# HEATSTORE WEBINAR SERIES

## HOW TO DEVELOP UNDERGROUND THERMAL ENERGY STORAGE (UTES) PROJECTS?

Learnings from the European HEATSTORE project

Host: TNO, The Netherlands

heatstore High Temperature Underground Thermal Energy Storage

GEOTHERMICA

**7, 14, 21, 28 Sept. and 5, 12 Oct. 2021 | all 15-16 h (CEST)**

Register on www.heatstore.eu

# HEATSTORE WEBINAR SERIES 2021

## All webinars are at 15 – 16 h CEST

Tuesday 7 Sept. (Holger Cremer, TNO): Challenges in Underground Thermal Energy Storage (UTES)

Tuesday 14 Sept. (Thomas Driesner, ETH Zurich): Advances in subsurface characterization and simulation

Tuesday 21 Sept. (Koen Allaerts, VITO): Integrating UTES and DSM in geothermal district heating networks

Tuesday 28 Sept. (Florian Hahn, Fraunhofer IEG): Abandoned coal mines – promising sites to store heat in the underground

Tuesday 5 Oct. (Bas Godschalk, IF Technology): The ECW Energy HT-ATES project in the Netherlands

Tuesday 12 Oct. (Joris Koornneef, TNO): The role of UTES in the future EU energy system – a moderated table discussion.

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# HEATSTORE

- HEATSTORE = GEOTHERMICA ERA-NET co-fund project
- 16.3 M€ | 23 partners in 9 EU countries
- 6 demonstration sites, 8 case studies.
- Coordination: TNO Netherlands Organization for Applied Scientific Research)

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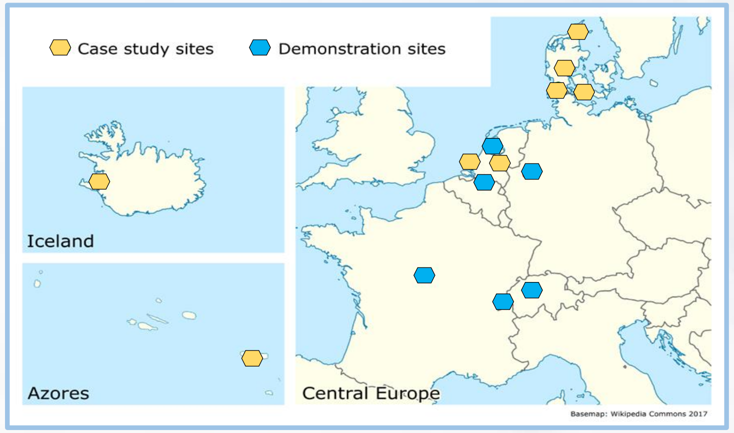


- **Best practice guidelines:** Design & System integration | Business models | Regulatory framework | Stakeholder perception & engagement | Monitoring technical, economic and environmental performance

Fast track market uptake

- Proof and operation of UTES and DSM technologies

Model & design validation

Characterization of UTES

Modelling sub-surface dynamics

Heating system integration & design optimisation

Demonstration

System performance monitoring

- **Roadmap Europe**: Technical future potential UTES and DSM in Europe | New business models | Stakeholder engagement | Roadmap for fast track uptake

**Design** → **Demonstration** → **Replication and scale-up**

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# HEATSTORE – 21 Sept. 2021 Integrating UTES and DSM in Geothermal district heating networks

- Koen Allaerts (VITO): Convenor & Opening
- Per Alex Sørensen (PlanEnergi): Modelling and managing district heating systems in Denmark
- Koen Allaerts (VITO): Smart control of a district heating network in Belgium
- Martijn Clarijs, Ryvo Octaviano (TNO): System integration and optimization of underground storage systems in the Netherlands

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# SYSTEM INTEGRATION AND OPTIMIZATION OF UNDERGROUND STORAGE SYSTEMS IN THE NETHERLANDS

