Heat Roadmap Europe 2050
A low-carbon heating and cooling strategy

4DH
4th Generation District Heating Technologies and Systems

reINVEST

3RD INTERNATIONAL CONFERENCE ON

SMART ENERGY SYSTEMS AND 4TH GENERATION DISTRICT HEATING

COPENHAGEN, 12–13 SEPTEMBER 2017

AALBORG UNIVERSITY
DENMARK

Optimizing thermal energy storage in 4GDH

Bram van der Heijde
Annelies Vandermeulen
Dieter Patteeuw
Robbe Salenbien
Lieve Helsen

Novelties

- Framework for optimal TES integration
- Optimization model for DHC pipes
- Synthetic neighborhood heat loads

Context – EFRO-SALK GeoWatt Project

"Towards a Sustainable Energy Supply in Cities"

Research topics

- Optimal design
- Thermal network control
- Flexibility
- Geothermal energy
- Fault detection
- Building models

Common case

- City of Genk (B)

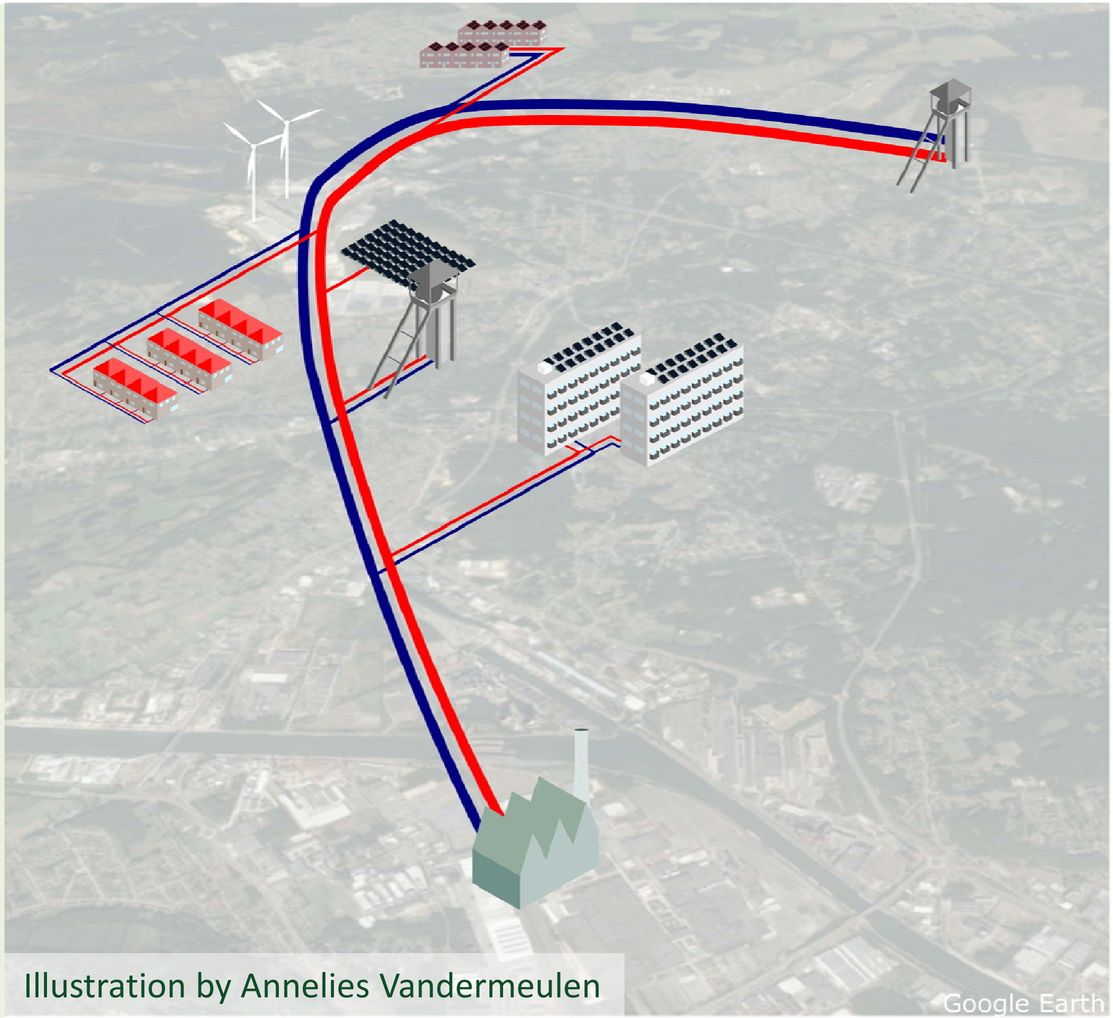
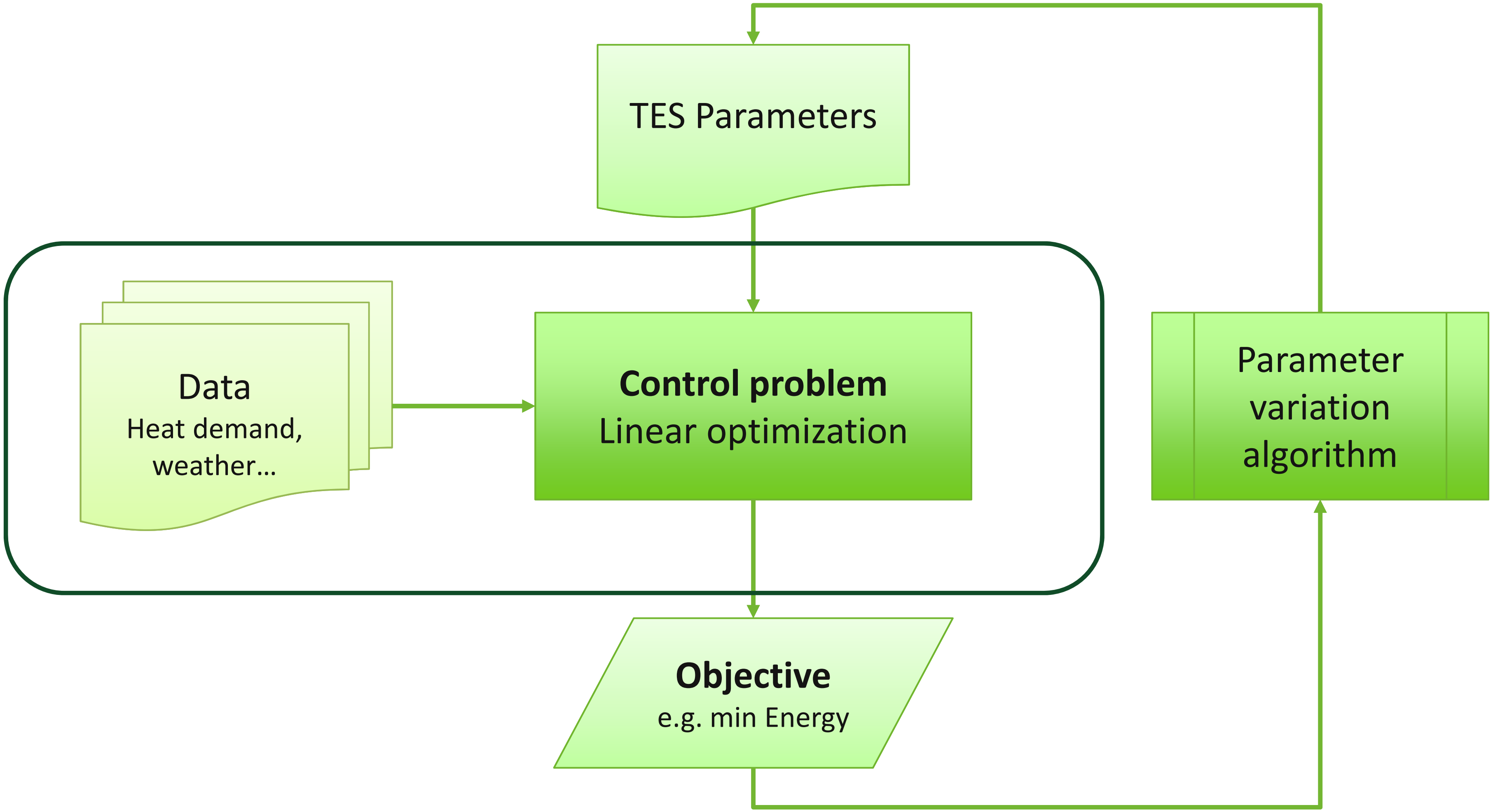


