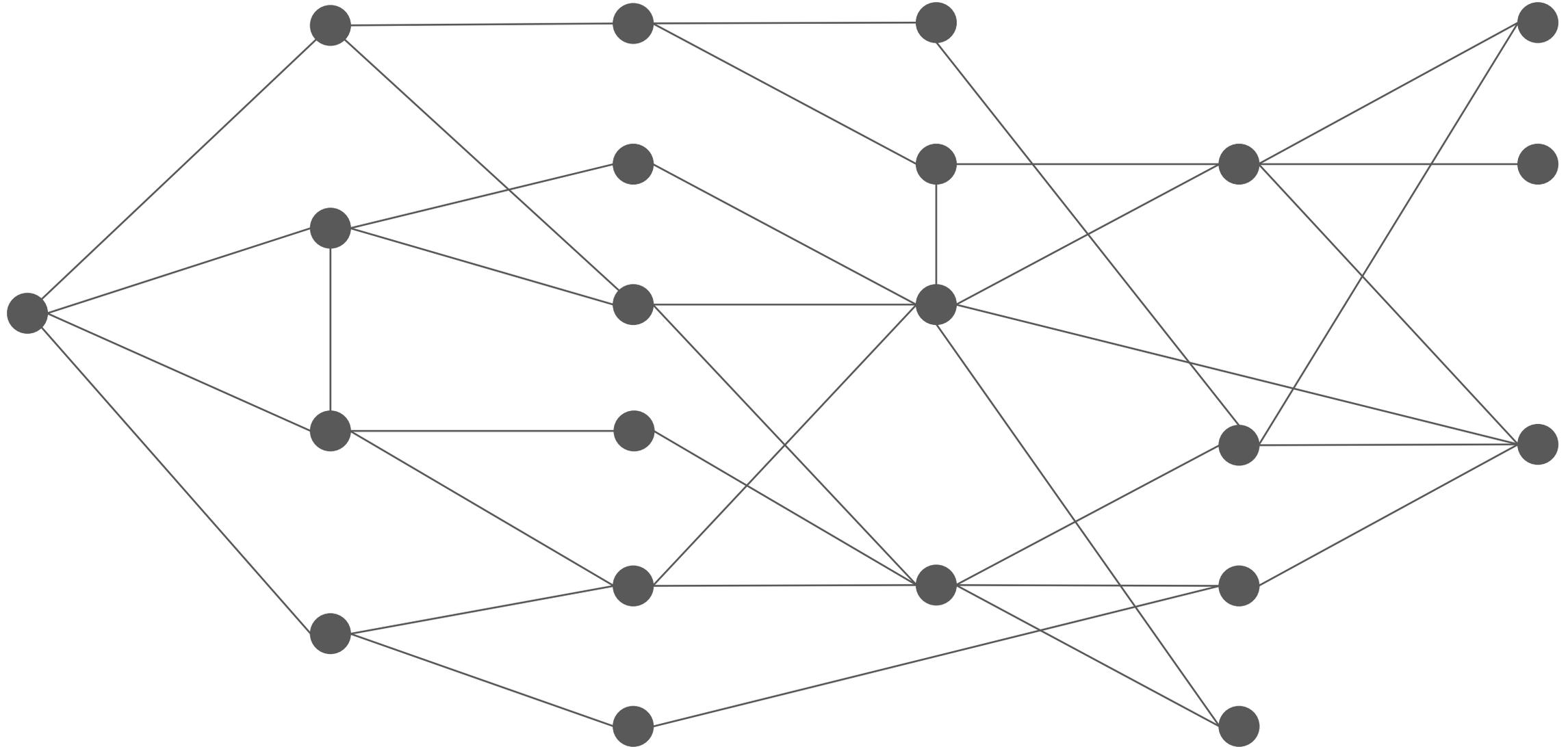




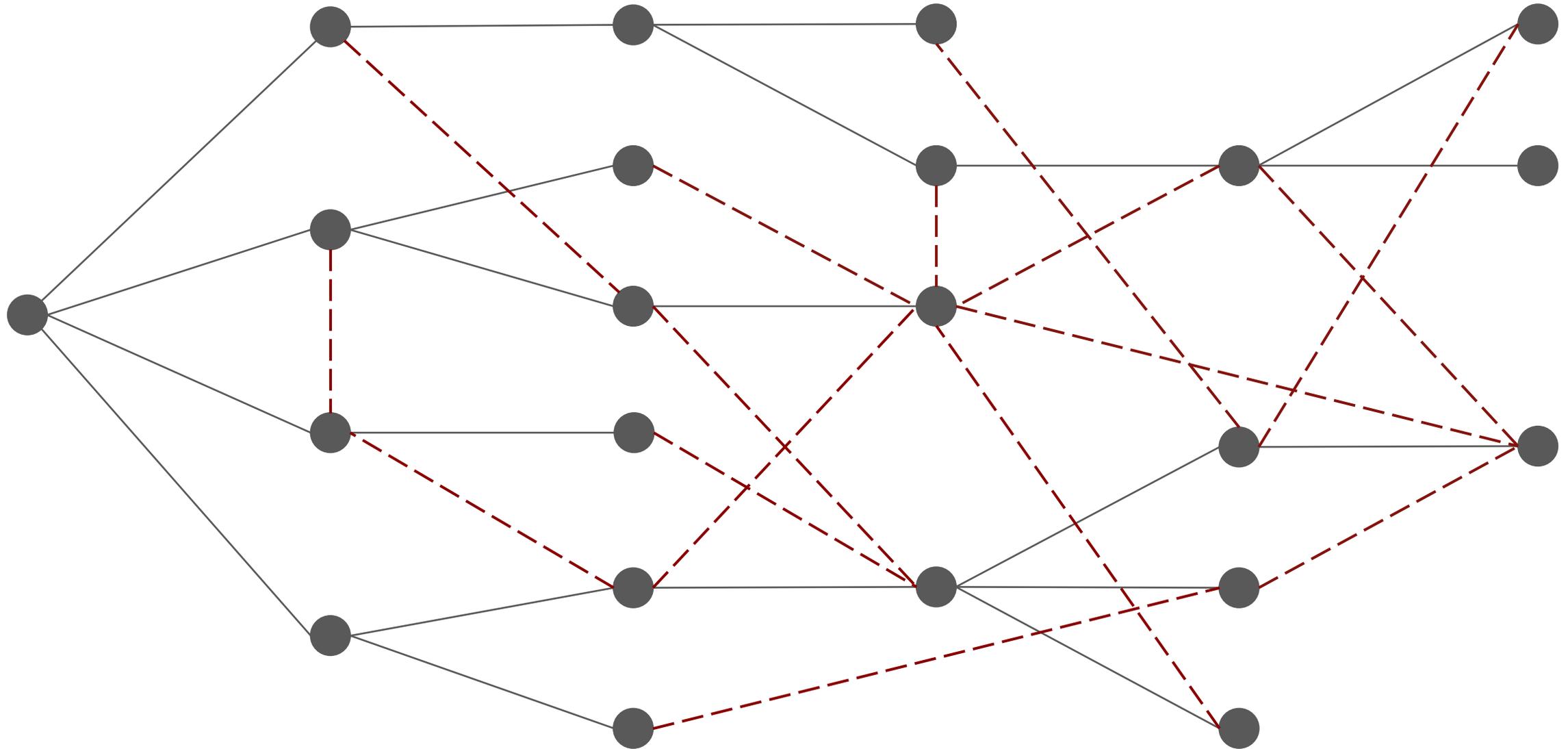
# Determining the