belspo GEOCAMB

LIÈGE université Sciences Appliquées

Five adjacent Aquifer Thermal Energy Storage (ATES) systems in Cenozoic and Palaeozoic aquifers in Brussels: numerical simulation of their possible interactions

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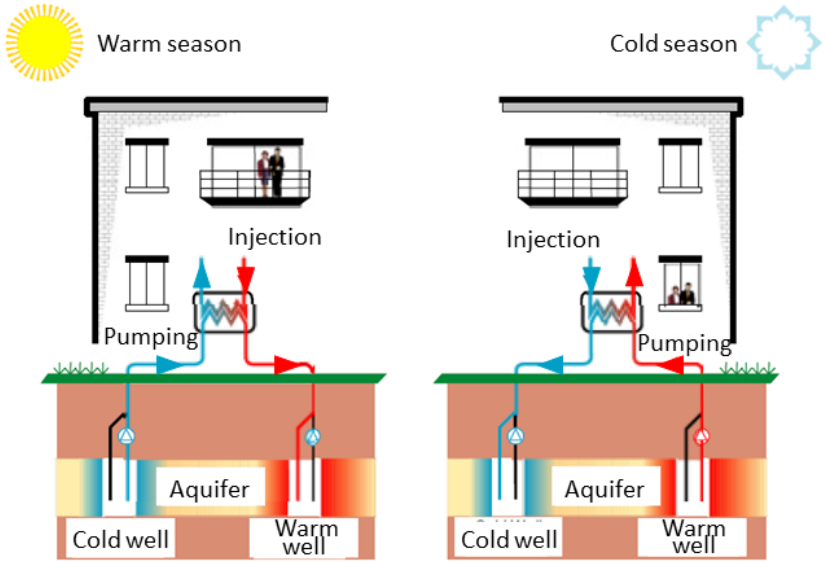
Hydrogeology
Environmental Geology