Illustration by Annelies Vandermeulen

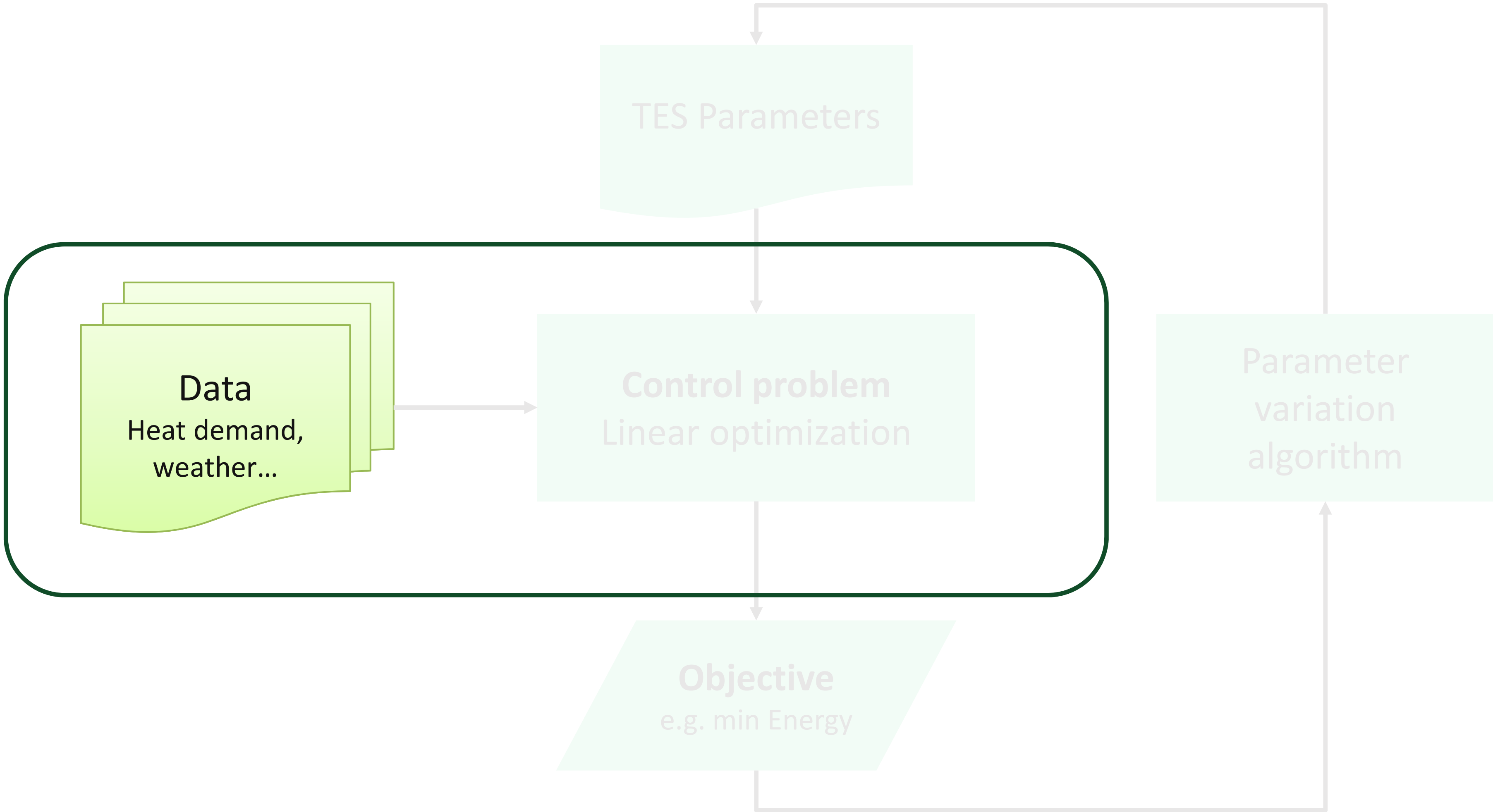
Aim & Objectives

- **FINAL:** Optimize storage size and location in 4DH
- This presentation:
  - Set up optimization framework
  - Model selection
  - Data collection

Framework


TES Parameters
Data
Heat demand,
weather…
Control problem
Linear optimization
Parameter
variation
algorithm
Objective
e.g. min Energy

