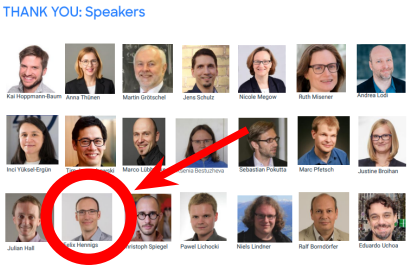
DOING THE MATH

Dimension Local Energy Hubs to Reduce Grid Congestion

Felix Hennings

Computational Optimization at Work 2024

About me



...and many more!

- I'm a local!
- Did my PhD at ZIB in the Energy group on optimising gas network control (see CO@Work 2020 videos)
- Work since 2023 as Optimisation Modelling Consultant at Doing The Math (DTM)

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About DTM

- Small consulting company founded in 2019
- Support organisations in improving their decision-making and achieving their sustainability goals
- Main sectors: Energy and supply chain
- Full-remote, members work from all over the EU
- Relatively large number of student assistants

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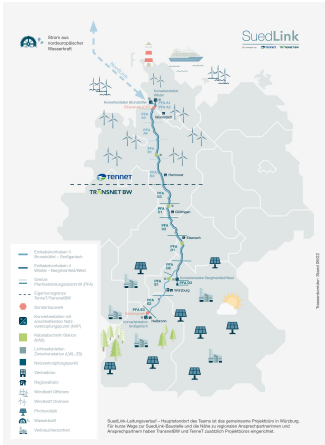
Grid Congestion Problems (1)

- Increasing usage of electricity in the energy transition
  - Electrification of transport 
  - Electrification of residential heating 
  - Electrification of industrial processes 
- Decentral and location-dependent energy generation 

Grid Congestion Problems (2)

- Electricity grids need extensions to avoid congestion!
- Example: the German SuedLink



https://www.tennet.eu/de/news/alle-suedlink-abschnitte-der-genehmigung-transnetbw-reicht-letzte-planfeststellungsunterlagen

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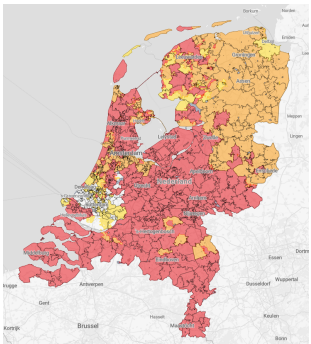
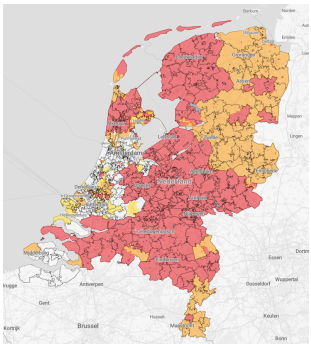
Grid Congestion Problems (3)

- The Dutch perspective on new connection capacity



Demand connections



Generation connections

- Free capacity
- Limited capacity
- Congestion measures
- No capacity

Congestion will occur for at least 10 more years!

https://capaciteitskaart.netbeheernederland.nl/

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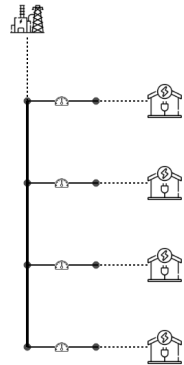
Local Energy Hubs

- Short-term solution: Collaborate in local Energy Hubs
- Industry parks or small residential areas



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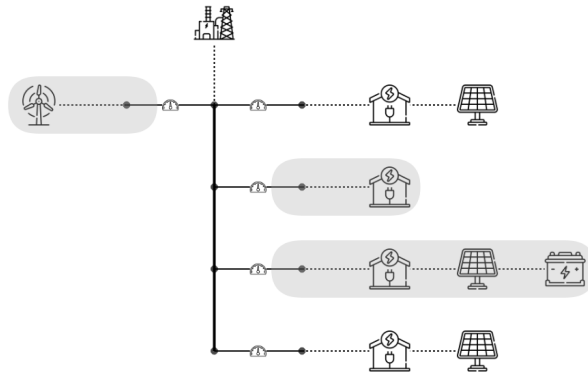
Local Energy Hubs