Geologica Belgica Luxemburga
Scientia & Professionis

The underground… a source of energy/storage

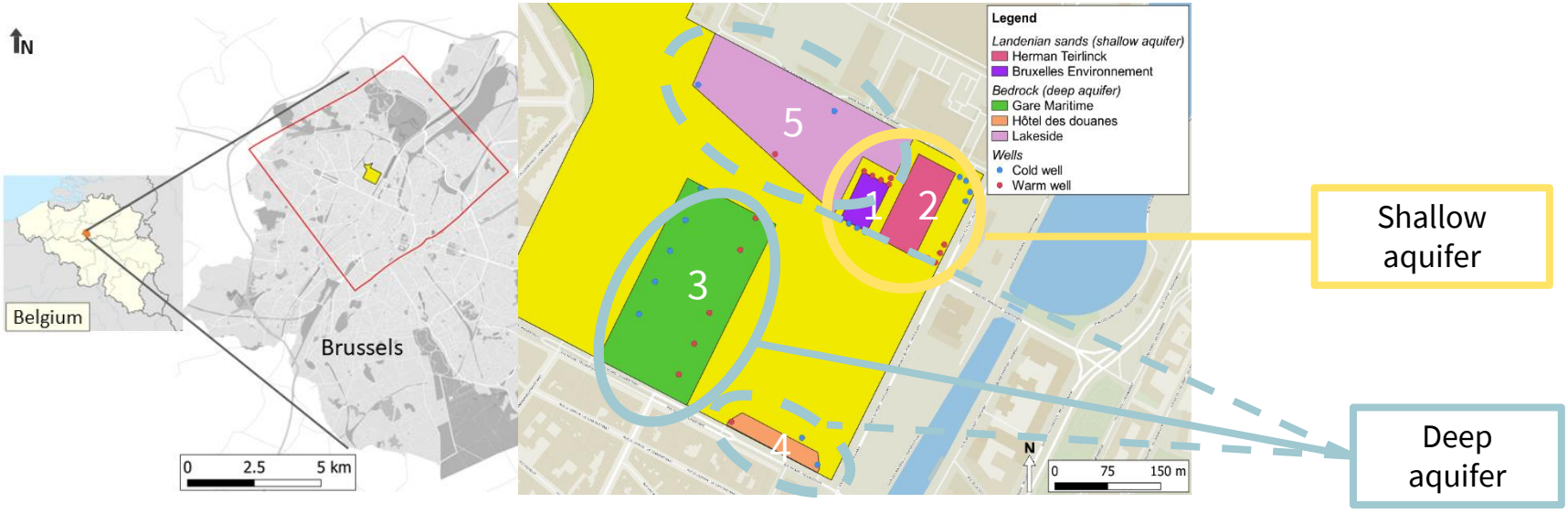


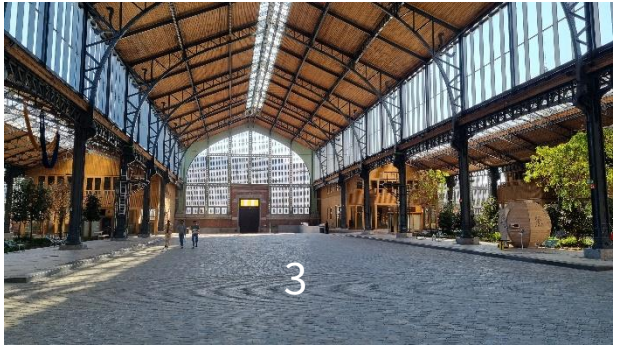
From Hoegaerden & Hagedoorn, 2007

- Geothermal systems are important for decarbonizing the heating/cooling of buildings
- Open loop geothermal systems
  - efficient for high power demand
  - P proportional to the water flow rate Q
    → large pumping rate needed

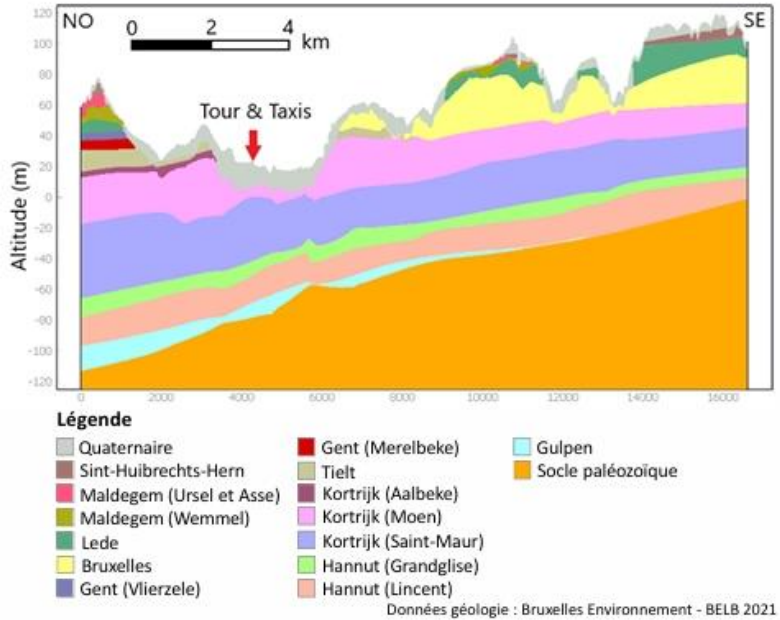
- Need of long-term efficiency
- What are the interactions between adjacent systems?