WEBINAR, 21-9-2021

MARTIJN CLARIJS & RYVO OCTAVIANO (TNO)

heatstore

High Temperature Underground Thermal Energy Storage

# INTRODUCTION

- **Objective**

*"To define the design and operational strategies for UTES and DSM based on the above-surface conditions (DHC networks, surplus of thermal production) of geothermal district heating networks and to assess the economic viability of the proposed district heating schemes."*

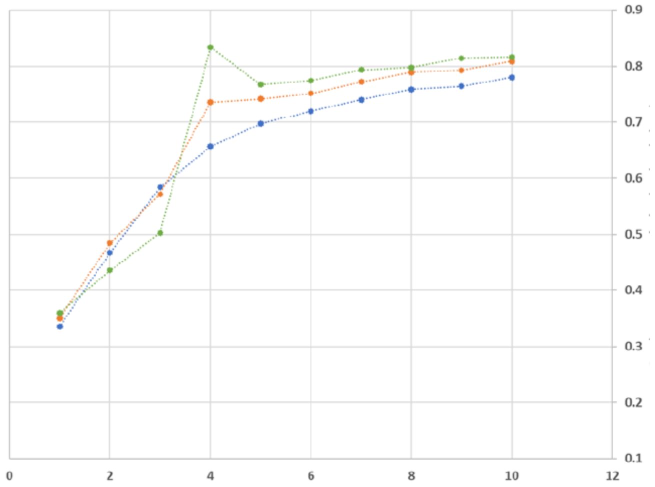
- **Research Question**

How can the HT-ATES be integrated in the horticulture heating network at ECW and operated in an optimal way?

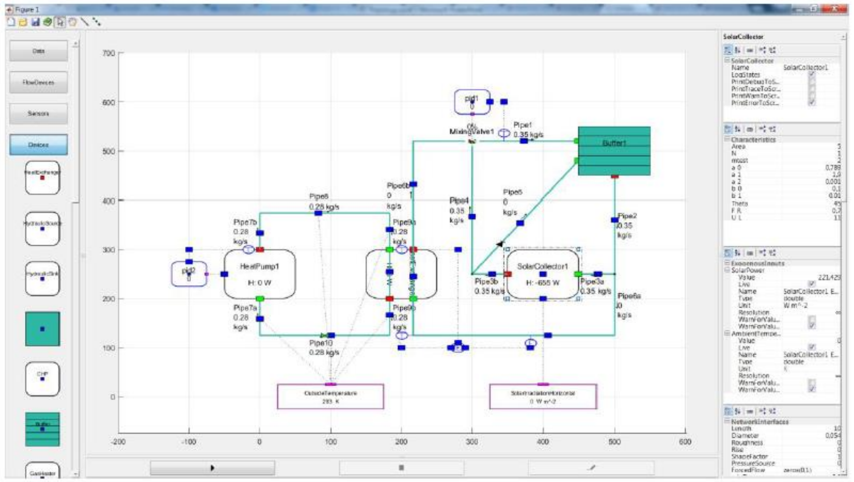
- **Heat Network**
  - 3 Geothermal Doublets (43 MW).
  - Future additional biomass (18 MW) and datacenter waste heat sources.
  - 391 ha green houses (tomato and paprika) divided into 12 demand clusters. Each green house has CHP and/or Boiler.
  - HT-ATES with a maximum flowrate 200 $m^3/h$
  - Grid Temperature 85/35 $^0C$.

