

*Contributing towards identifying feasible, effective and economical solutions,  
focusing both on system layout and operation/control of Positive Energy Districts (PEDs)*

Javier Arroyo

Expert meeting IEA HPT Annex 61

January 30<sup>th</sup>, 2023

# Outline

- Motivation
- Goals
- Team
- Progress

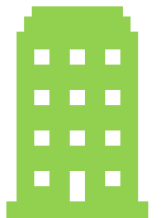
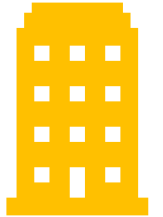
# Motivation

# Motivation

- 29% of global energy-related emissions from Buildings in 2019
- To achieve Net-Zero carbon building stock by 2050
- 60% decline in energy-related emissions from buildings required (IEA)



*Toward Positive Energy Districts (PEDs)*



# Goals

# Goals

- **TECHPED** = Technically feasible positive energy districts
- A fundamental research project (C2) managed by KU Leuven and EnergyVille
- Runs for 4 years (Oct 2021 – Oct 2025)
- Project proposal, in a nutshell:

*How to develop scientifically-backed and technically feasible  
“Positive Energy Districts” within cities?*

# Goals



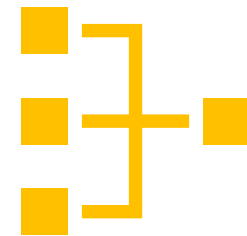
**Modeling  
approaches**



**Advanced  
control**



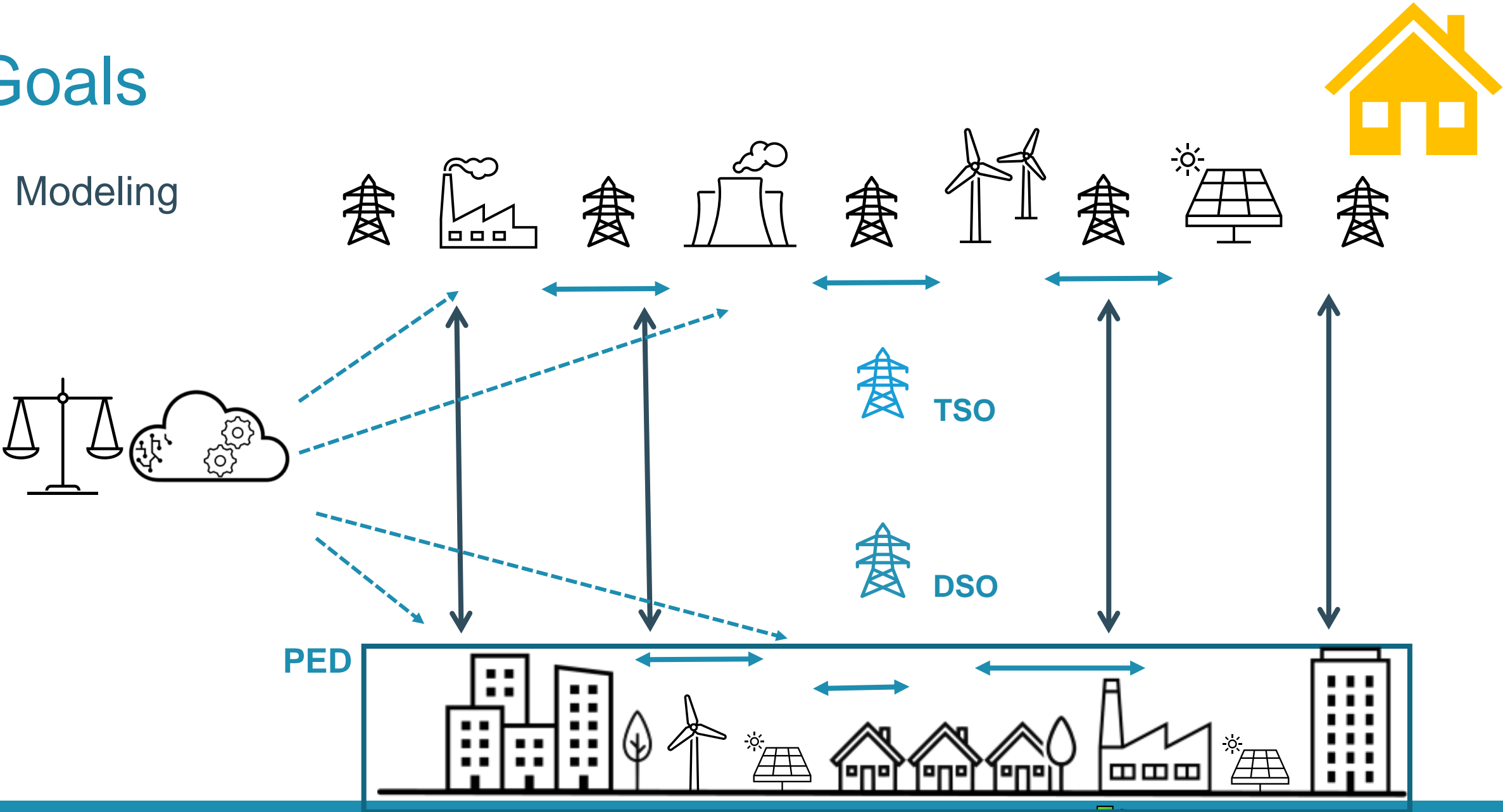
**Incentive  
framework**



**Integrated  
concepts**

# Goals

- Modeling



# Goals



- Advanced control
  - For the operation under uncertainty
  - To optimally use the data
  - Aiming for the combination of control paradigms
    - Model predictive control
    - Reinforcement learning



# Goals

- Incentive framework
