Multi Energy Systems (MES)

Investigating Hidden Flexibilities Provided by Power-to-X Converters Considering Grid Support Strategies

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Research Problem

- With increasing share of renewable energy, power balance became more challenging for grid operators
- Due to approximations made in model formulations, flexibilities provided by MES components to network can be concealed in the simulation results (hidden flexibility)
- Inaccurate flexibility analysis of P2X may lead to increased transmission losses, higher operational cost or misinterpretation of MES capacity.
- Existing hierarchical management of MES models not considers operational cost of production. This results with unnecessary trading of electricity and increse in operational cost.

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Flexibility

”In this project, flexibility defined as the amount of consumed energy that is provided by changing the consumed power state of P2X by controlling the output product flow rates.”

” Changing the storage tank set values, when the flexibility is “on”, will accelerate the electrical power consumption of P2G and P2H to nominal values or to a specific power state coming from CEMS.”

Research Questions

- What options exist for minimizing curtailment of renewables in MES?
  - Which options are available in Port of Rotterdam?
  - Which option provides the highest amount of flexibility?
  - Which combination of MES is the most cost-effective one?

- How much the model detail impact the amount of flexibility provided?
  - What should be the detail of a model for desired MES analysis?
  - What is the amount of flexibility provided by detail of electrolyser model?
  - What is the amount of flexibility provided by detail of heat pump model?

- How can different energy domains can be combined and optimized for flexibility?
  - What should be the control architecture of MES?
  - How should be the optimization algorithm in order to reduce operational cost during flexibility provision?
  - What are the dependencies between flexible load pairs?