grids' layouts



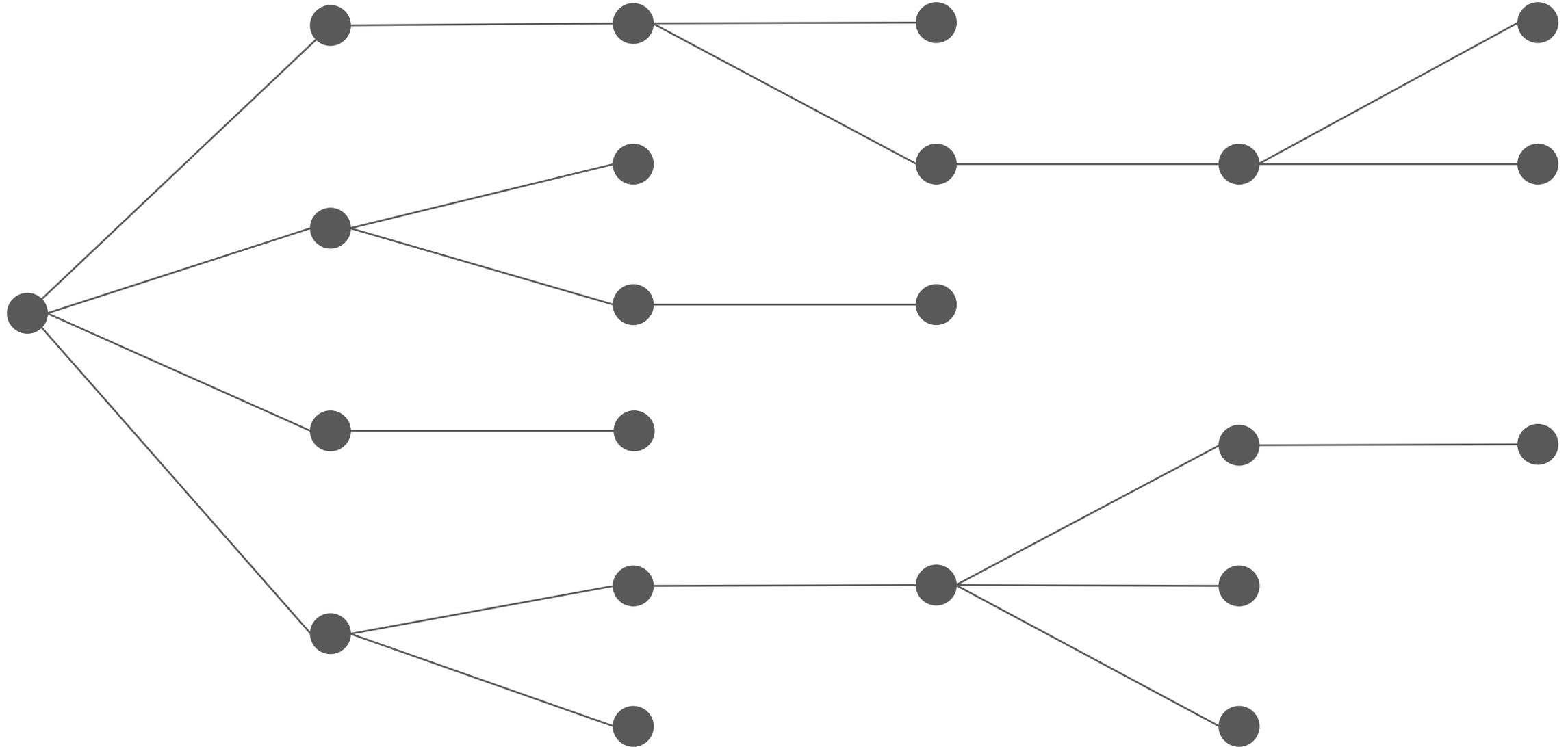
# Electrical grid components