  - Investigate peer-to-peer trading strategies
  - In the context of multiple energy carriers
  - Volumetric vs capacity tariffs



**Heat carrier**



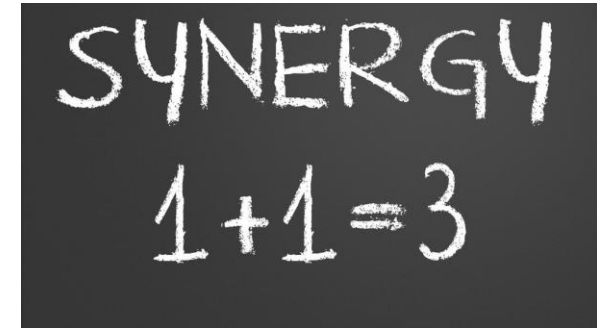
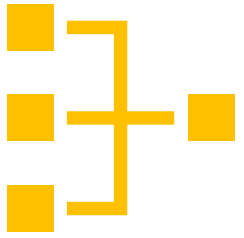
**Electricity carrier**



**Gas carrier**

# Goals

- Integrated concepts
  - Integrated modeling framework
  - Subject to automated testing
  - Techno-economic analysis of collaborative settings



# Team

# Team



**Prof. Johan Driessen**  
*Electrical systems*



**Prof. Lieve Helsen**  
*Thermal systems*



**Prof. Geert Deconinck**  
*Smart grids*



**Prof. Erik Delarue**  
*Energy markets*



**Javier Arroyo**  
*Advanced building control*



**Lucas Verleyen**  
*Positive energy districts*



**Cas Bex**  
*Smart grids*



**Yucun Lu**  
*Energy markets*



**Joris Deportere**  
*Data science and AI*



**Louis Hermans**  
*Multi-energy vector districts*



**Muhammad Hafeez Saeed**  
*Control expert*



**Attila Bálint**  
*Data science and information technology*

# Progress

# Progress

- PED definition

Positive Energy Districts (PEDs) are clusters of buildings in well-defined geographical areas that generate an annual surplus of energy while fulfilling the needs of their occupants. They reduce energy-related climate impact, maximize energy efficiency, and offer flexibility services to the wider grid. PEDs support the integration of distributed renewable energy sources by using multi-energy carrier systems and energy storage