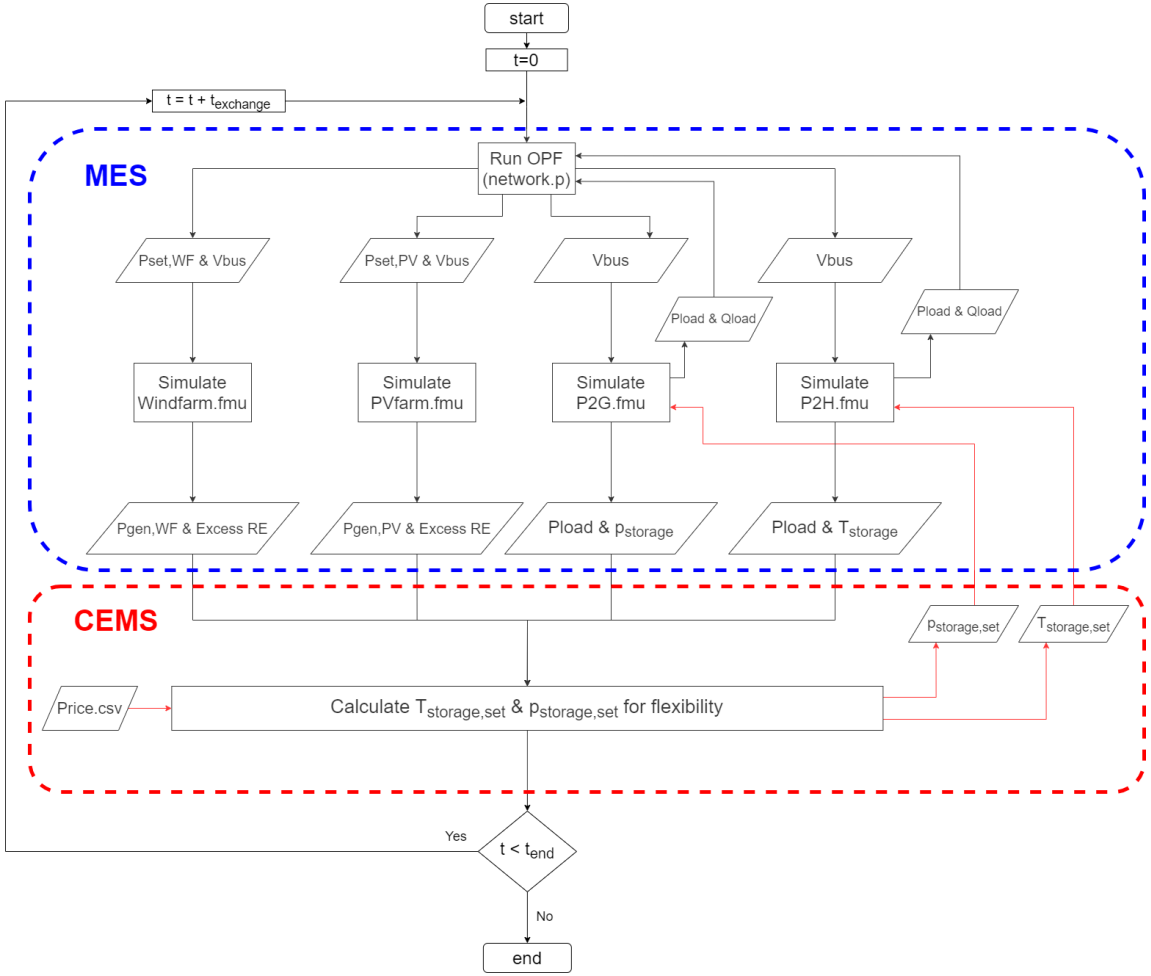
Methodology – Tools

1. OpenModelica
   - For fast simulation of complex dynamics from different energy domains

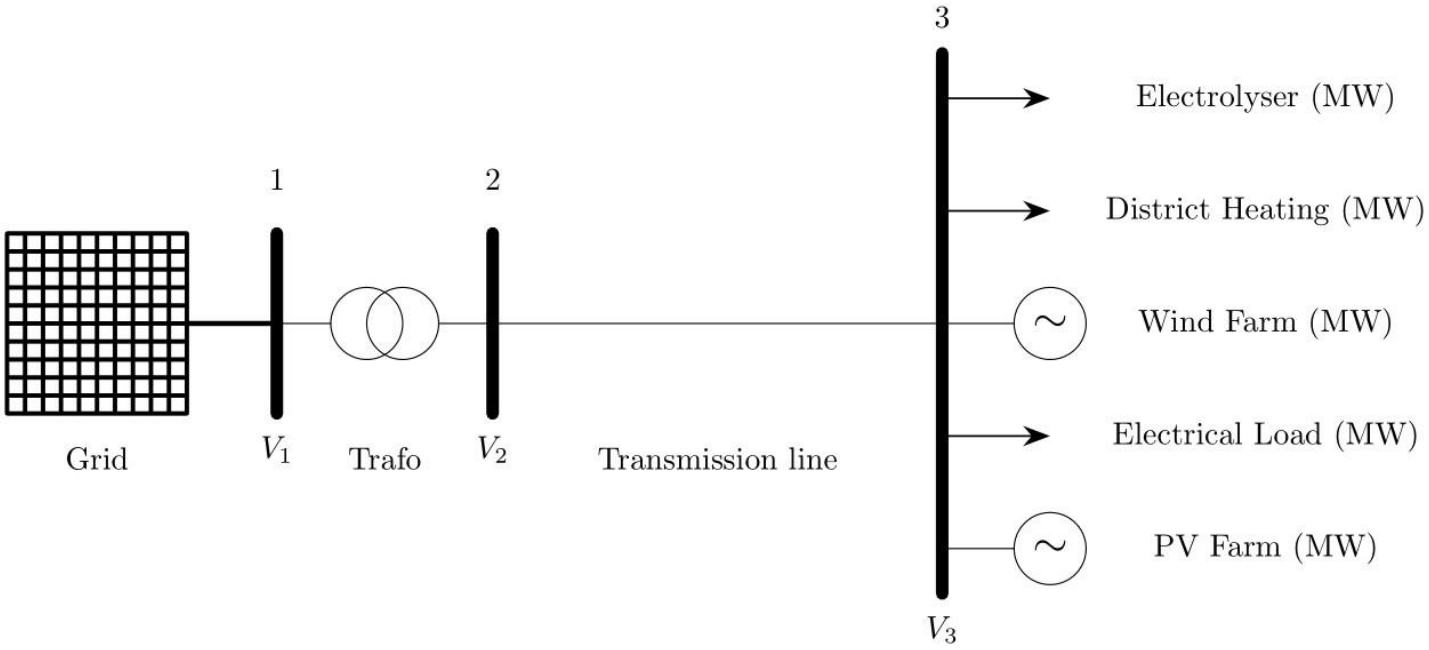
2. Pandapower
   - To initialize OM models

3. Energysim (Co-simulation)
   - To implement hierarchical control, reduce computational burden and couple different energy domains.

