The energy transition & the electricity network

Simulations, data science and machine learning

16-01-2019

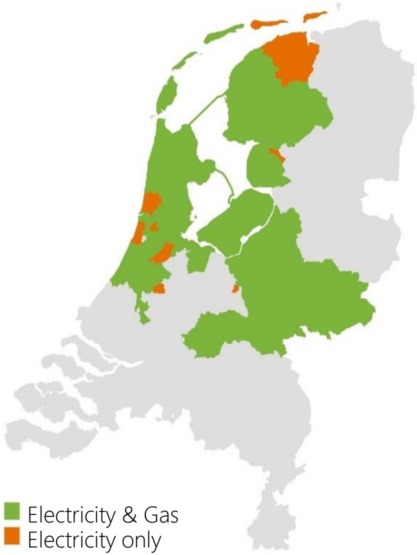
Werner van Westering MSc.

Senior data scientist & PhD candidate
Data & Insight Alliander

Index

1. Introduction
2. Our context
3. Highlights
4. Case I: Network planning
5. Case II: Real time control
6. Outlook

Alliander Service Area



Key Figures

Liander is the largest DNO in the Netherlands and serves over 3 million customers

- 3 million small-scale consumers
- 13,000 large-scale consumers

Key figures asset base Liander

- 50,000 km low voltage cable
- 35,000 km medium voltage cable
- 37,000 transformers
- 230 substations

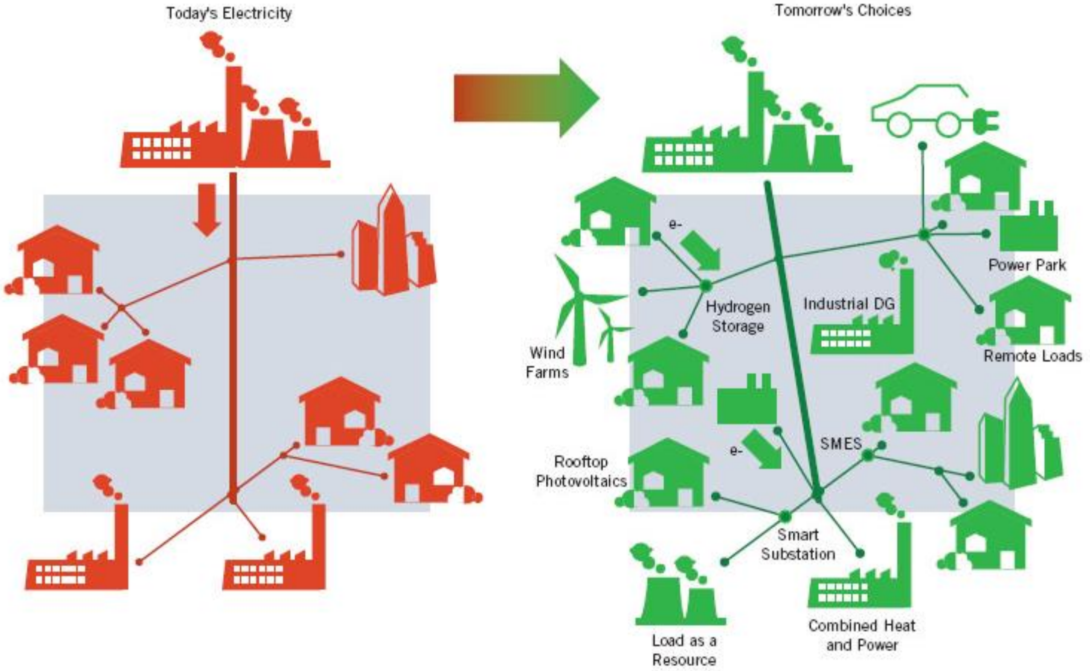
Our context

Challenge:

- Peak electricity load to increase three times
- 2.5% maximum replacement per year

Tools:

- 25 data scientists
- Data sets of:
    - The entire Alliander grid
    - Electricity consumption (anonomized)
    - Sociographic data on neighbourhood level
- R/Pyhton programming language
- 512 GB RAM machines