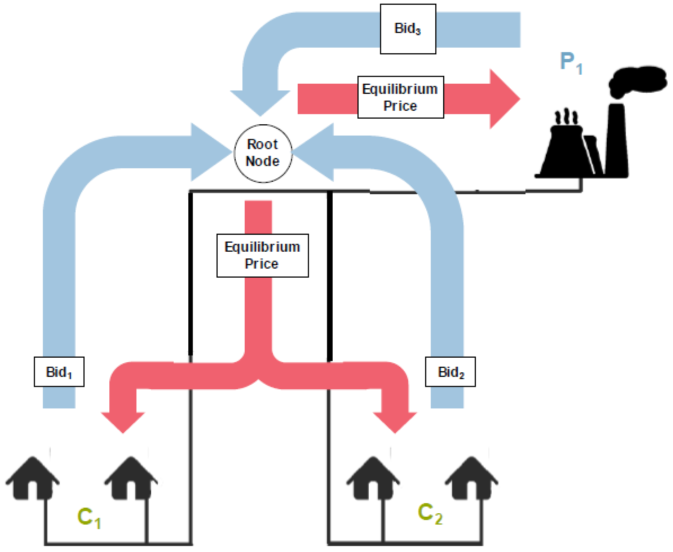
# SYSTEM SIMULATIONS AND SMART CONTROL ON DISTRICT HEATING

- Modelling studies were performed by IF Technology to optimize the optimal distance between the hot and the cold HT-ATES wells

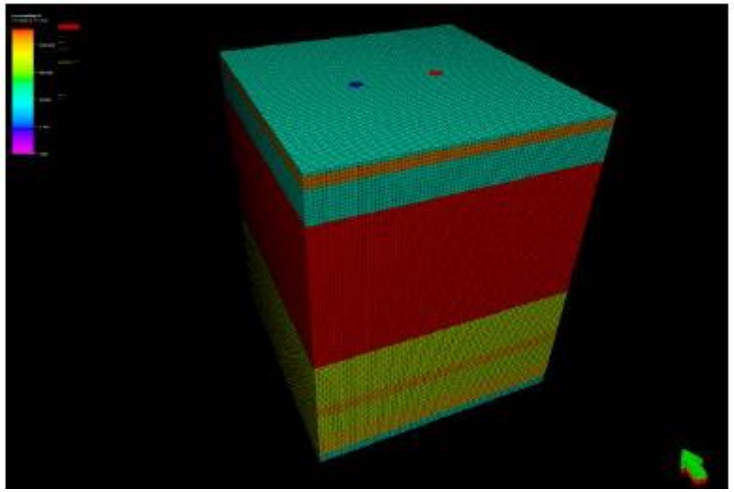



- While, the overall system simulation framework (DHC + HT-ATES) were assessed by TNO using a hydraulic and thermal solver (CHESS) and an agent based controller (HEATMATCHER) using market-based algorithm