Framework



TES Parameters
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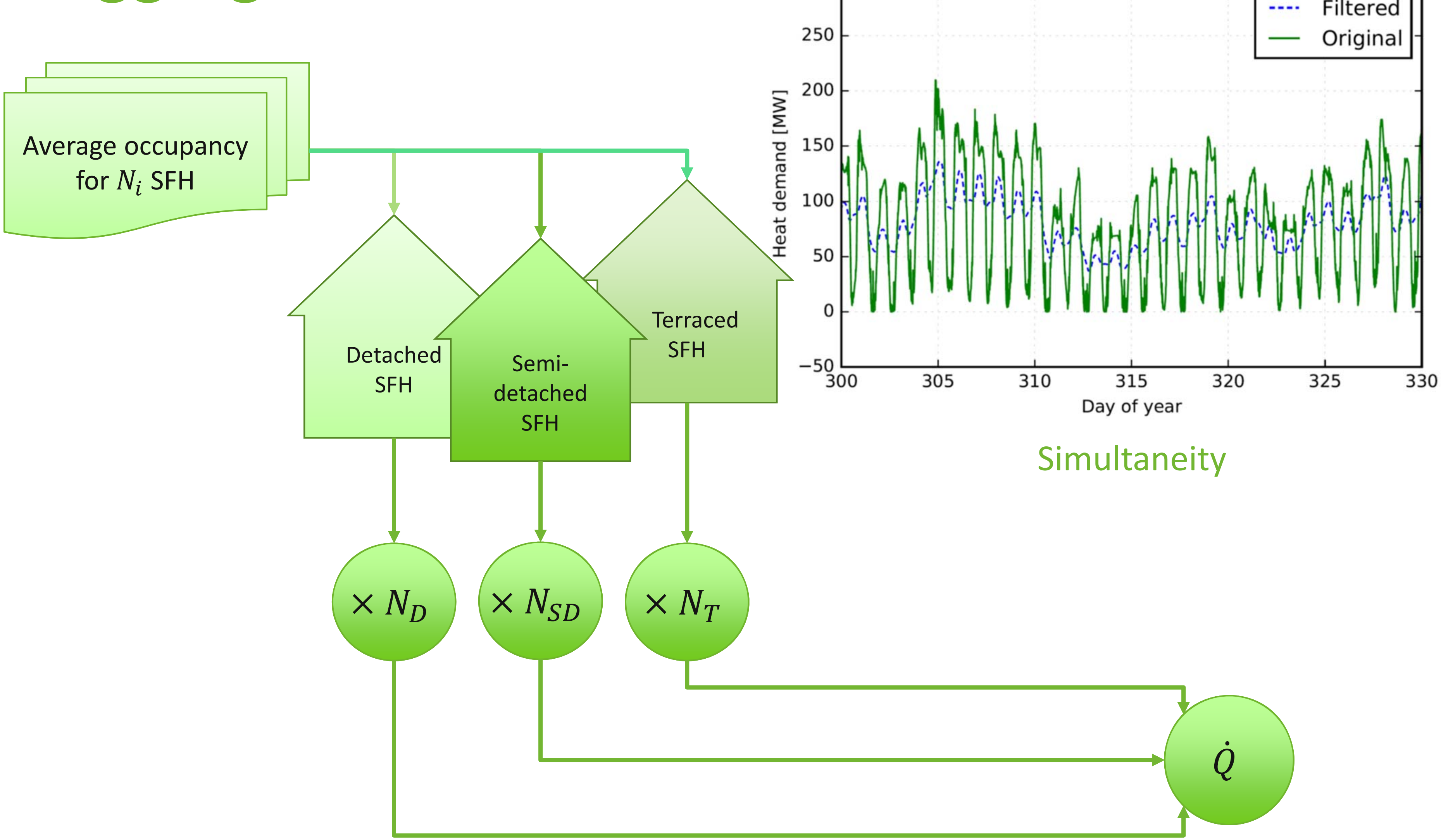
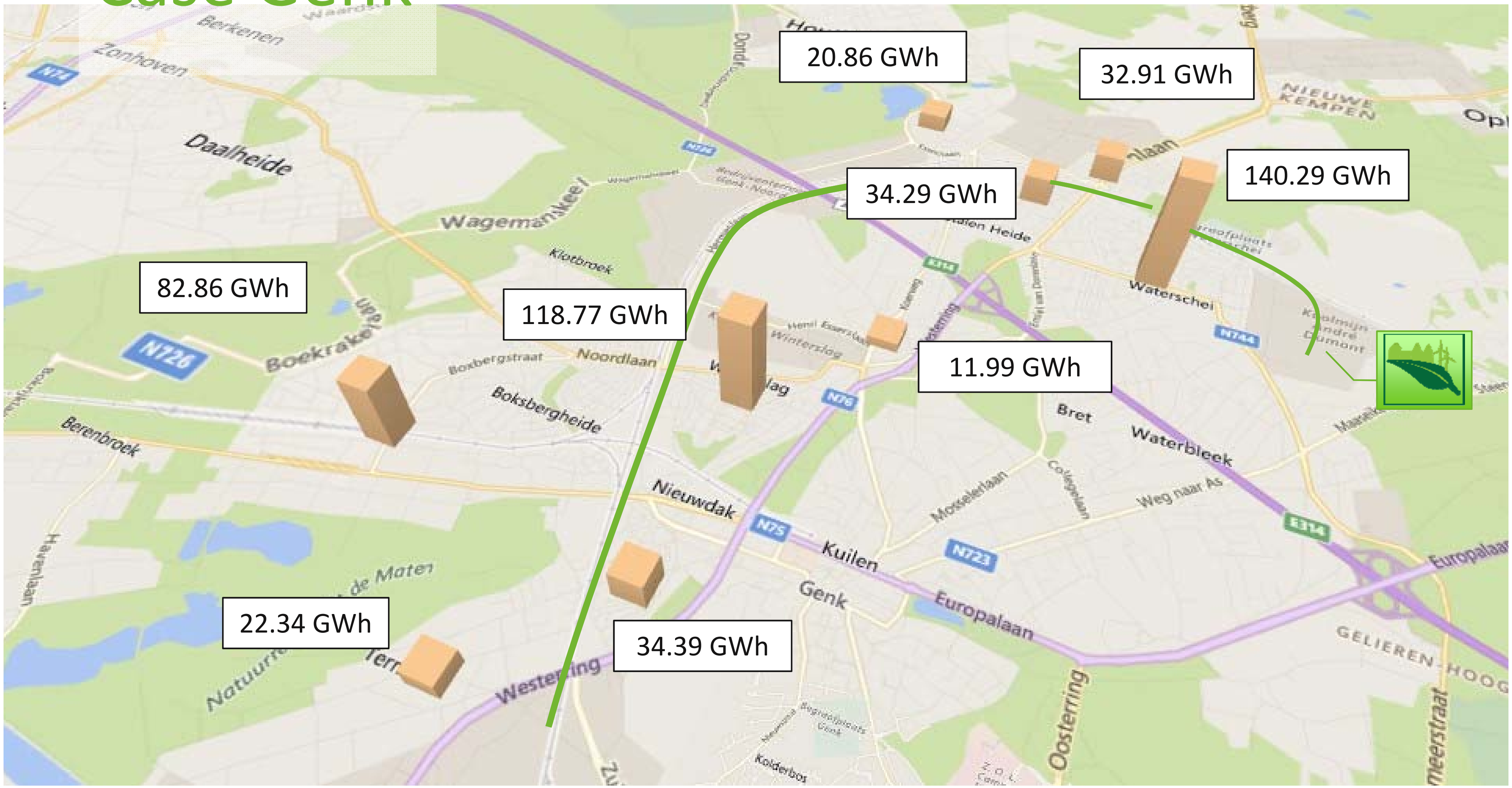
Aggregated heat demand