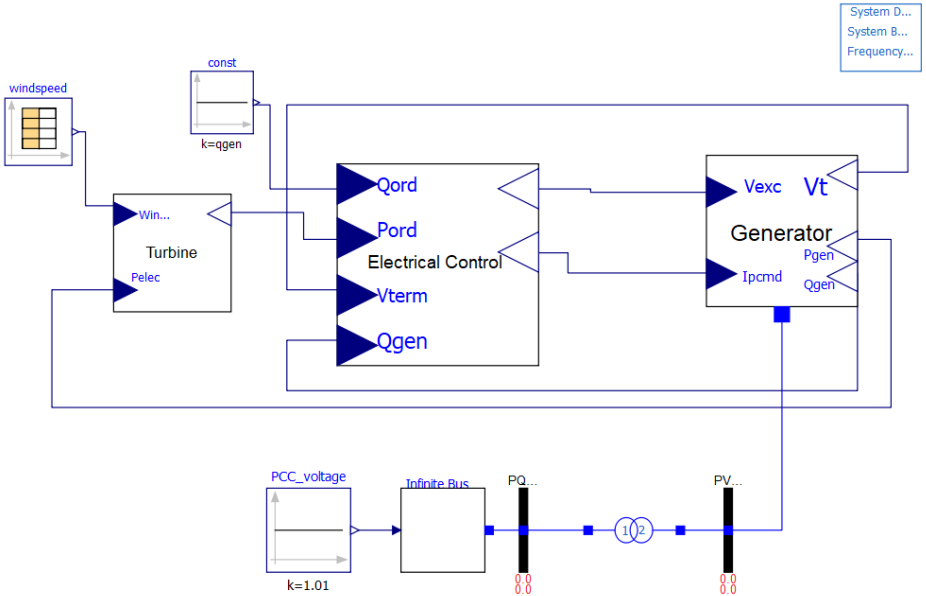
Methodology – Hierarchical Control



Methodology – Maasvlakte Energy Park

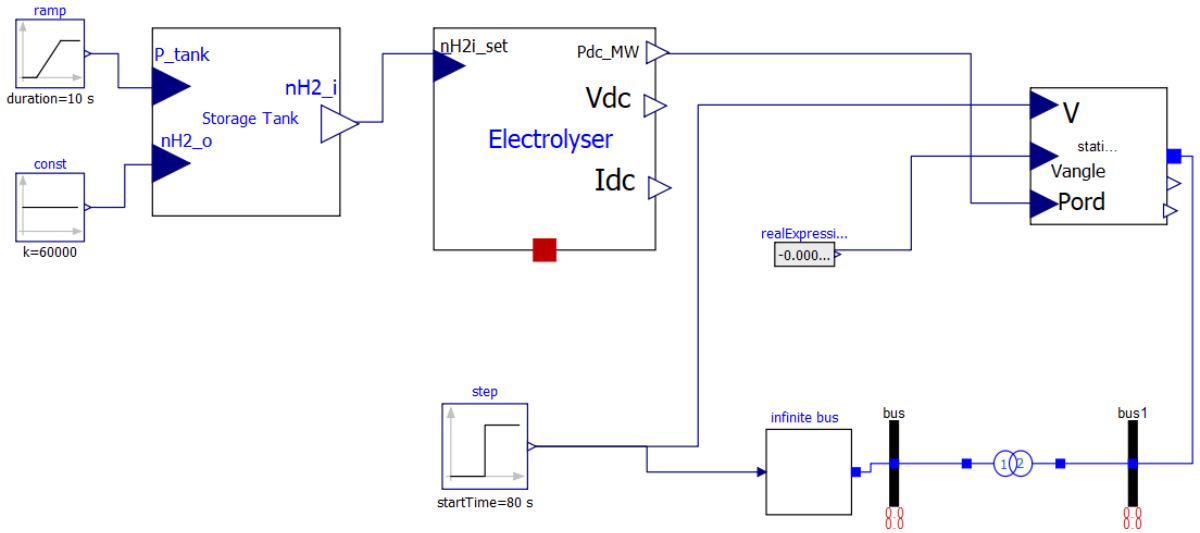


Modelling – Wind Turbine Generator



- Turbine, converts mechanical power from wind into AC power order
- Control, commands the active and reactive power generated
- Generator, provides interface between the controller and network

Modelling – P2G



- Storage, calculates input hydrogen molar flow rate from demand flow rate and pressure
- Electrolyser, calculates DC power consumed
- StaticGenerator, provides interface and controls Qload

Cases

First case:
To determine the holding duration for providing flexibility, plot the “active power demand/generation at bus3 vs. time” without any flexibility. Plot the same figure in all cases in order to investigate the effect of flexibility on active power balance.

Second case:
To investigate the hidden flexibilities, compare the amount of flexibility provided at nominal power set value for different Electrolyser models for same holding time decided in case 1. Do the same for heat pump model.

Third case:
To investigate the effect of hierarchical control on flexibility, add community energy management system to the combined (P2H & P2G) system and measure the amount of flexibility for P2G & P2H.