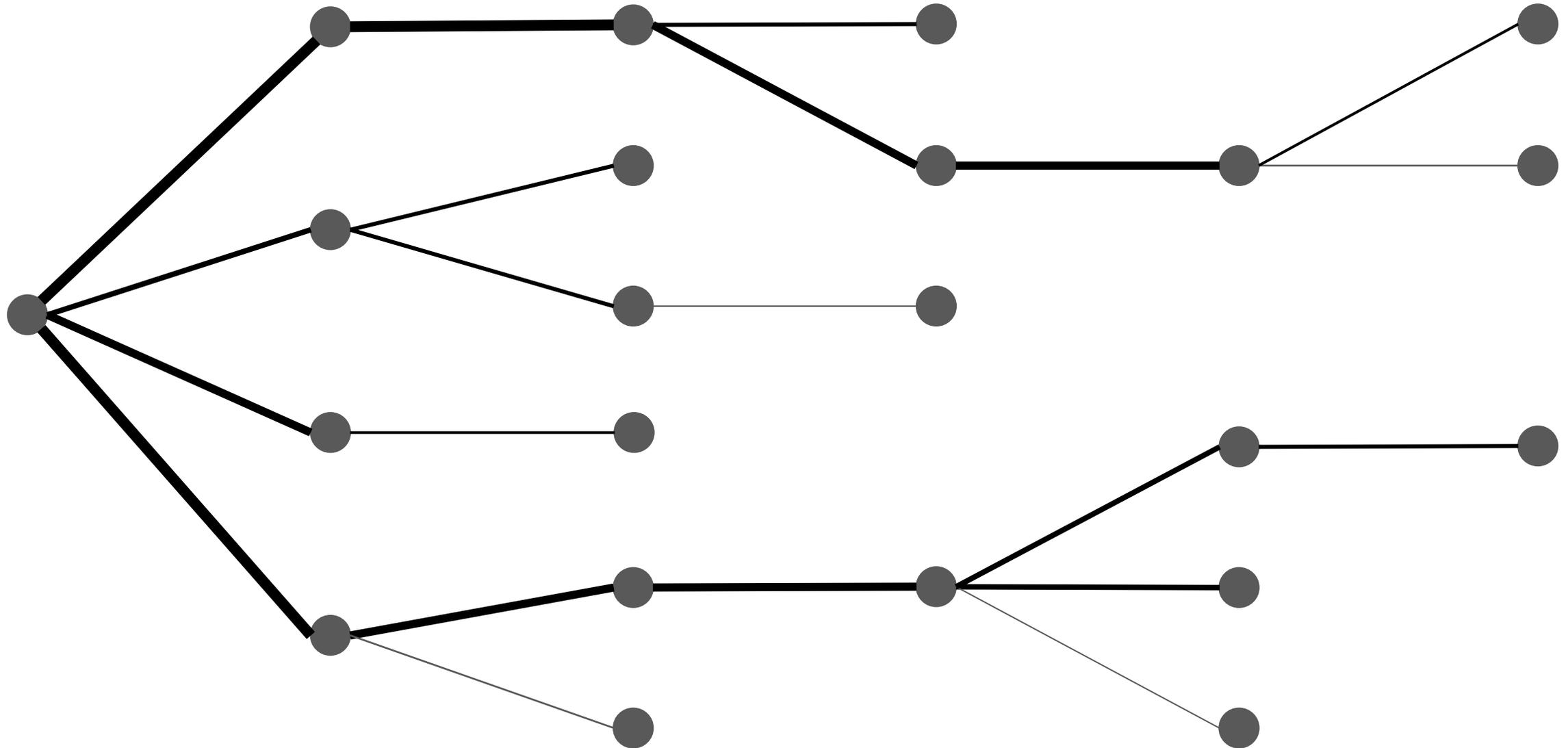
# Electrical grid components



# Electrical grid components



# Electrical