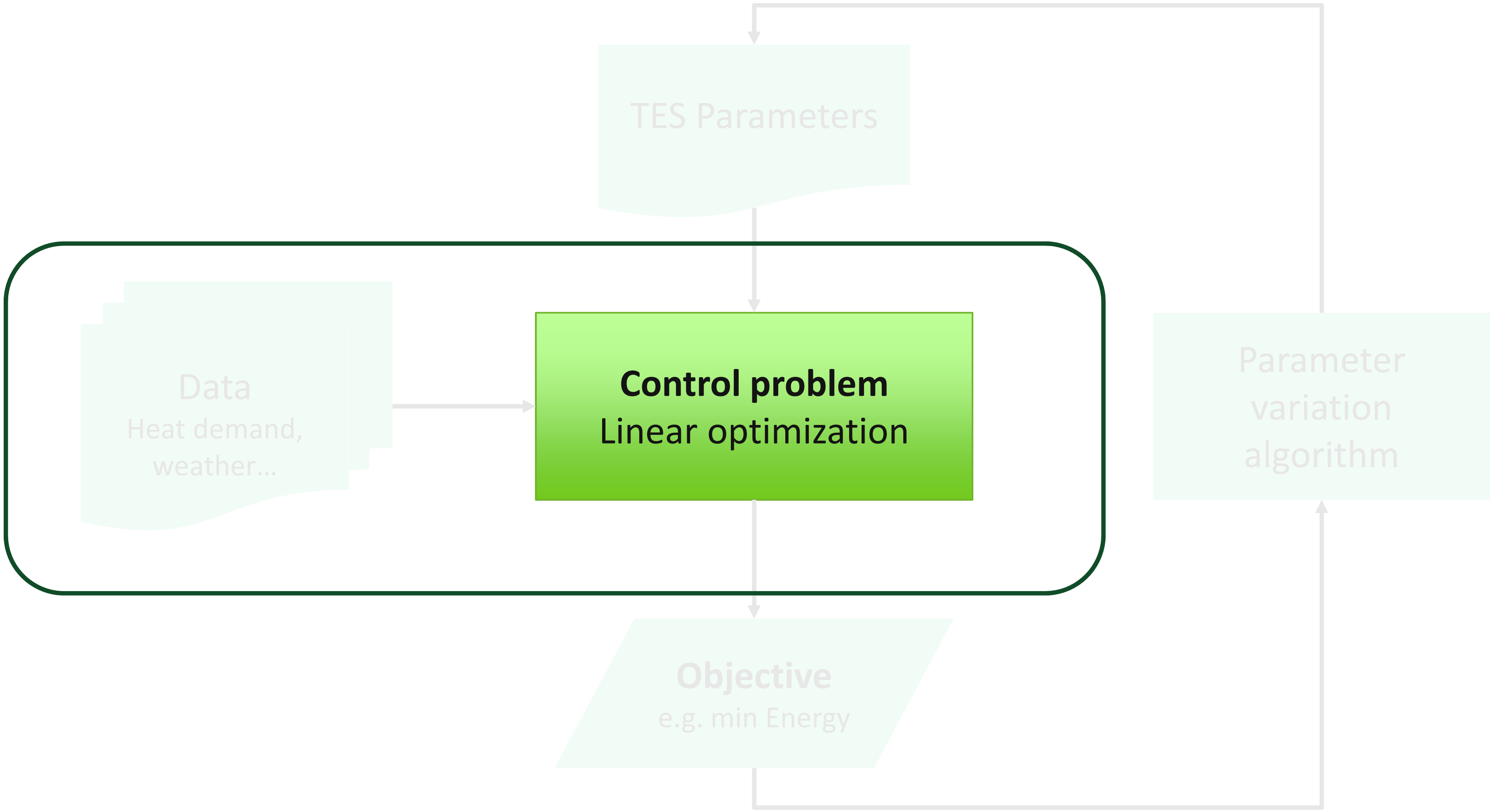
Simultaneity

Case Genk



20.86 GWh
32.91 GWh
140.29 GWh
34.29 GWh
82.86 GWh
118.77 GWh
11.99 GWh
22.34 GWh
34.39 GWh

Framework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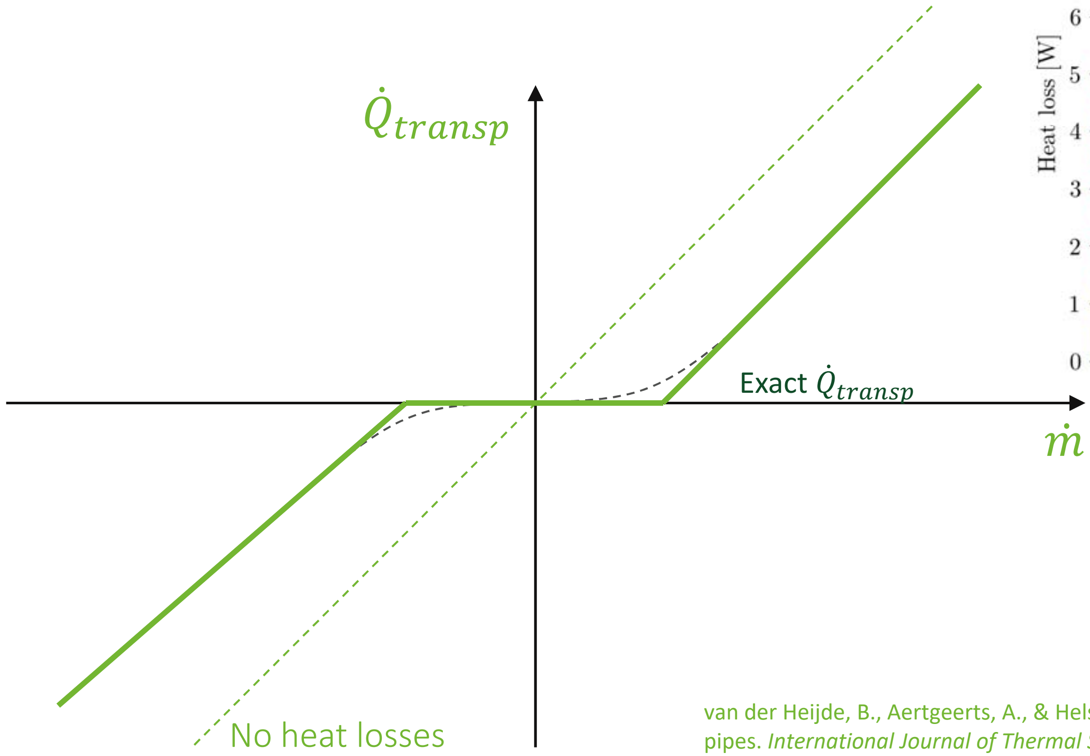
Control optimization

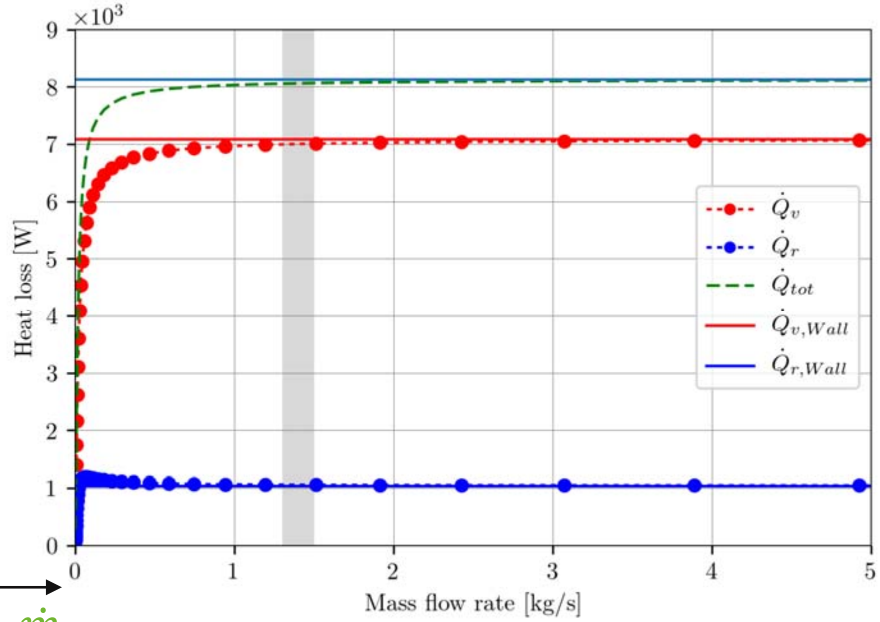
- Linear, fixed nominal temperature levels
- Predefined pipe diameters
- **Novel:**
  - Model of mass and heat flow in pipes (van der Heijde *et al.*, 2017)
  - $\dot{Q}$ and $\dot{m}$ decoupled, except at demand

van der Heijde, B., Aertgeerts, A., & Helsen, L. (2017). Modelling steady-state thermal behaviour of double thermal network pipes. *International Journal of Thermal Sciences*, *117*, 316–327. https://doi.org/10.1016/j.ijthermalsci.2017.03.026