A few highlights

1. Asset health analytics

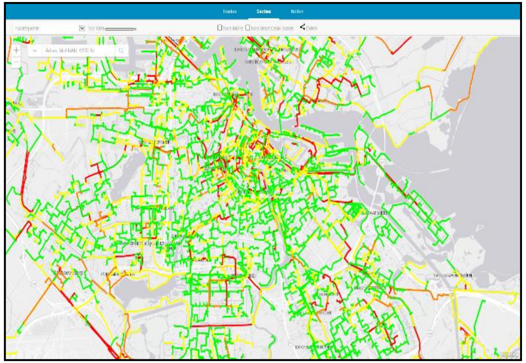
- ~200 variables
- Random forest
- Result: Priority list

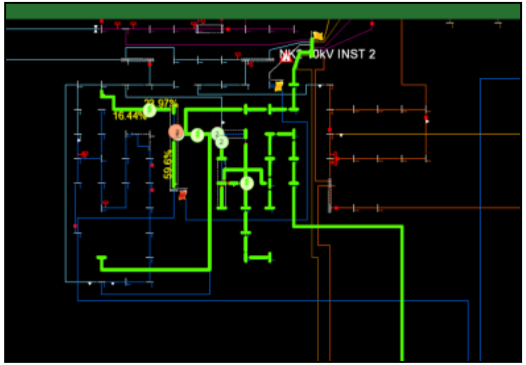
2. Network recovery plans

- Real time data
- Linearized physics, brute force
- Result: Recovery plan in seconds

3. Smart meter deployment

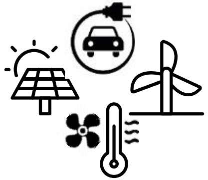
- ~150 variables
- SVM for clustering
- Result: Risk map





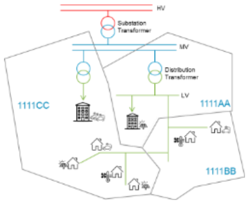
Case I: Network planning

The ANDES model determines the impact of the energy transition

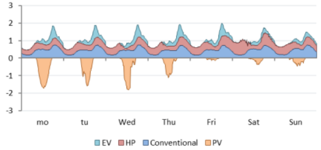


REGIONAL ADOPTION

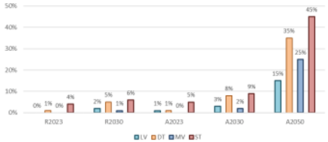
LOCAL ADOPTION



PROJECT ON GRID TOPOLOGY



CALCULATE LOAD PROFILE PER ASSET



DETERMINE # OF OVERLOADS

1 → 2 → 3 → 4 → 5

ANDES technology adoption model

Input: 150 demographical aspects

Socio-demographic, e.g.:
- income
- education
- Life phase

House properties, e.g.:
- Type of house
- Value house
- Owned/rented

Financial info, e.g.:
- Savings
- insurance
- Other financial info

Vehicle information, e.g.:
- Number owned
- Segment
- Age

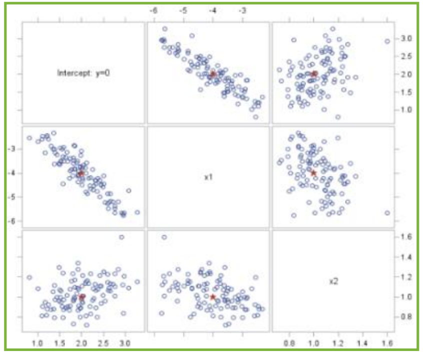
Media, e.g.:
- Internet behaviour
- Magazines
- TV channel preference

Buying habits, e.g.:
- Clothing segment
- Holidays
- Charity

Etcetera

Analysis: Probability of adoption is determined

- Multiple regression techniques were studied.