- Short-term solution: Collaborate in local Energy Hubs
- Industry parks or small residential areas
- Possible measures
  - Invest in individual renewable generation
  - Invest in shared assets, like a large battery or a wind turbine
  - Form a Collective for sharing contractual capacity



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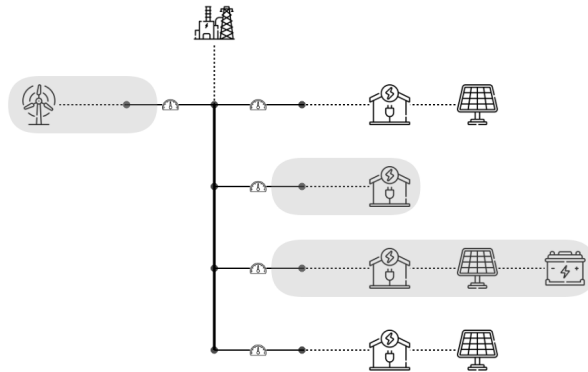
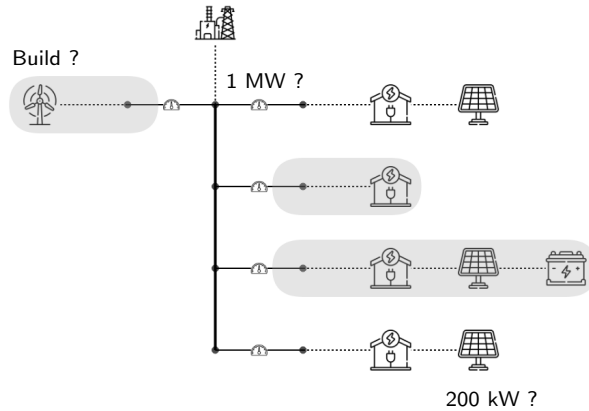
Problem: How to Dimension Energy Hubs?

- Cooperation with Firan
  - Subcompany of the Dutch network operator Liander



Problem: How to Dimension Energy Hubs?

- Cooperation with Firan
  - Subcompany of the Dutch network operator Liander
- Key questions to answer
  - Which assets should be added or extended?
  - What is the capacity of the new/extended assets, s.t. forecasted future energy demands are met?
  - What contract sizes are required?



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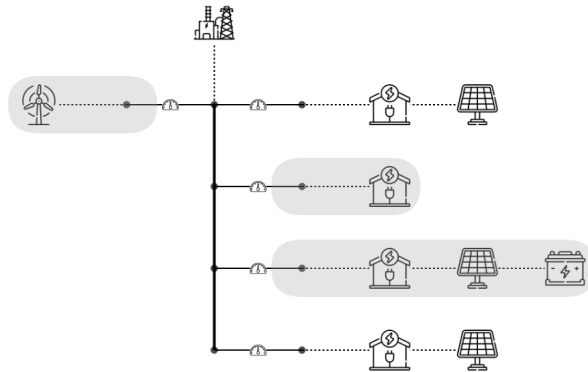
Modelling Basics

- Linear power flow model, cable losses as fixed %, no voltages
- Given forecasted future demand at companies
- Variable capacity at renewable generators, batteries, etc.
- Capacities scale the generation, storage capacity, etc.
- Shared contractual capacity in a collective



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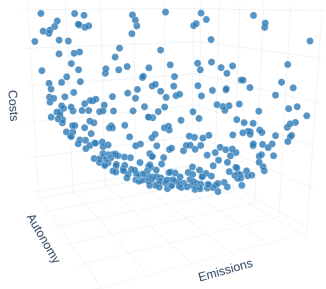
Advanced Modelling and Algorithms