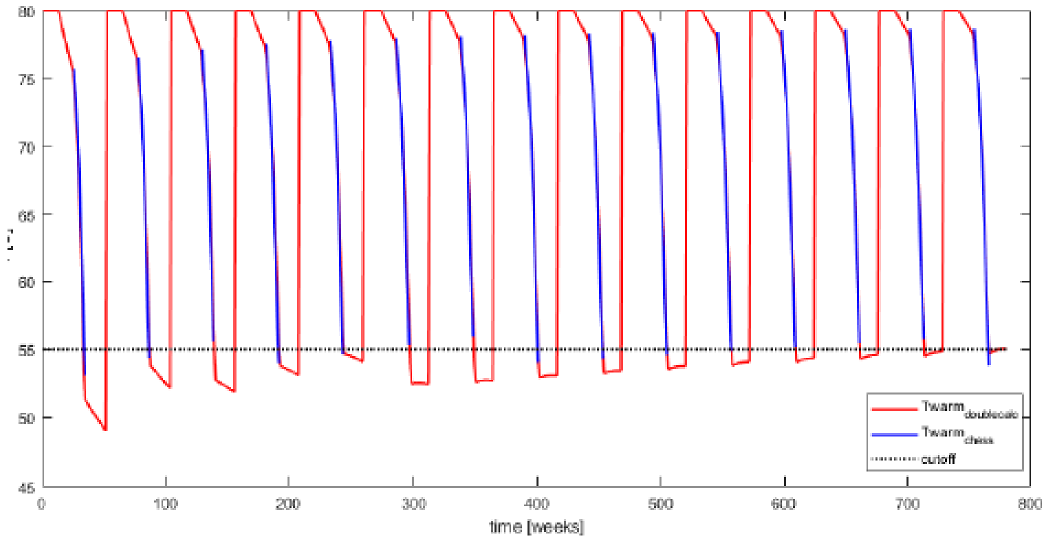
# ATES REDUCED ORDER MODEL

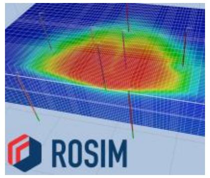


- 3D numerical model of HT-ATES is too costly (time consuming) for design analysis of HT-ATES integration in a heat network.
- Thus, a faster HT-ATES model is needed in order to run several scenarios and to compute an optimal operating control strategy.
- A simplified analytical model to predict hot and cold storage temperature is calibrated to a 3D numerical model

$$T_{\text{startcycle}} = T_{\text{soil}} + F_{\text{temp}}\,(T_{\text{injection}} - T_{\text{soil}})$$
$$T_{\text{well}} = T_{\text{startcycle}}\,F_{\text{mix}} + T_{\text{soil}}(1 - F_{\text{mix,warm}})$$

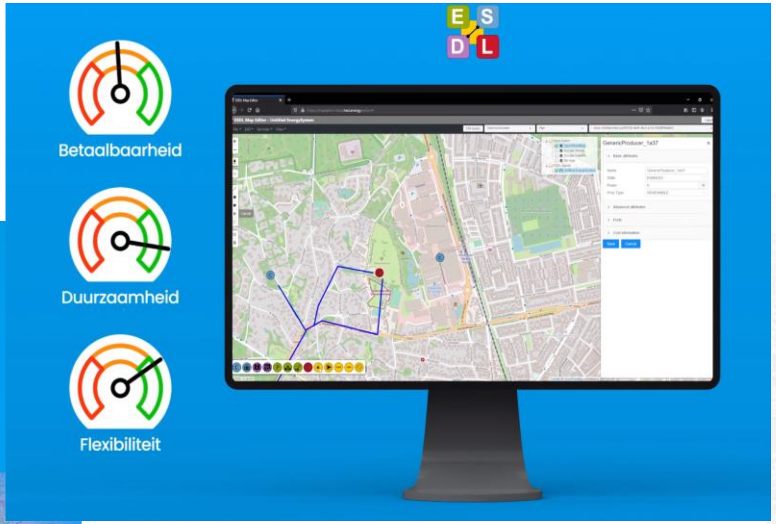
$T_{\text{injection}}$ is the injection temperature to ATES
$T_{\text{soil}}$ is the soil temperature
$T_{\text{startcycle}}$ the initial temperature of the well for each cycle year
$T_{\text{well}}$ is the well temperature
$F_{\text{temp}}$ is a fit function for initial temperature as a function of cycle year
$F_{\text{mix}}$ is a fit function for temperature drops as a function of volume produced



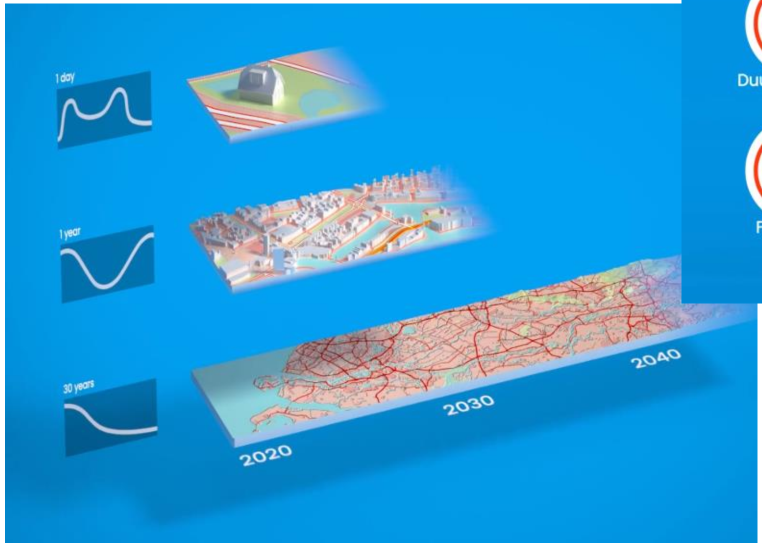
# CHESS Thermal solver,  ATES model and HeatMatcher for Networks are part of WARMING UP DESIGN TOOLKIT