Regression analysis

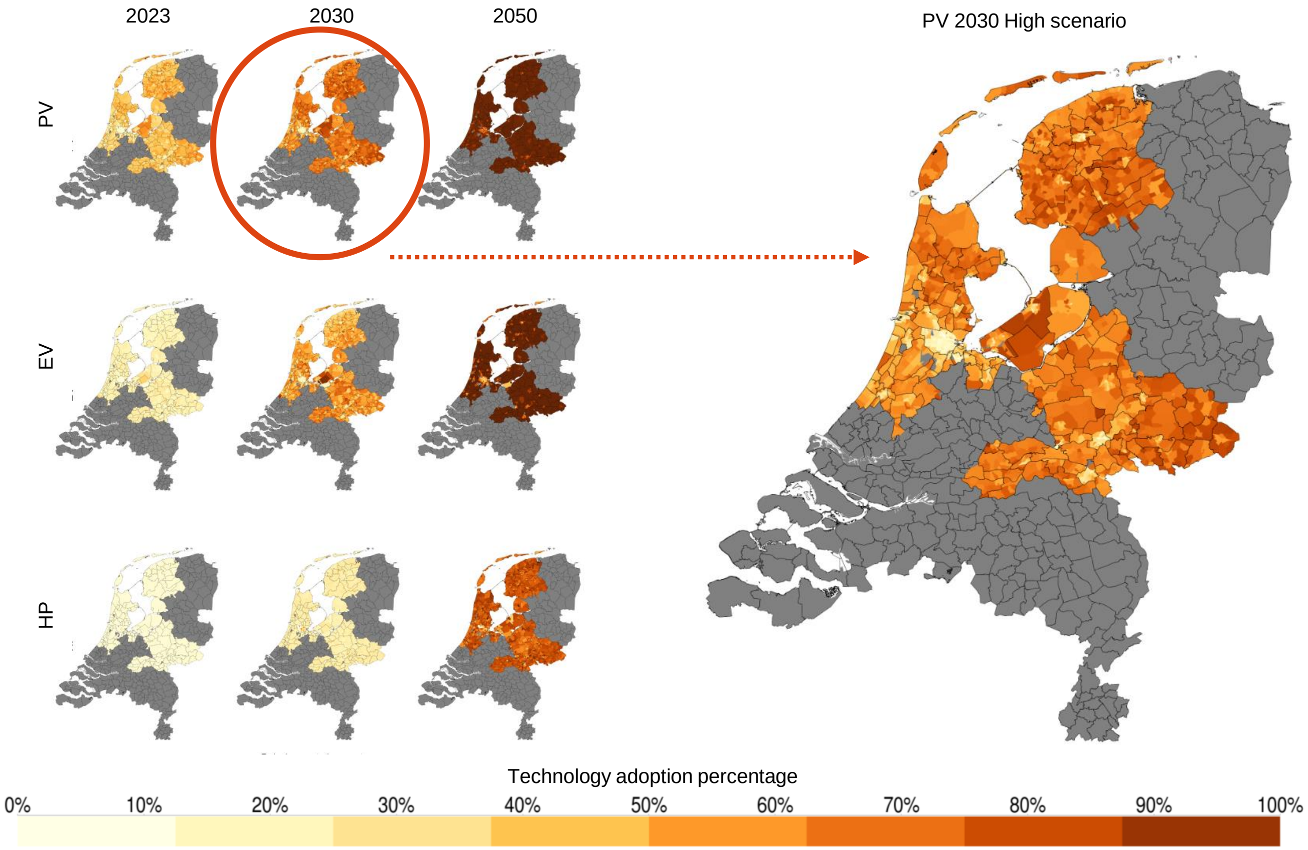
Output: The adoption is predicted at zip-code level per technology up to 2050

- The result is an absolute number of EVs, HPs, and PV systems per zip code for every year.