grid components

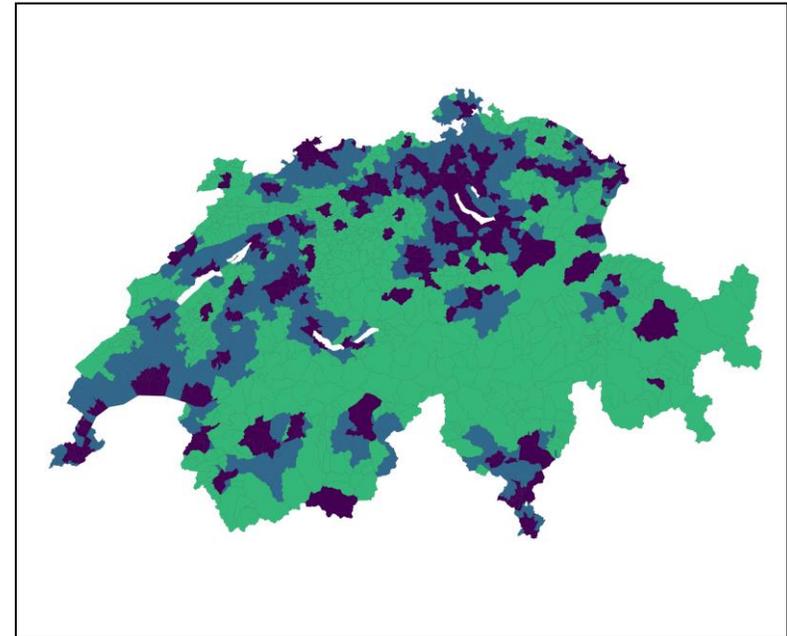
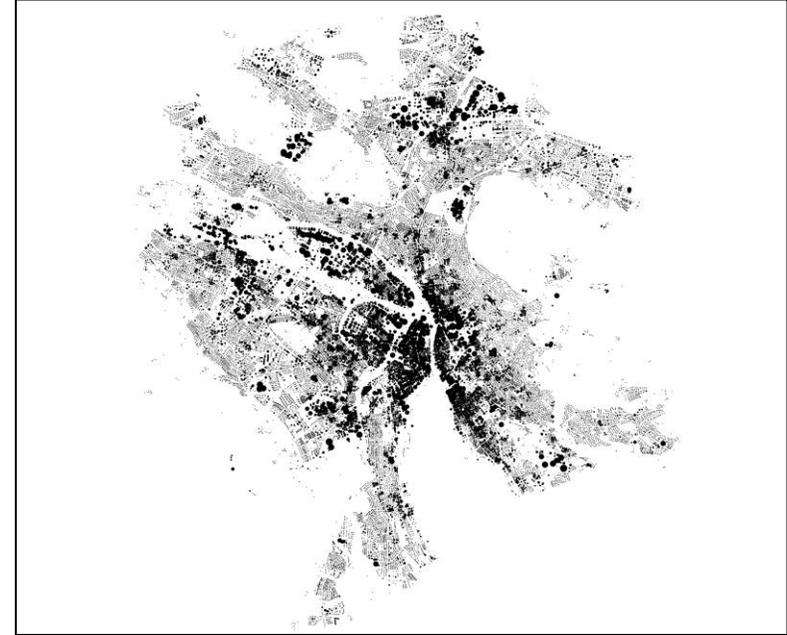