- Multiple competing objectives
- Multi-scenarios analysis
- Different energy carriers
- Piece-wise linear efficiency definitions



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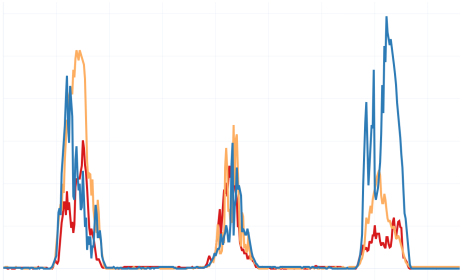

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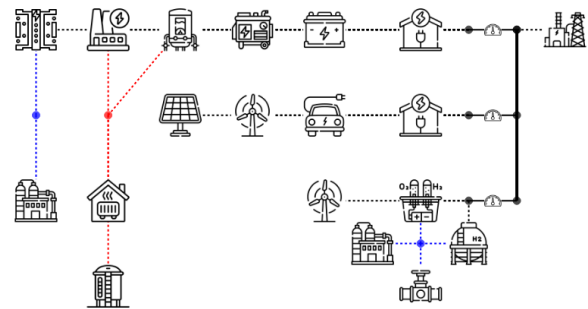

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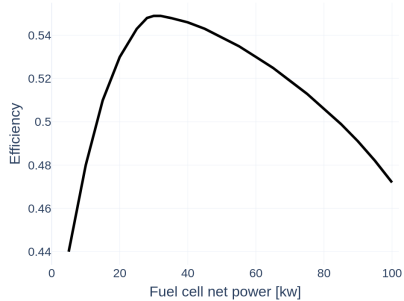

based on "Research on Energy Management Method of Fuel Cell/Supercapacitor Hybrid Trams Based on Optimal Hydrogen Consumption", Bu et al., 2023, https://doi.org/10.3390/su151411234

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Model Complexity

Main problem: The large time dimension

- The goal is to decide on capacity values for the assets
- Need to take into account the demand/generation development over the next 2-10 years

Weltzeituhr Berlin, photographer: Andreas Steinhoff

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Model Complexity

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- Simple aggregation to larger time steps would relax the peaks and lead to too-small capacity values

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- 15-minute granularity $\Rightarrow$ 35040 time points/year $\Rightarrow$ 70-350k time points

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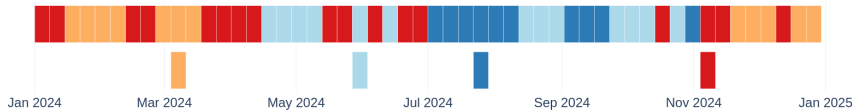
Solution Strategies

Main goal: Find a smaller time representation

- Use typical periods as time approximation for capacity decisions
- Verify them on the full horizon using a rolling horizon approach



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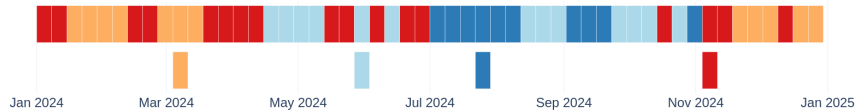

- Stress periods may be underrepresented
- Iteratively add stress periods to the time approximation

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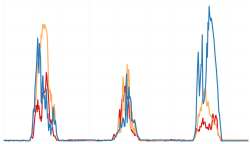
Mathematical Optimisation in Practice

- Data preparation
  - Input data generation, e.g.,
    weather forecasts, EV charging demands
  - Group equivalent categories, e.g., cost
  - Infeasibility/slack analysis



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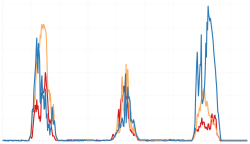
  - Sensitivity analysis (what-if)



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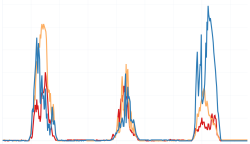

Effort is often larger than for solving the mathematical problem!

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The Last Slide

Questions?

Find out more about our work at `doingthemath.nl`

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