Local adoption for each household…

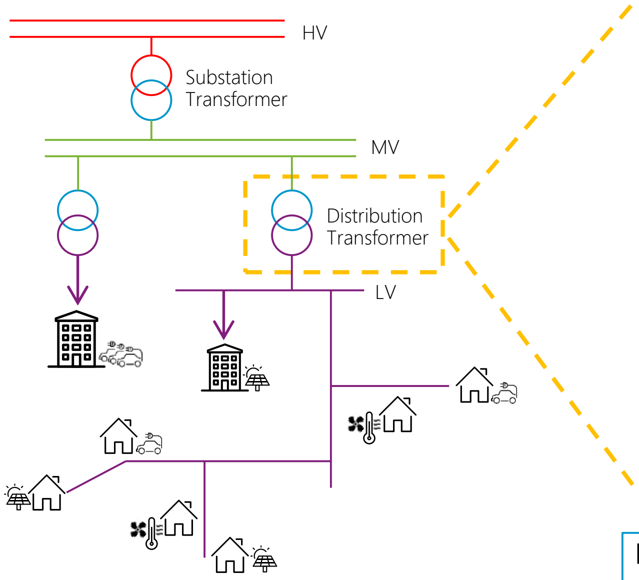
…in the Liander Service Area

Geographic representation of the technology adoption

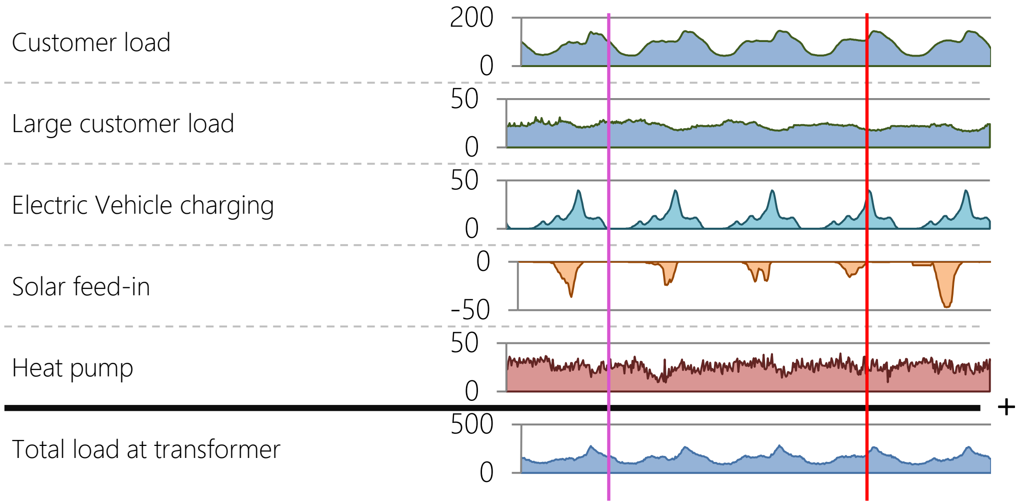


An example of determining network overload

Sample power grid



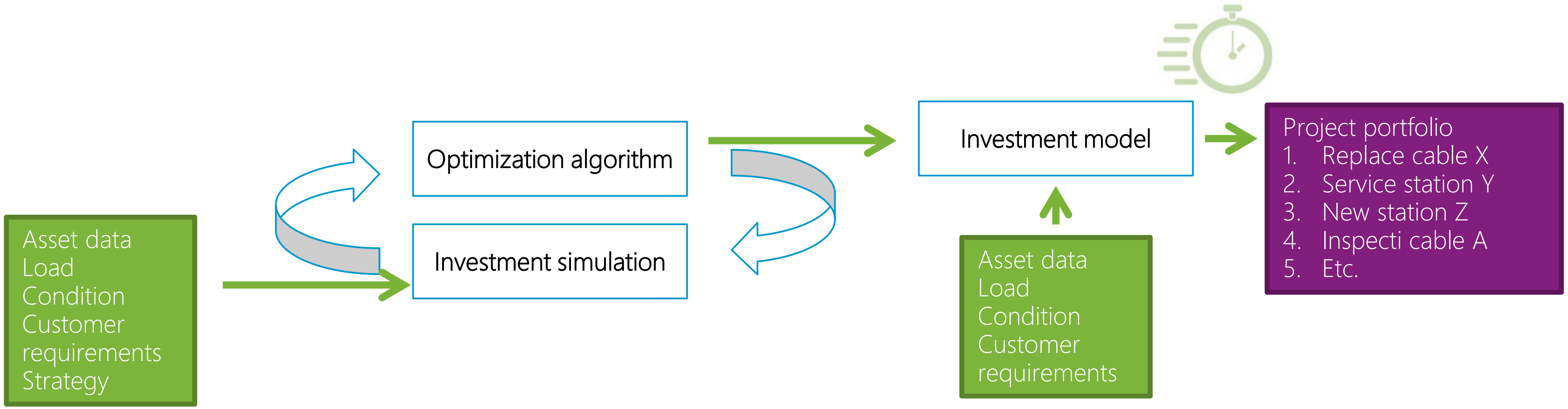
Load profile calculation



Based on the analytical model with approximately 250 billion data points peak loads per asset are determined