Pipe model

- Fixed supply and return T to calculate heat losses
- Linear model
- Integers for flow direction



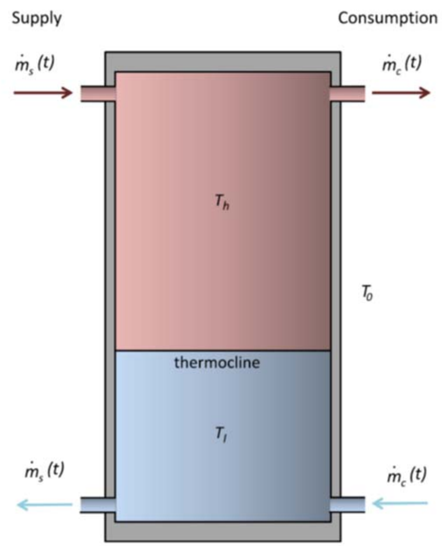


Source: van der Heijde *et al.*, 2017

van der Heijde, B., Aertgeerts, A., & Helsen, L. (2017). Modelling steady-state thermal behaviour of double thermal network pipes. *International Journal of Thermal Sciences*, *117*, 316–327. https://doi.org/10.1016/j.ijthermalsci.2017.03.026

Network nodes

Component	Temperatures	Mass flow rate	Heat flow rate
Storage	Fixed	Variable	Variable
Heat demand	Fixed	Preset	Preset
Solar thermal	Fixed	Preset	Preset
Central heat production	*Floating*	Variable	Variable