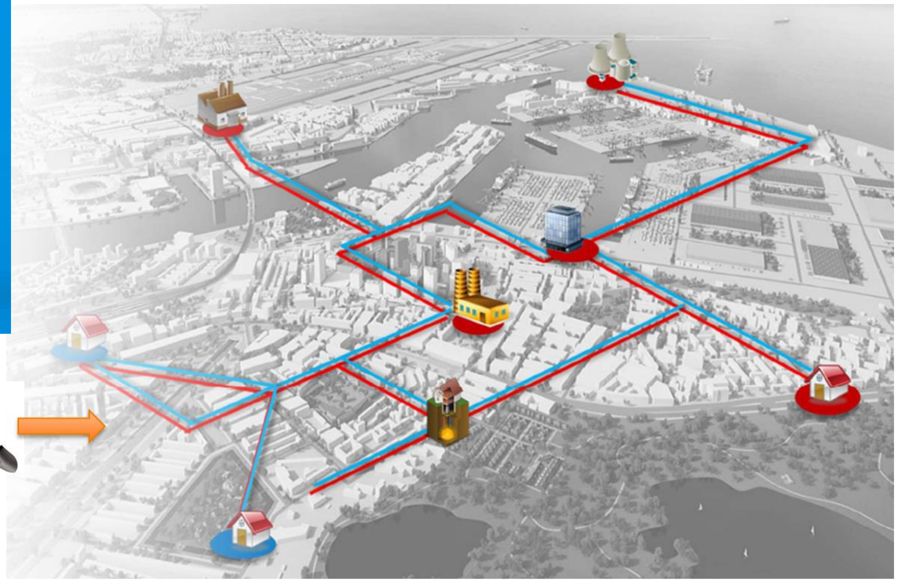
One common platform for different development stages of thermal networks