1. Motivation
2. Distribution grid models
3. **Swiss distribution grids**
4. Conclusion and opportunities

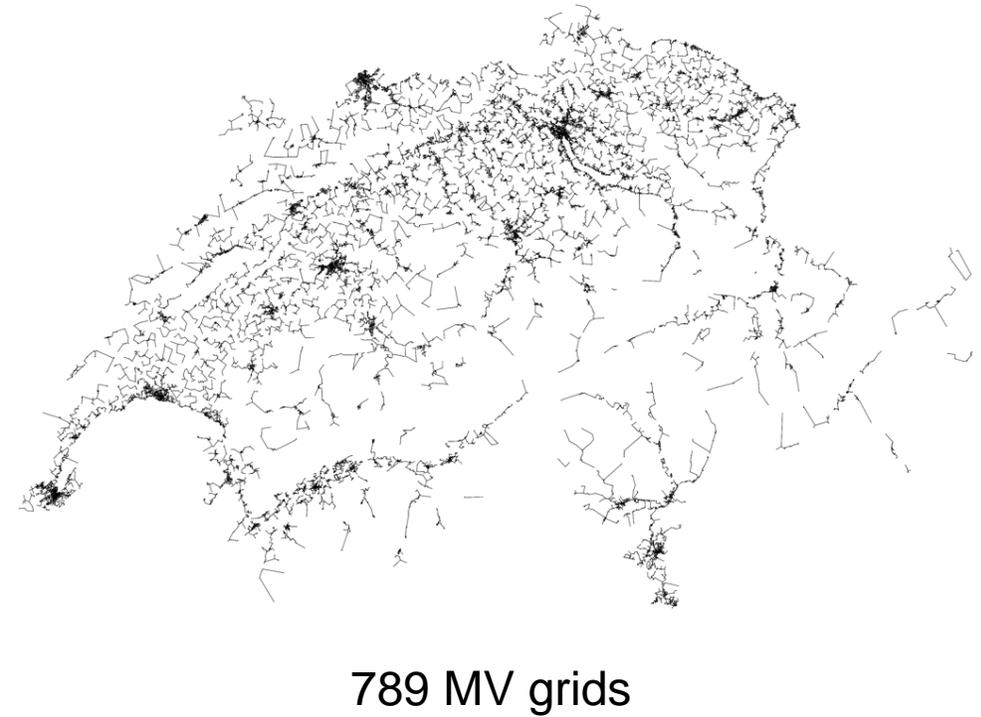
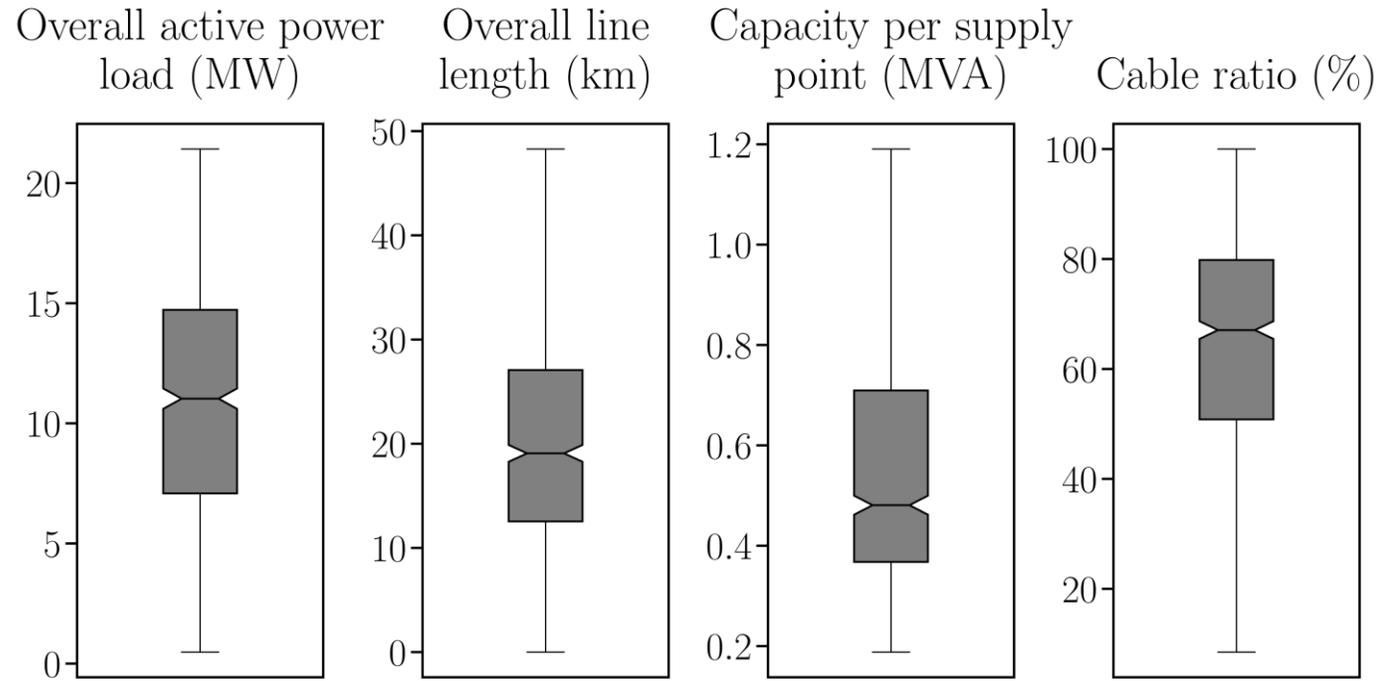