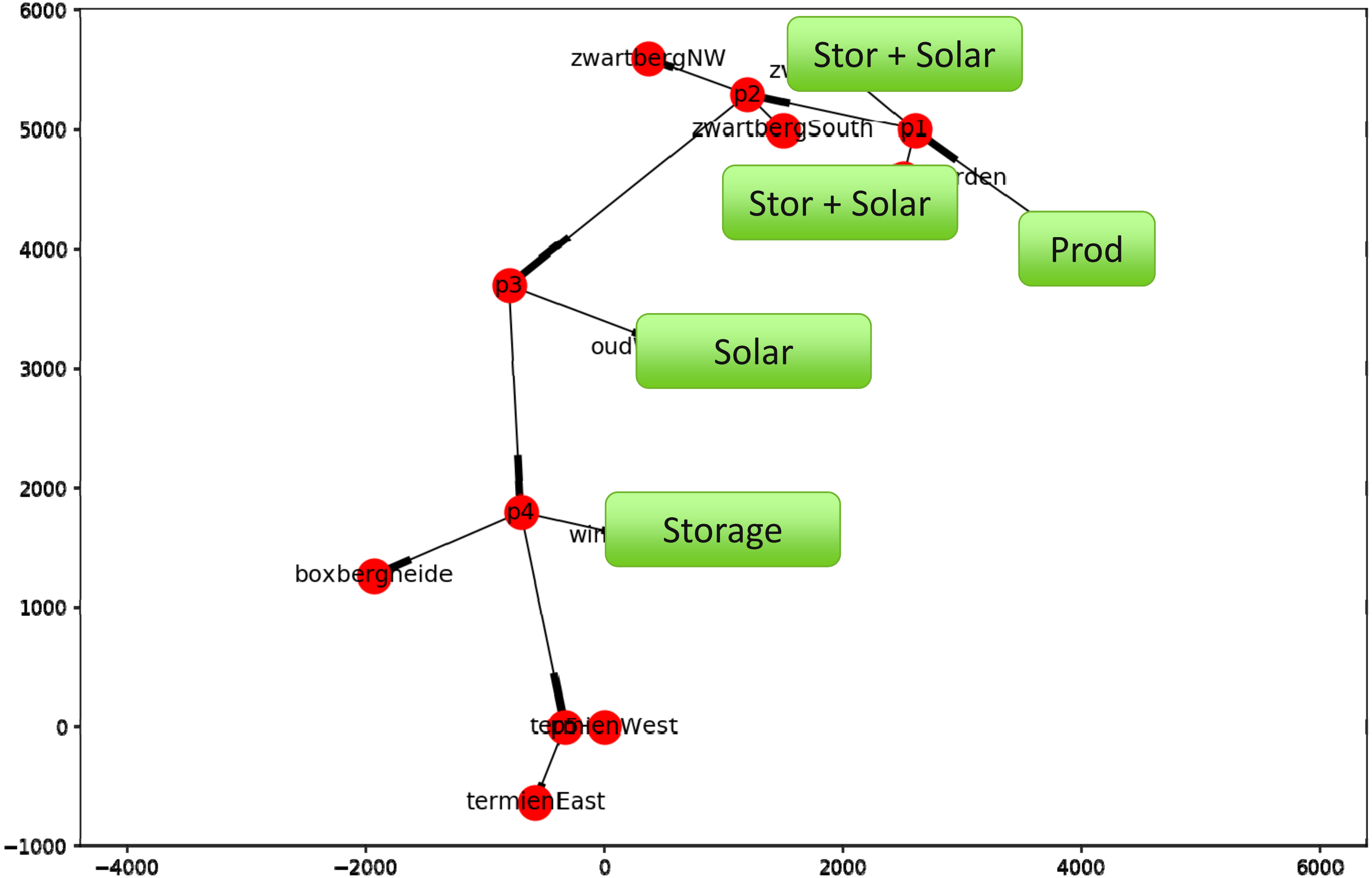


Source:
Vandewalle and D'haeseleer, 2014

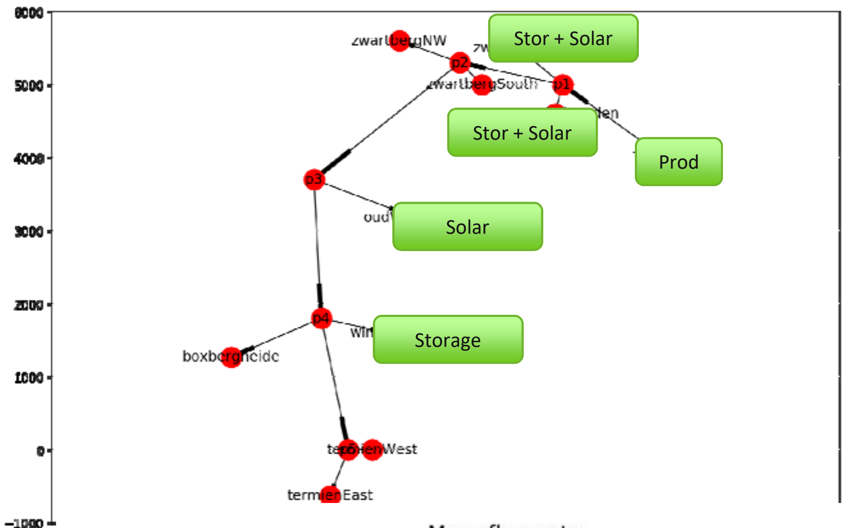
- Heat and mass flow balance in every node
- **But** $\dot{Q} = \dot{m} \cdot c_p \, (T_H - T_L)$ **only valid at fixed components**

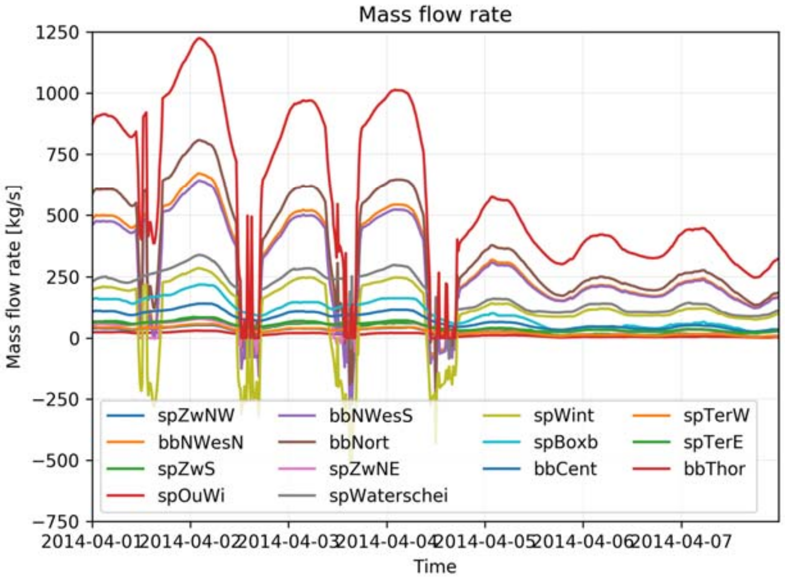
Vandewalle, J., & D'haeseleer, W. (2014). The impact of small scale cogeneration on the gas demand at distribution level. *Energy Conversion and Management*, *78*, 137–150. https://doi.org/10.1016/j.enconman.2013.10.005