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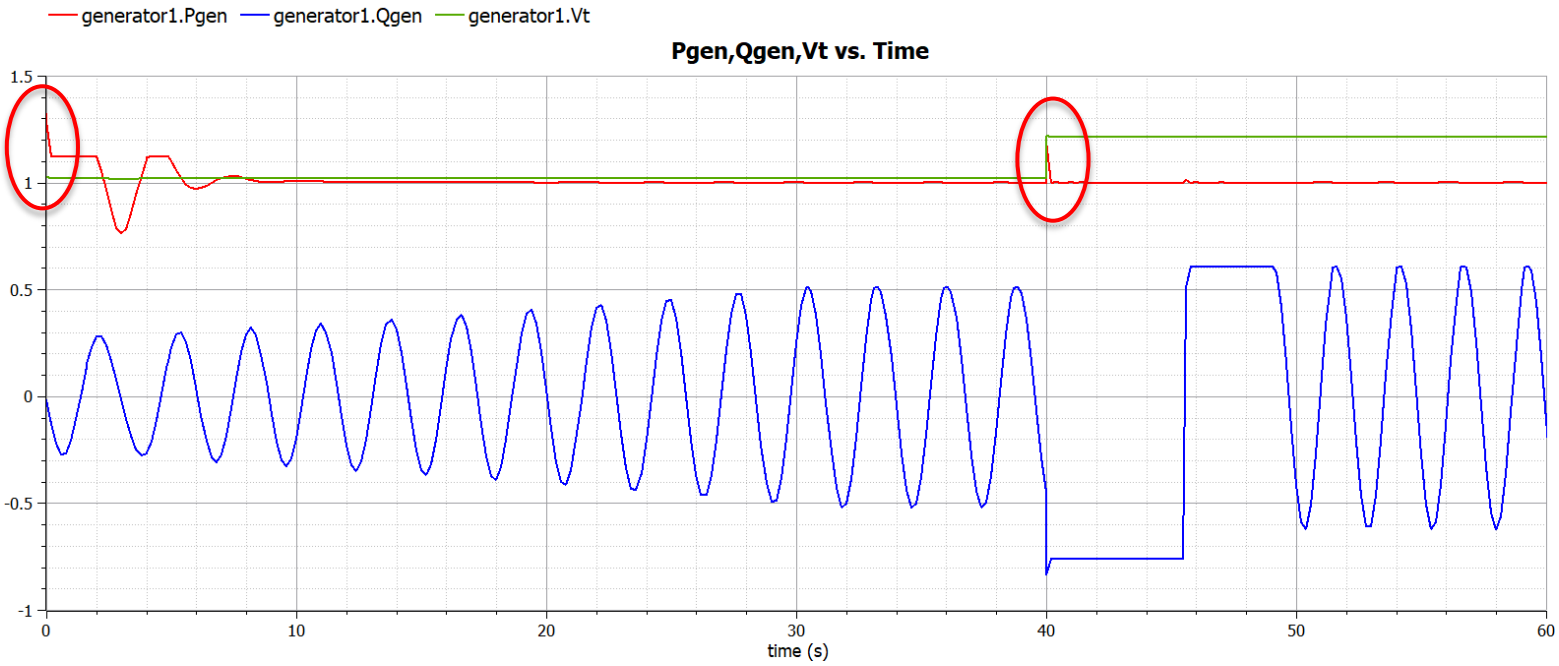
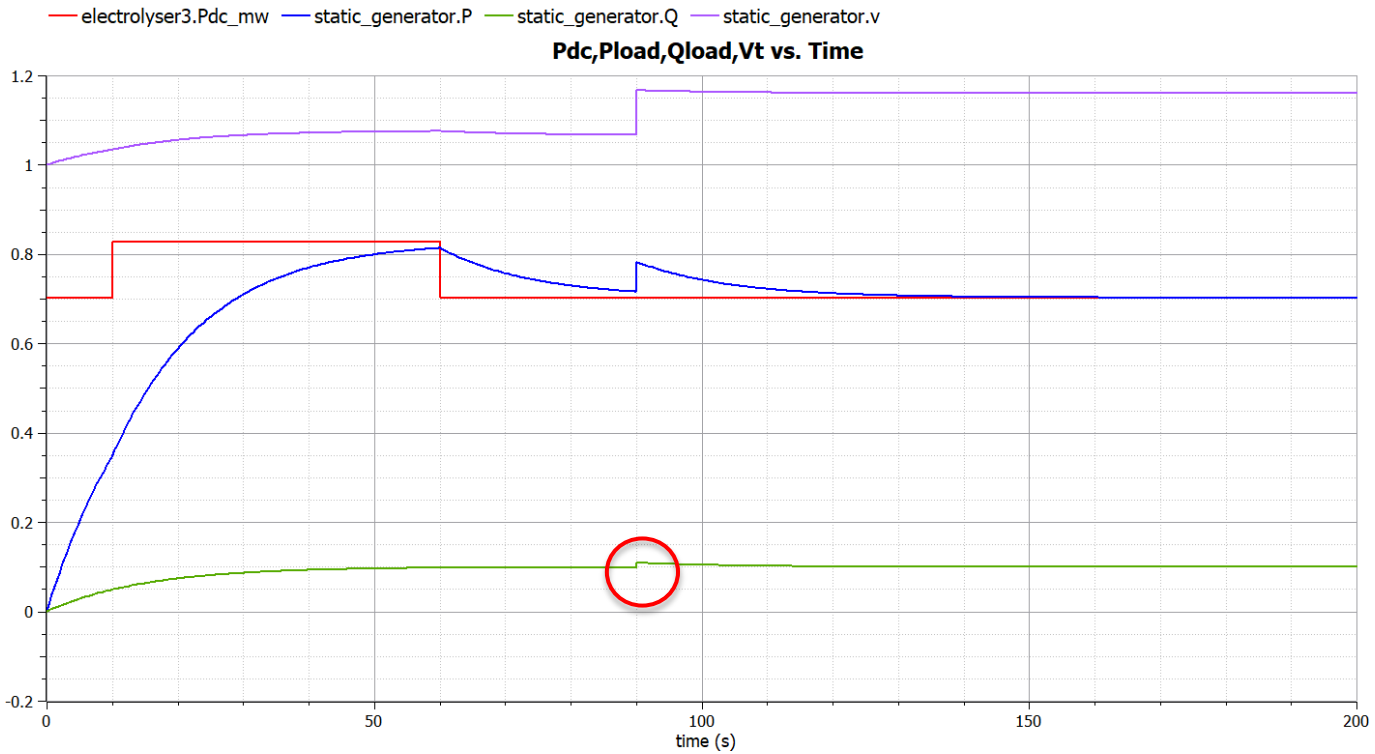
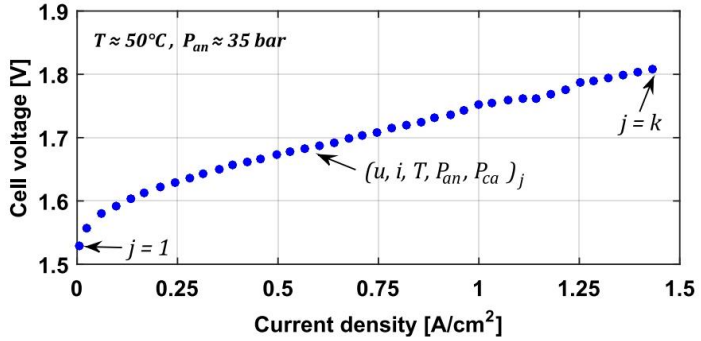
Initial Results - WTG