# Input data

- Power demand at a building scale
- Load areas are identified for different types of regions
- Transport infrastructure data is obtained
- We select standard component types
- We model AC power flows, imposing regulatory constraints

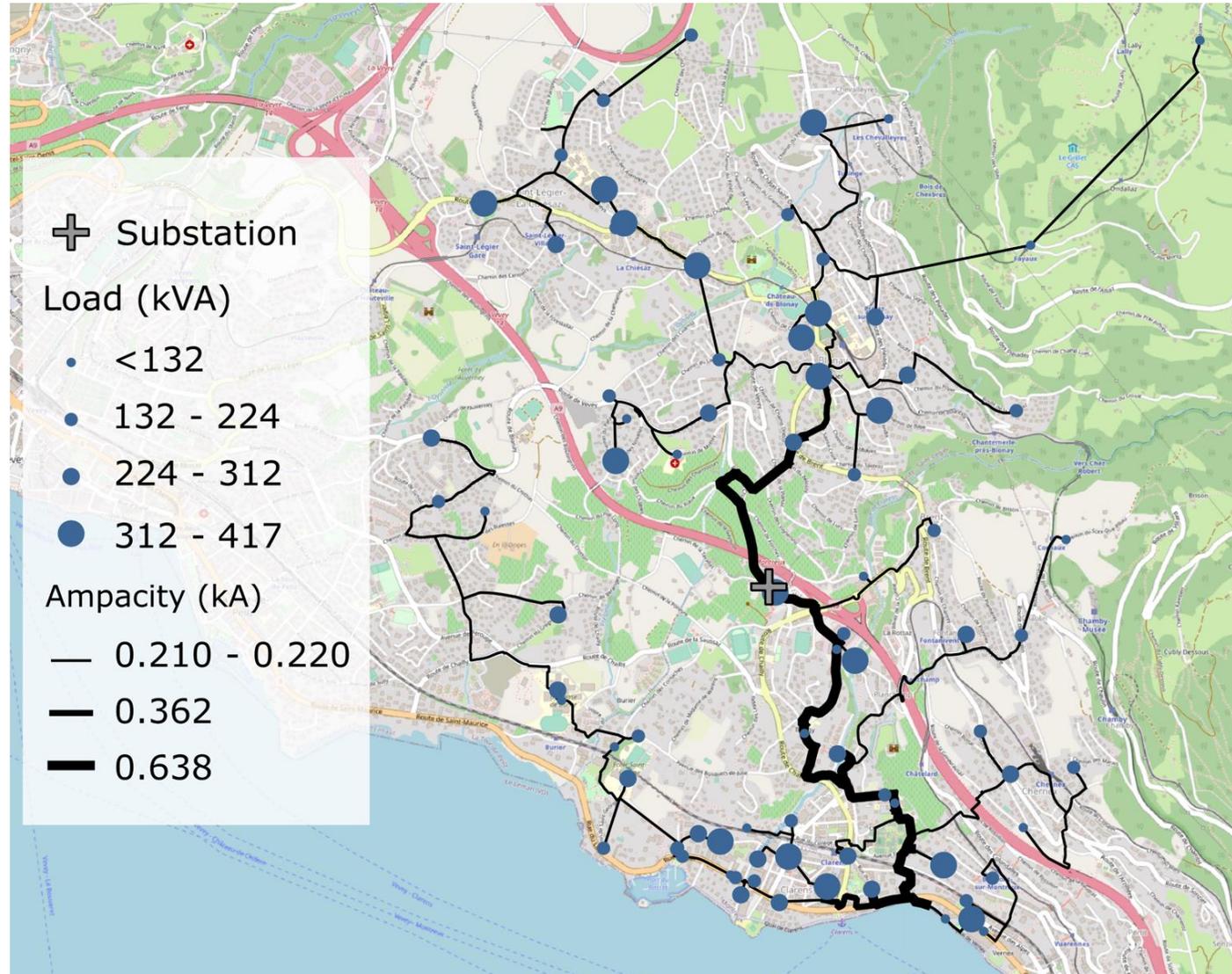


# MV grids

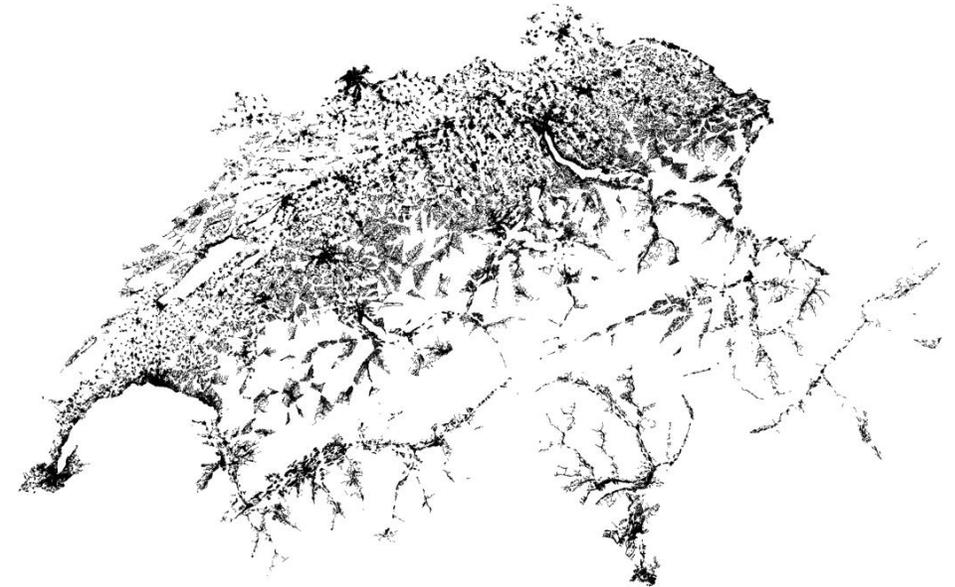
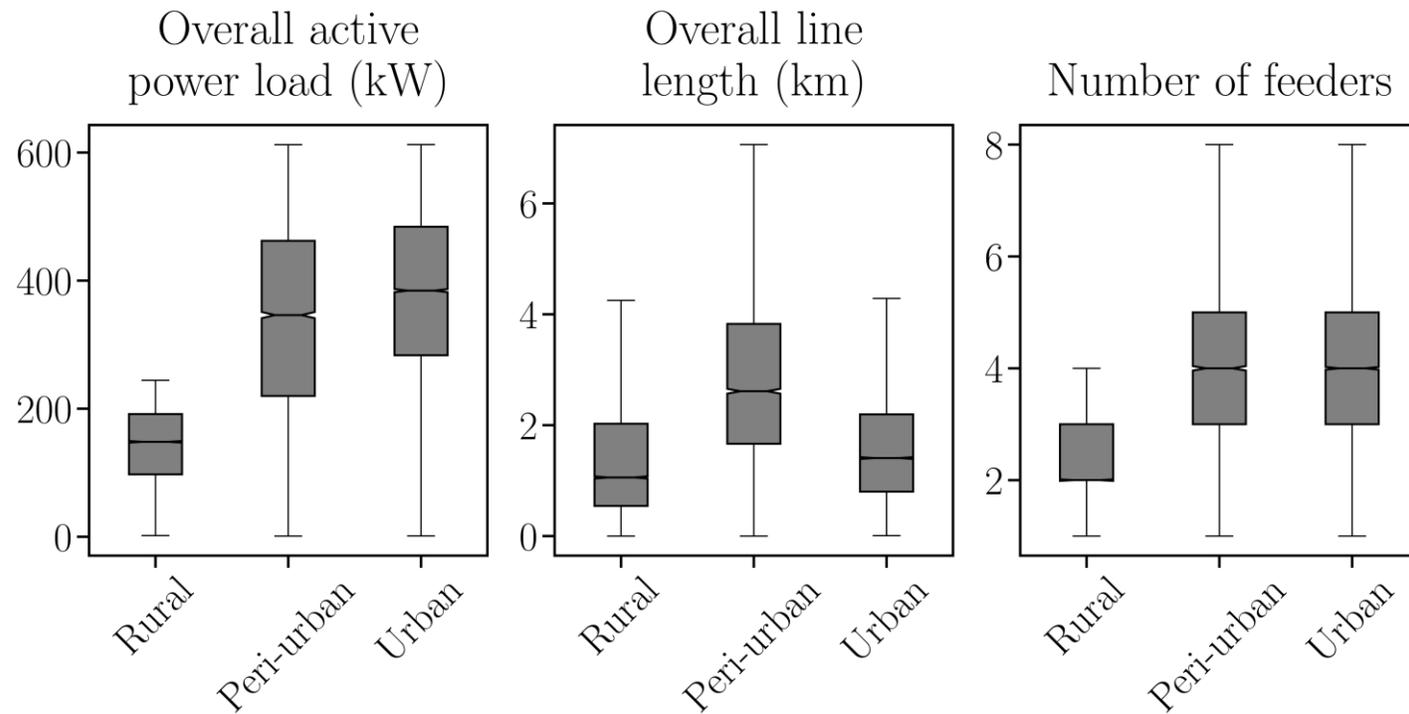