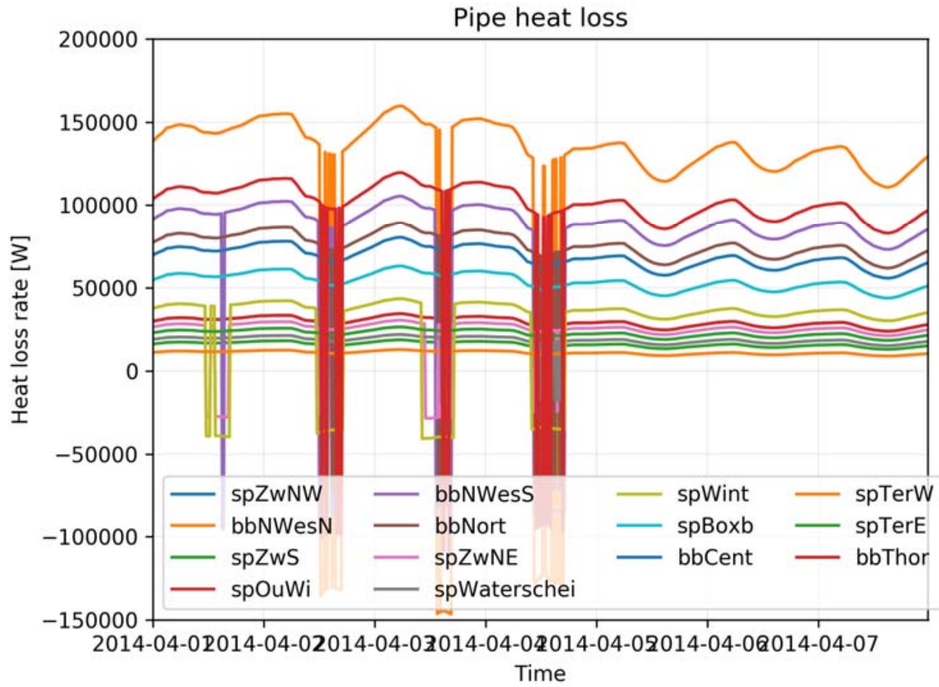
Preliminary results

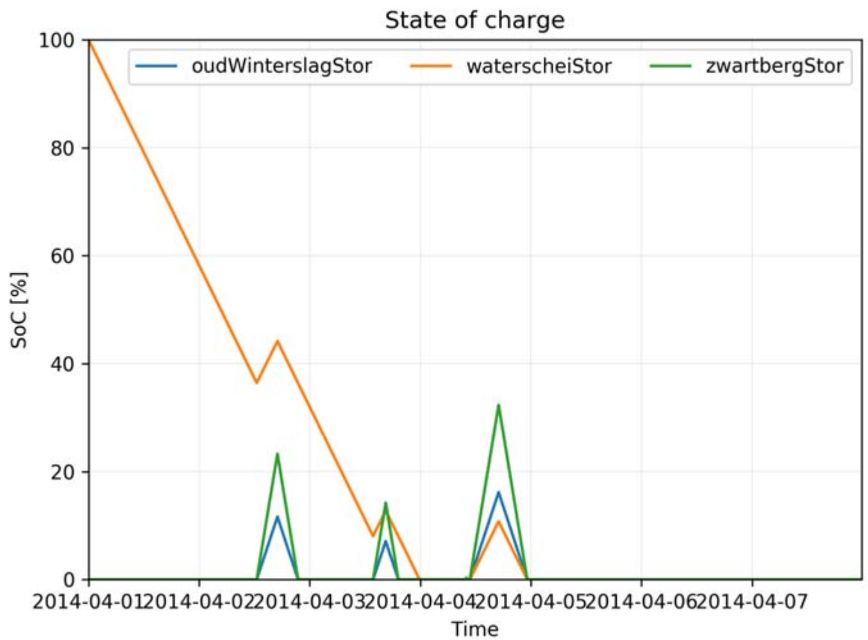


Preliminary results









Conclusion

- Framework for optimal TES integration
- Optimization model for DHC pipes
- Synthetic neighborhood heat loads

Future work

- Storage optimization loop
- Implement representative weeks
- Evaluate different objective functions

EnergyVille

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THERMAL SYSTEMS SIMULATION

Europese Unie
Europees Fonds voor Regionale Ontwikkeling
Hier wordt geïnvesteerd in uw toekomst!

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AGENTSCHAP INNOVEREN & ONDERNEMEN

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References

- van der Heijde, B., Aertgeerts, A., & Helsen, L. (2017). Modelling steady-state thermal behaviour of double thermal network pipes. *International Journal of Thermal Sciences*, *117*, 316–327. https://doi.org/10.1016/j.ijthermalsci.2017.03.026
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Illustration by Ina De Jaeger