In development: INP AI

Portfolio Optimization System



Content by Matthijs Danes and Willem van Doesburg

Case II: Real time Control

Case II: Buurtbatterij

Algorithm design goal priority

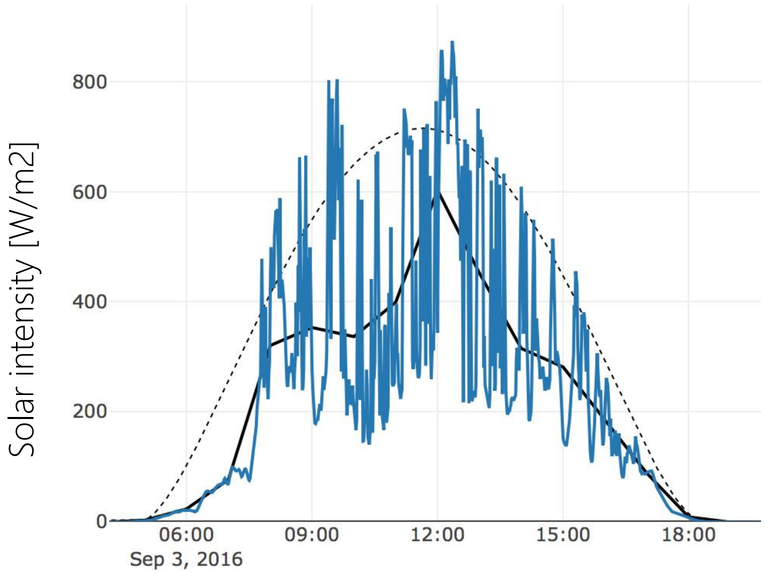
Predicting solar power generation

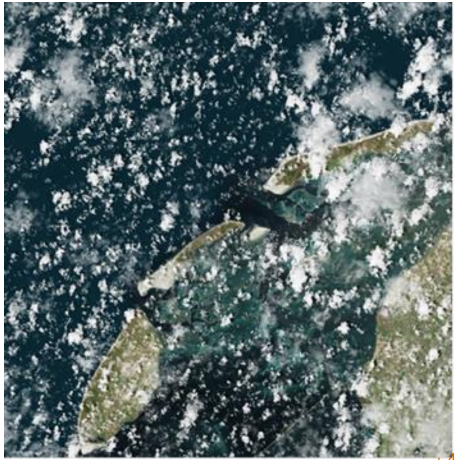
State-of-the-art

Resolution of KNMI model:
- Time : ~1 hour
- Spatial resolution : ~2 km

Results Research WUR & Alliander

Variability:
- Time: 15 minutes
- Spatial resolution: 100 m



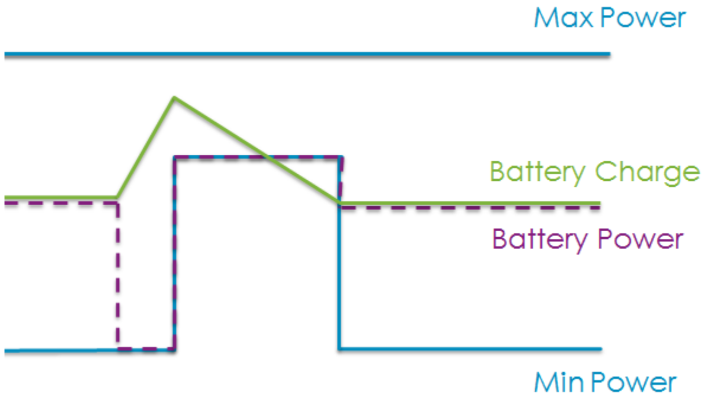


Content by Frank Kreuwel

Determining the optimal charge path

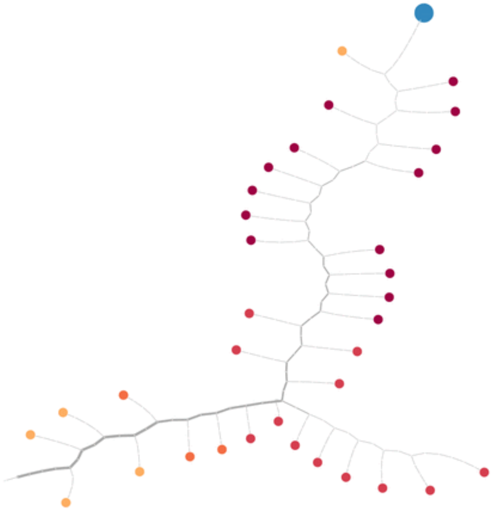
Optimization problem formulation:

$$\begin{aligned} \underset{P}{\text{minimize}} \quad & \sum_{t=1}^{N} |E - E_{\text{ref}}| \\ \text{subject to} \quad & P_{\min} \leq P \leq P_{\max} \\ & 0 \leq E_t \leq E_{\max,t} \\ & U_{\min} \leq U_{k,t} \leq U_{\max} \\ & I_{\min} \leq I_{l,t} \leq I_{\max} \end{aligned}$$