# MV grid example

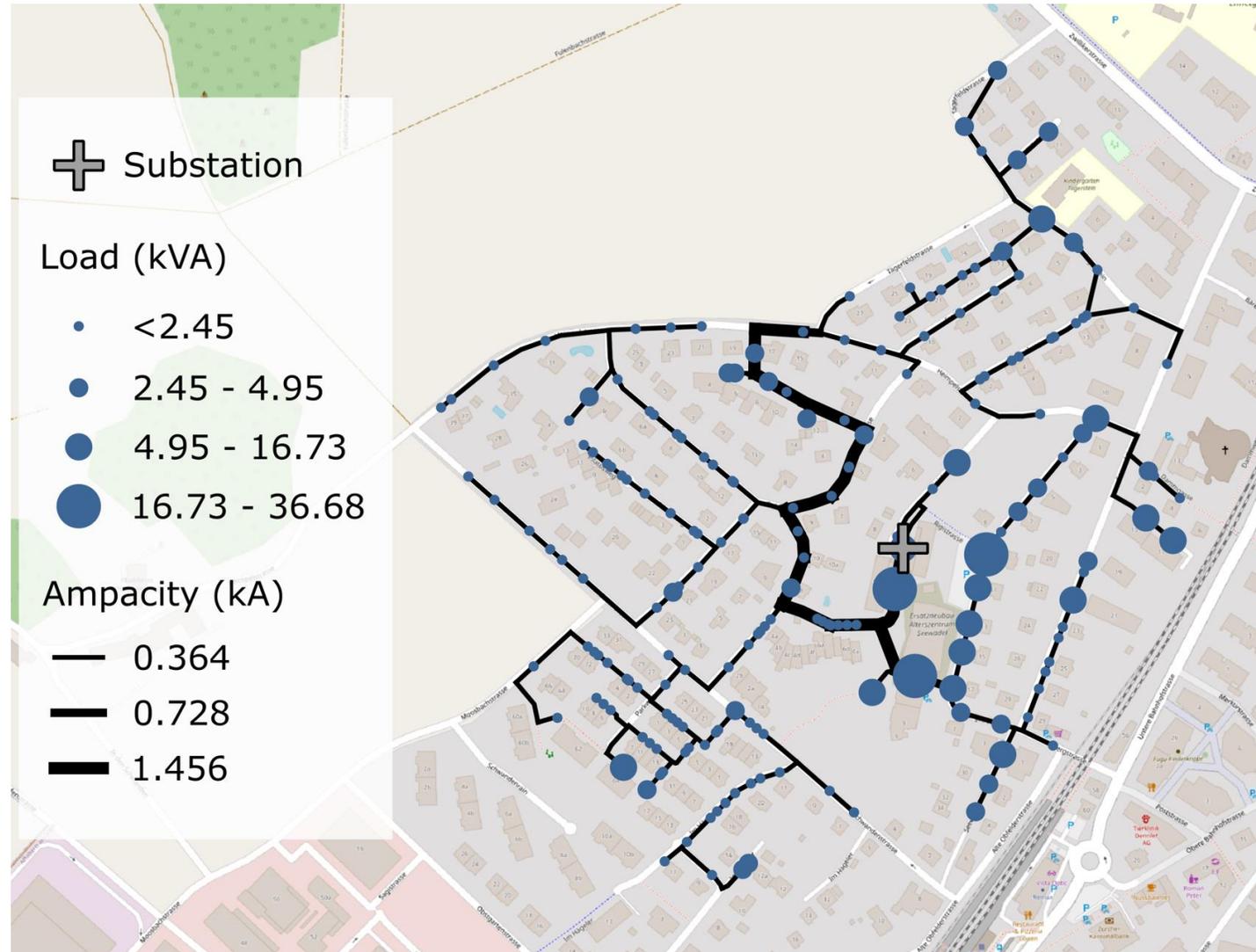


# LV grids



36 555 LV grids

# LV grid example



1. Motivation
2. Distribution grid models
3. Switzerland's present situation
4. **Conclusion and opportunities**



# Conclusions plus opportunities regarding PV inverters

- We develop a framework for large-scale inference of PDGs using open data.
- The inferred Swiss grids display the expected properties of real and synthetic reference grids.
- Planning the Swiss PDGs should consider PV inverters:
  - Inverters can provide reactive power support
  - Stabilize voltage deviations
  - Increase the hosting capacity
  - Reduce expansion costs



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# Limitations

- We model balanced three-phase grids. However, PDGs are usually unbalanced, and operating under this condition can cause voltage deviations.
- We model steady-state power flows under peak demand without considering transient effects on the PDGs. Additionally, lines placed on the same geographical path are deemed parallel to the power flows, simplifying the topological representation of the feeders.
- The MV grids are generally meshed, but in this work, we only infer radial topologies since it is their usual operational configuration.
- The framework does not identify renewable distributed generation and energy storage systems, which can influence the temporal profiles of generation and demand in PDGs.
- The framework does not differentiate between diverse types of transport paths and allows the placement of underground cables in any path, such as dirt roads and pedestrian ways. In reality, this does not often occur.