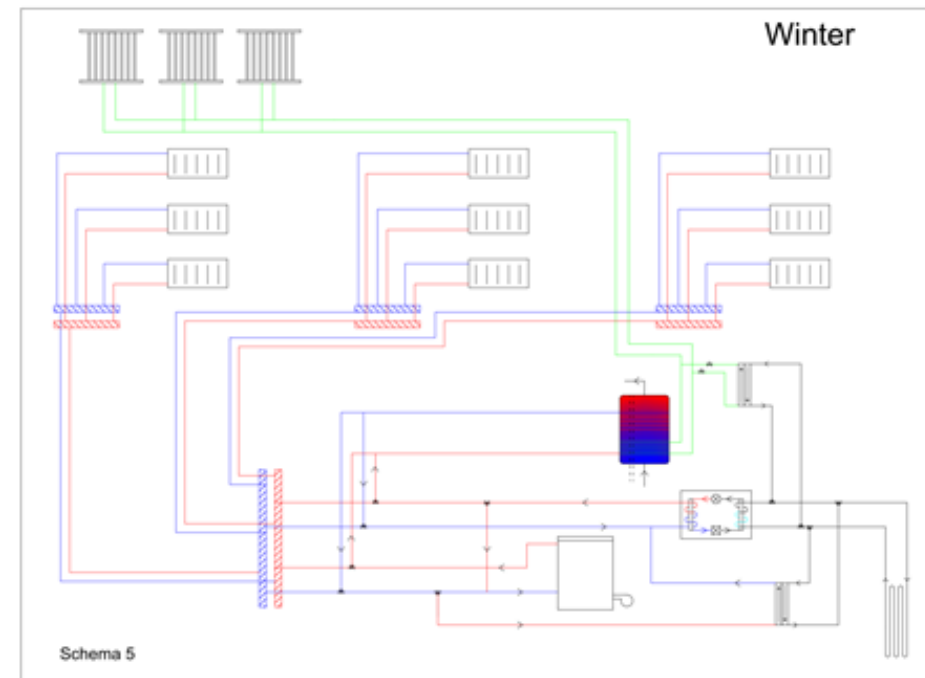
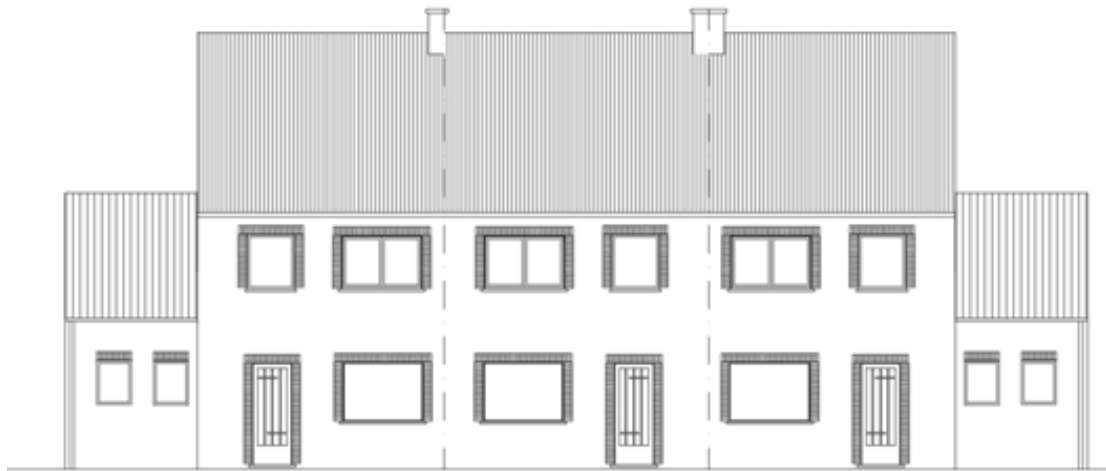
*(Definition established by the TECHPED Project Team)*

# Progress

- Terminology:
  - A **district use case** cluster of buildings without specifying a particular energy system. It is characterized by the district location, type of buildings (and thus occupancy), the number of buildings, and the wider grid market.
  - A **district layout** is a realization of a district use case with a selection of technologies for energy supply, storage, emission, and all (inter)connections between the technologies and the buildings.