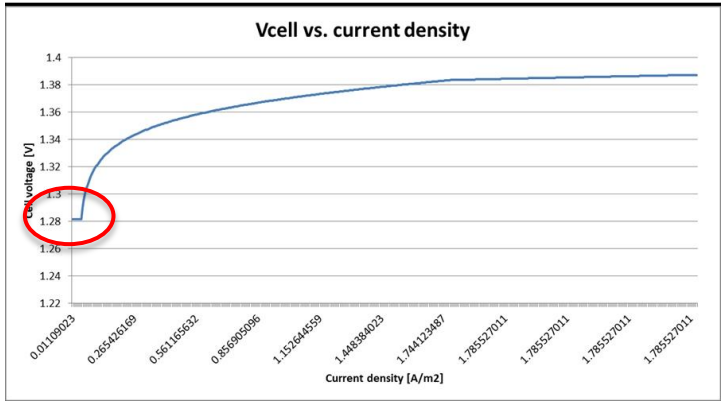


Initial Results – P2G



Initial Results - Electrolyser





Future Plans

1) Finalize PV farm.fmu and P2H.fmu models
2) Combine models in Energysim and create CEMS
3) Create input datasets for demand
4) Add more losses and ambient temperature connector “heatport”
5) Improve resolution of weather data

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Version Control: https://github.com/caneryagci/Multi-Energy-Systems-Thesis-Project.git

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