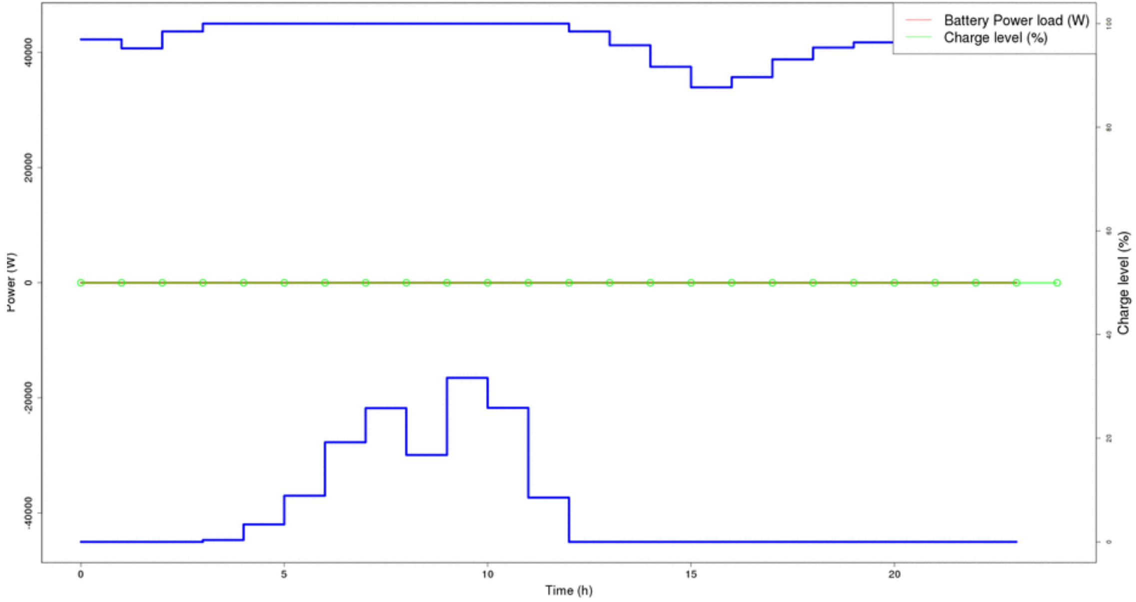


Buurtbatterij real time control

Network load and voltages at 8:00



Battery charge path and charge level at 8:00

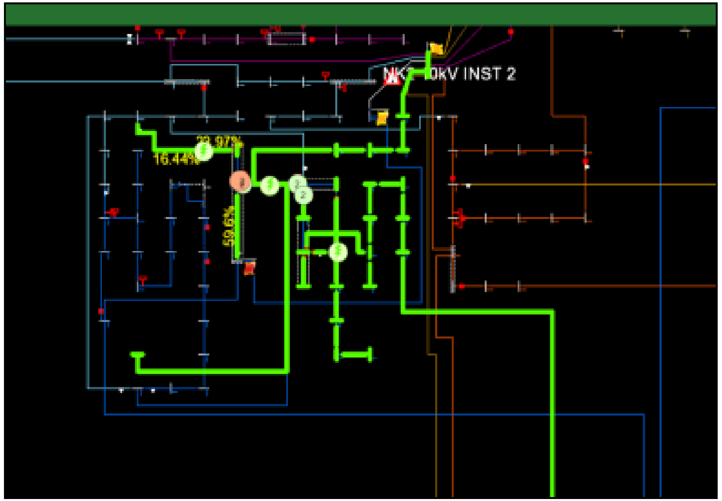


Final remarks

New insights warrant new decisions

Dilemma I: Is everybody equal or are some more equal than others?

Dilemma II: Lower CO2 emissions or more reliability?



Final remarks

- Feel free to contact me for:
  - Model/data exchange
  - Co-authorship

- Werner.van.Westering@Alliander.com