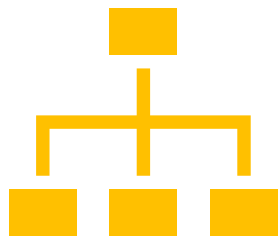
# Progress

- **The tiny cluster use case:** The preliminary idea was launched and pre-explored in combined student master thesis work of Ghent university and KU Leuven in 2020-2021-2022 (work of Gommers & Meessens & Van Regenmortel, supervised by prof Boydens & Helsen) and boosted to scientific level in our C2 project

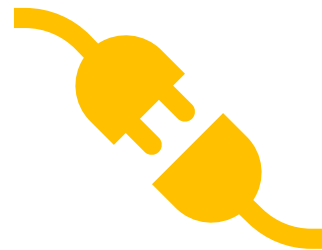


# Progress

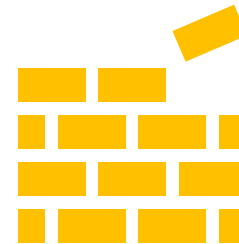
- Modeling



Object-oriented programming



Plug-and-play philosophy



Modular approach

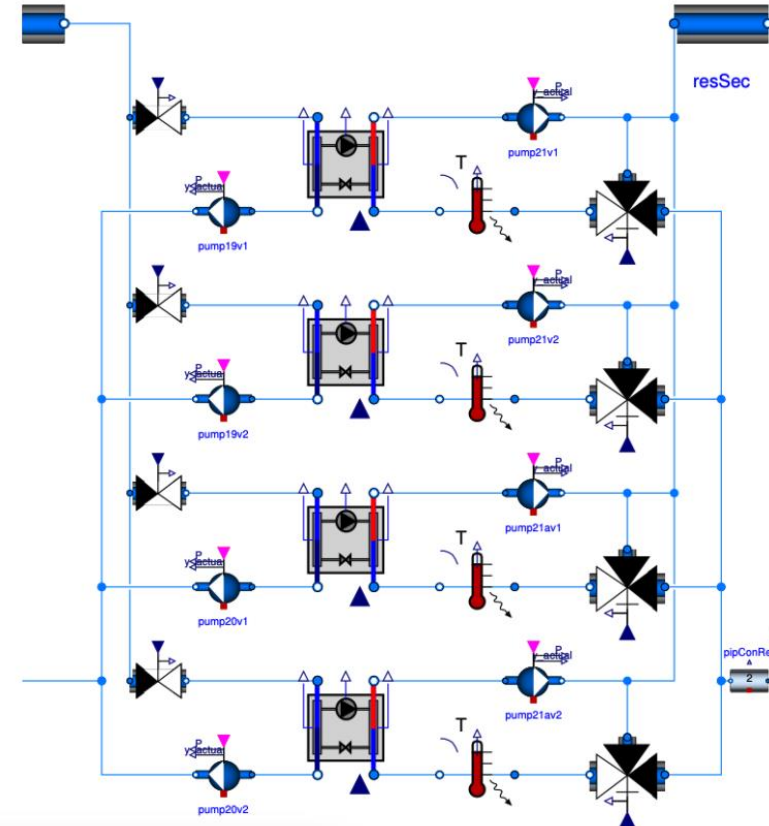
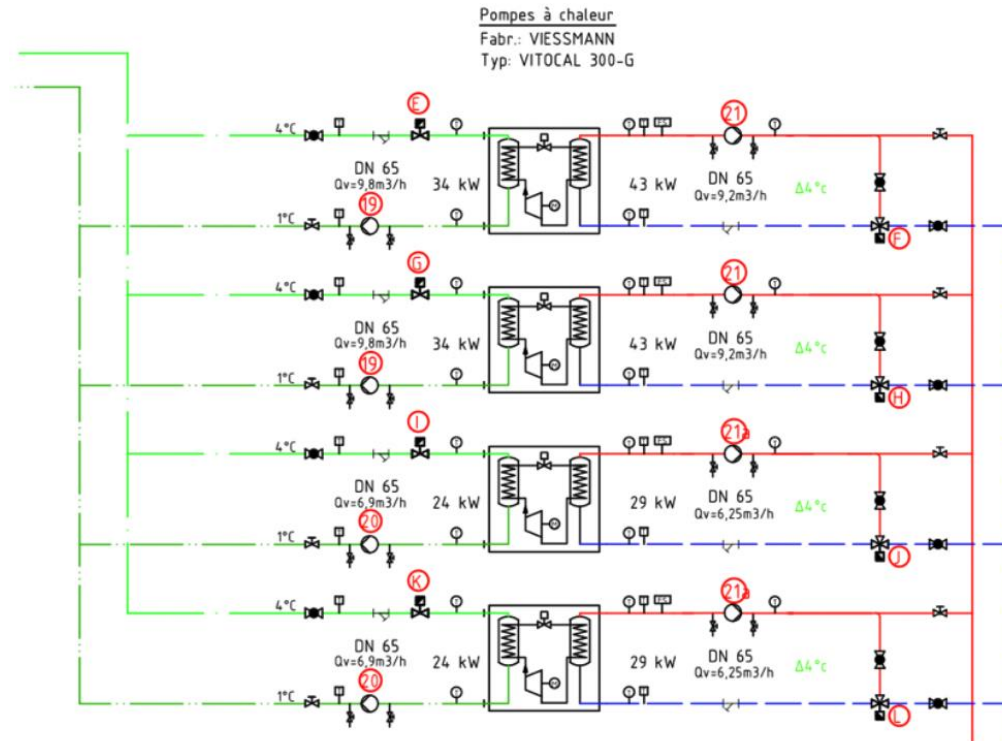