Dynamic simulations on different time scales



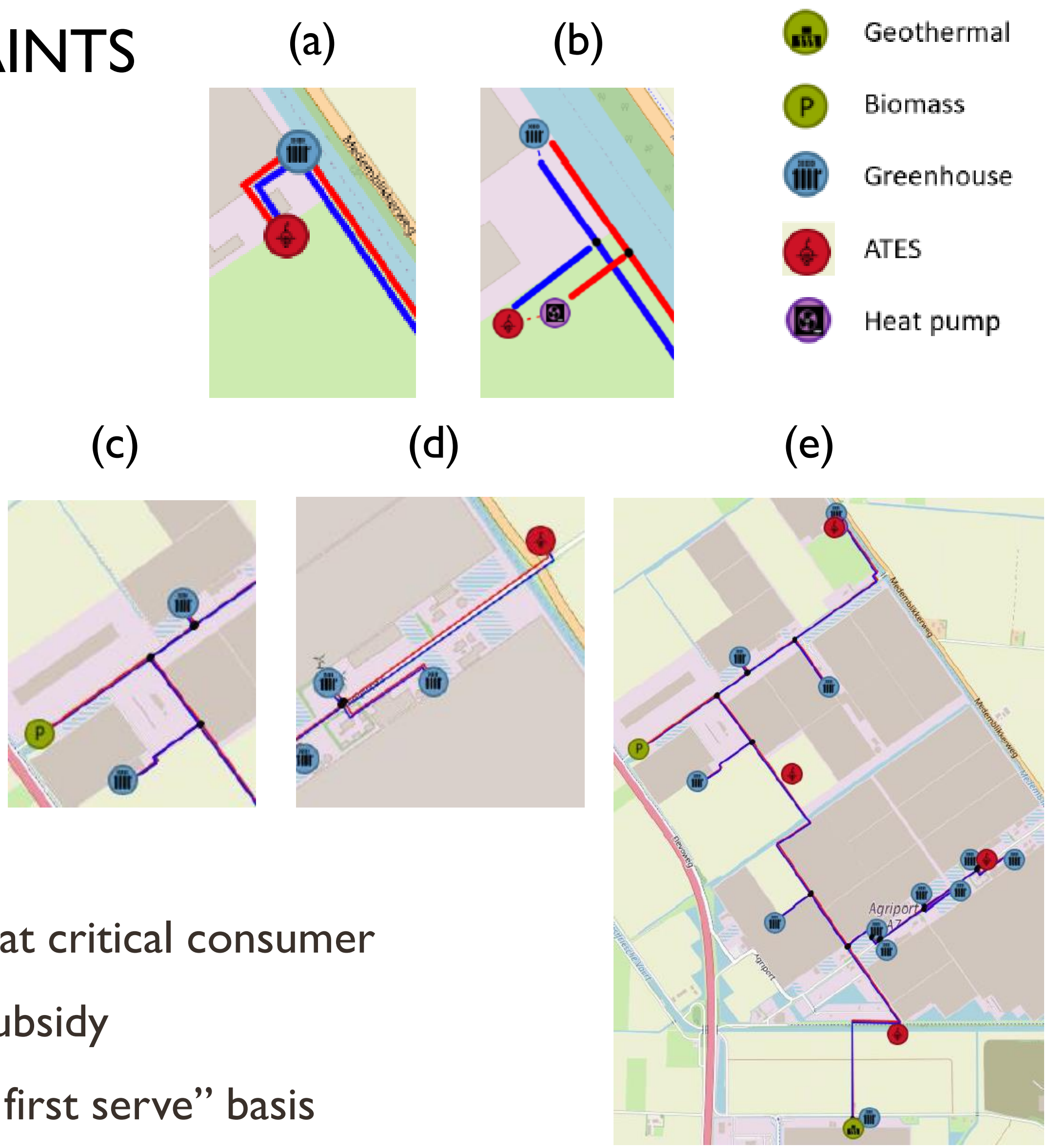

Design of future-proof heat networks cost-efficient, sustainable and flexible



# CASE SCENARIO AND CONTROL CONSTRAINTS

In order to answer WP3 objectives and support the business case, several case scenarios are assessed :

a) ATES is integrated directly to a green house.
b) ATES is integrated to the heat grid with a heat pump.
c) Additional heat source allocation.
d) Using a large ATES to an existing network.
e) Using several smaller ATES to an existing network.



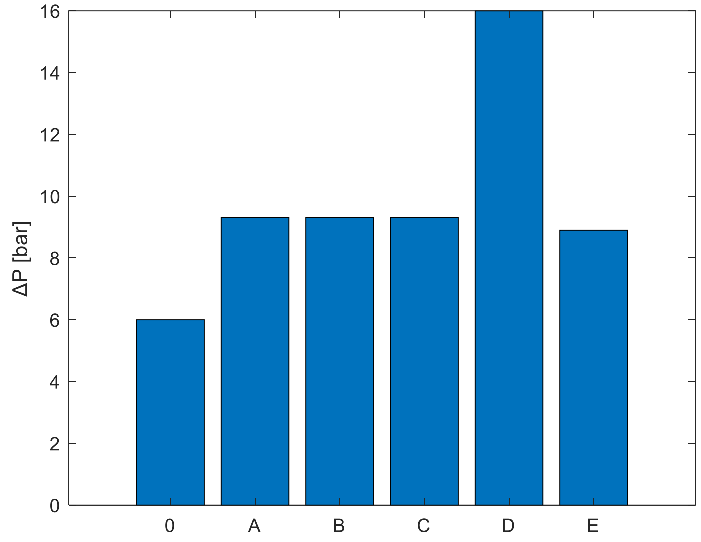

There are requirements for control constraints :