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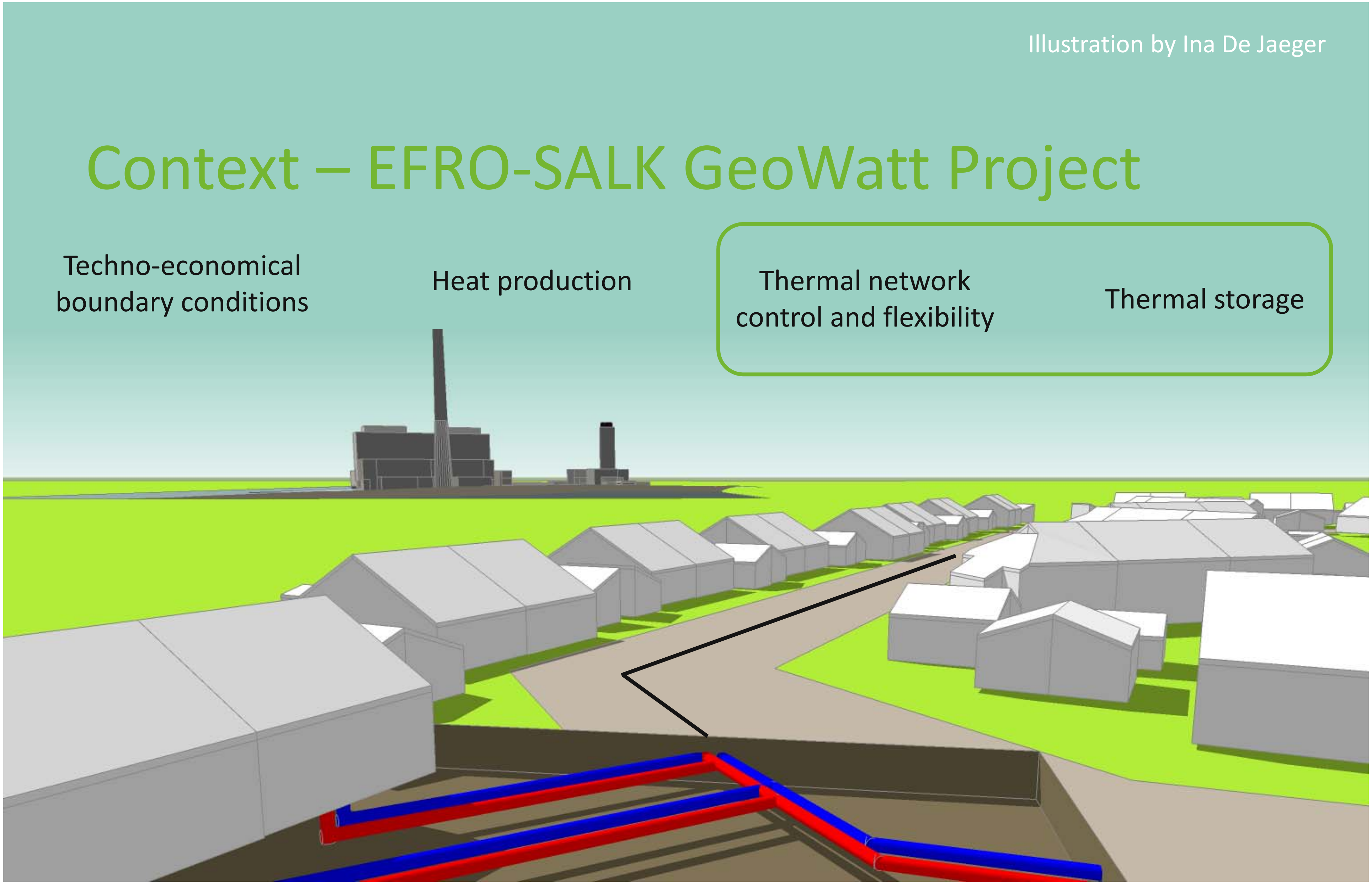
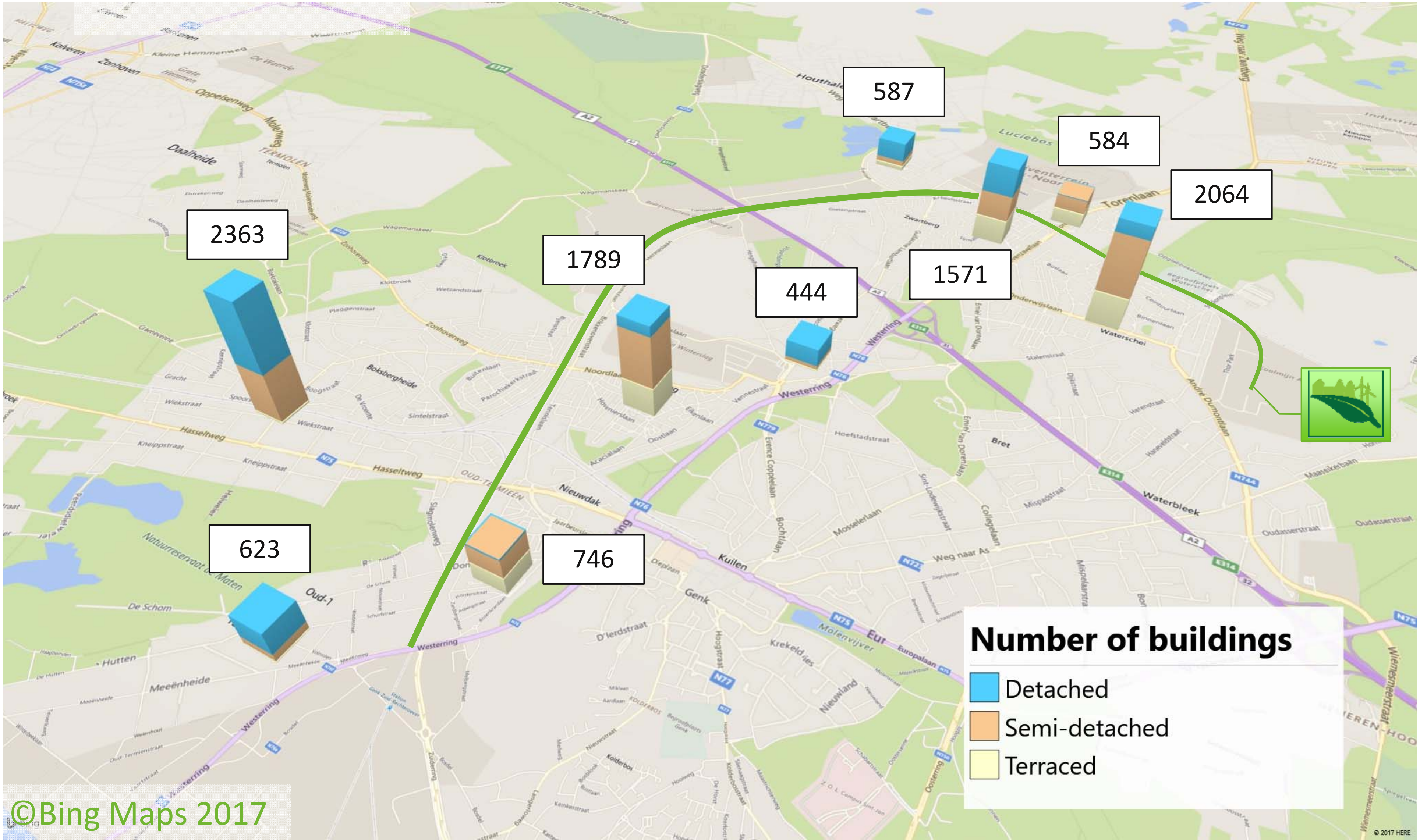


Building Count Map

Case Genk



Case Genk


74.4 TJ
118.5 TJ
505.0 TJ
123.4 TJ
298.3 TJ
427.6 TJ
43.2 TJ
80.4 TJ
123.8 TJ