Vectorized approach



# Progress

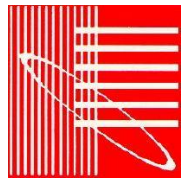
- One-to-one mapping between schematic and model



F. Jorissen et al. 14<sup>th</sup> Modelica Conference, Linköping, Sweden, 2021

# Progress

- **MoPED** = Models of positive energy districts
- Builds on top of:



IBPSA Modelica library



Modelica Buildings library



Modelica IDEAS library



# Progress

<https://gitlab.kuleuven.be/positive-energy-districts/moped>



Positive Energy Districts > MoPED

**M** MoPED Project ID: 7745

🔔 Unstar 1 🍴 Fork 6

📄 465 Commits 🌿 7 Branches 🏷️ 0 Tags 📦 74.5 MB Project Storage

Library of positive energy district models.

pipeline **passed**

Merge branch 'issue61\_extendGitignore' into 'main' e61b8b24   
Javier Arroyo authored 37 minutes ago

main ▾ moped / + ▾ Find file Web IDE 📄 Clone ▾

README LICENSE CI/CD configuration

Name	Last commit	Last update
MoPED	Merge branch 'main' into issue46_fix_AAHP_...	2 hours ago
bin	Add test-networks not makefile. Not added ...	1 month ago
.gitignore	Extend .gitignore	51 minutes ago
.gitlab-ci.yml	Switch back to specific gitlab runner.	1 week ago
README.md	Add pipeline status in README.md	1 month ago
license.md	Added license	8 months ago

- Agents
- Districts
- Electrical
- Networks
- Resources
- package.mo
- package.order

# Thank you!

## TECHPED

Technically feasible positive energy districts

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