- $\Delta T$ 1 $^{0}$C at heat exchanger consumer and minimum $\Delta P$ 1 bar at critical consumer
- Minimum geothermal and biomass running hours to get the subsidy
- Demand allocation based on minimum delivery at "first come first serve" basis

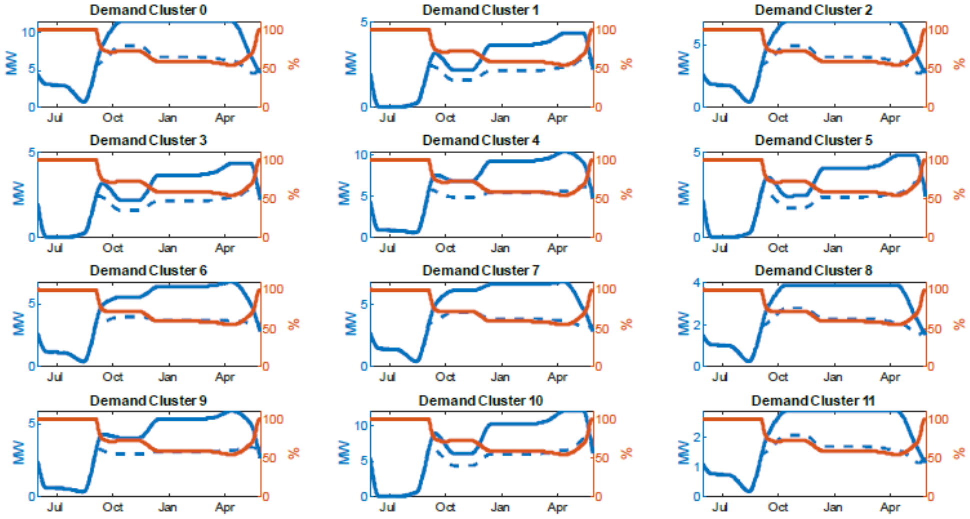
# RESULTS

- CHESS can produce KPI results in terms of technical and cashflow analysis for business case.
- User can inspect the maximum pressure drop over the pipe, heat losses, and ATES charging/discharge efficiency dynamically in several years based on demand profile.
- When the cost profile is given (CAPEX, OPEX, subsidy, $CO_2$ tax, etc.). It also can compute the cashflow, NPV, payback period in investing ATES.

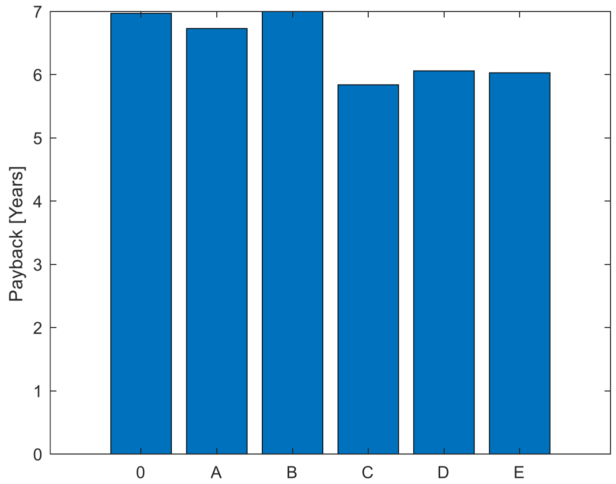
*Max system pressure drop*



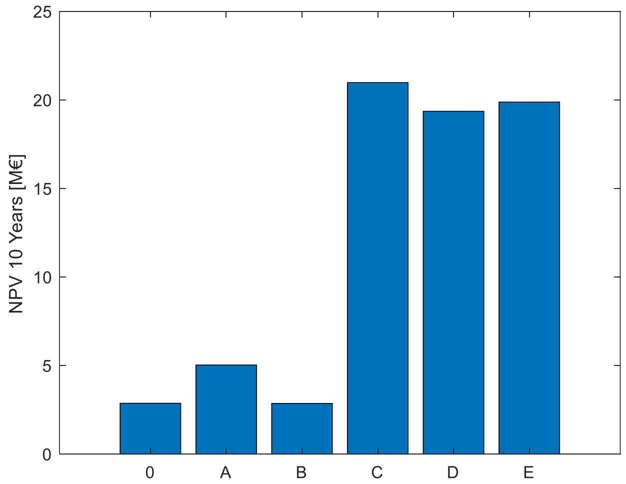

*Demand allocation control*




*Payback period*

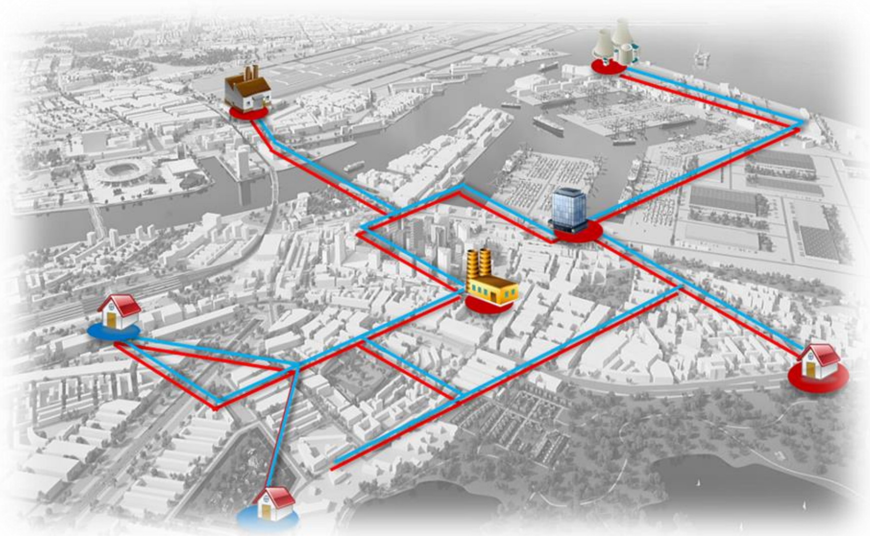



*NPV 10 years*



# CONCLUSION

- The design specifications and operational strategies for the integration of an ATES in the existing heat network at ECW were evaluated with CHESS and HeatMatcher.
- Several possible integration options and scenarios were assessed. The simulation results provide a better understanding of the interaction between the ATES and the heat network and also give more insight in the business cases.
- ATES simplified model can help to evaluate multi-years design simulation.



# THANK YOU FOR YOUR ATTENTION

HEATSTORE (170153-4401) is one of nine projects under the GEOTHERMICA – ERA NET Cofund aimed at accelerating the uptake of geothermal energy by 1) advancing and integrating different types of underground thermal energy storage (UTES) in the energy system, 2) providing a means to maximise geothermal heat production and optimise the business case of geothermal heat production doublets, 3) addressing technical, economic, environmental, regulatory and policy aspects that are necessary to support efficient and cost-effective deployment of UTES technologies in Europe. The three-year project will stimulate a fast-track market uptake in Europe, promoting development from demonstration phase to commercial deployment within two to five years, and provide an outlook for utilisation potential towards 2030 and 2050.

This project has been subsidized through the ERANET cofund GEOTHERMICA (Project n. 731117), from the European Commission, RVO (the Netherlands), DETEC (Switzerland), FZJ-PtJ (Germany), ADEME (France), EUDP (Denmark), Rannis (Iceland), VEA (Belgium), FRCT (Portugal), and MINECO (Spain).