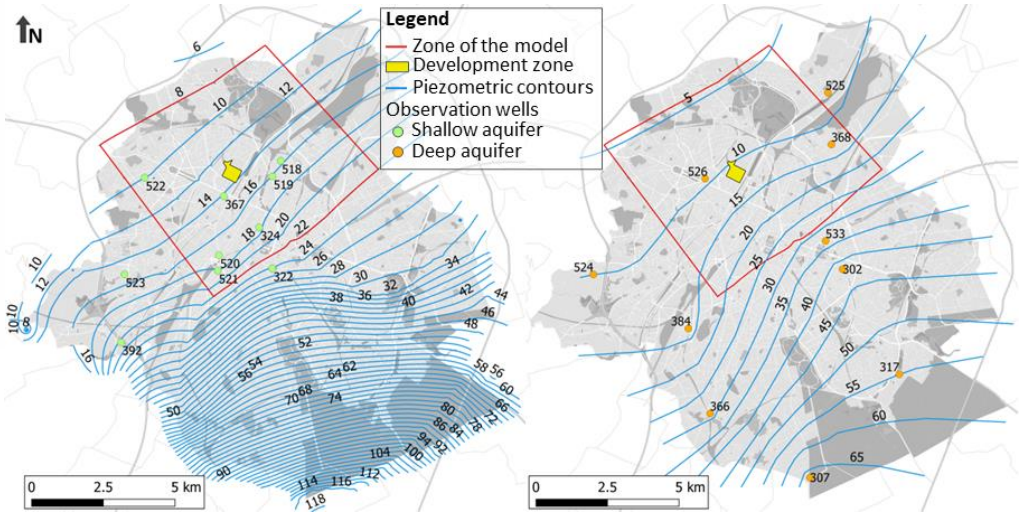
Case study: Tour & Taxi site



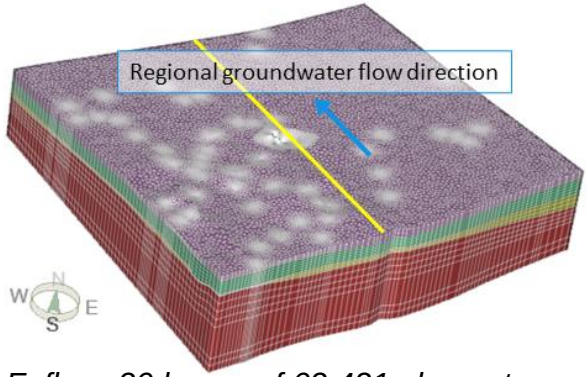


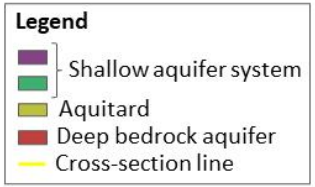
Methodology : Compilation of data



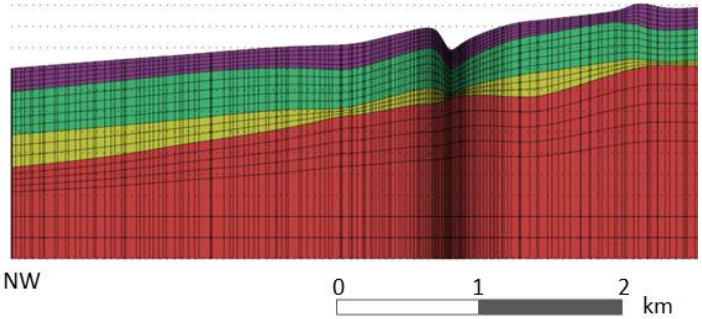


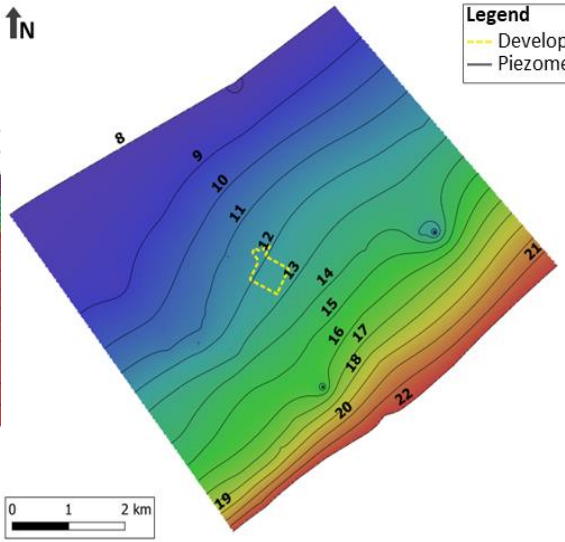
Methodology: Transient state 3D groundwater flow and heat transfer model



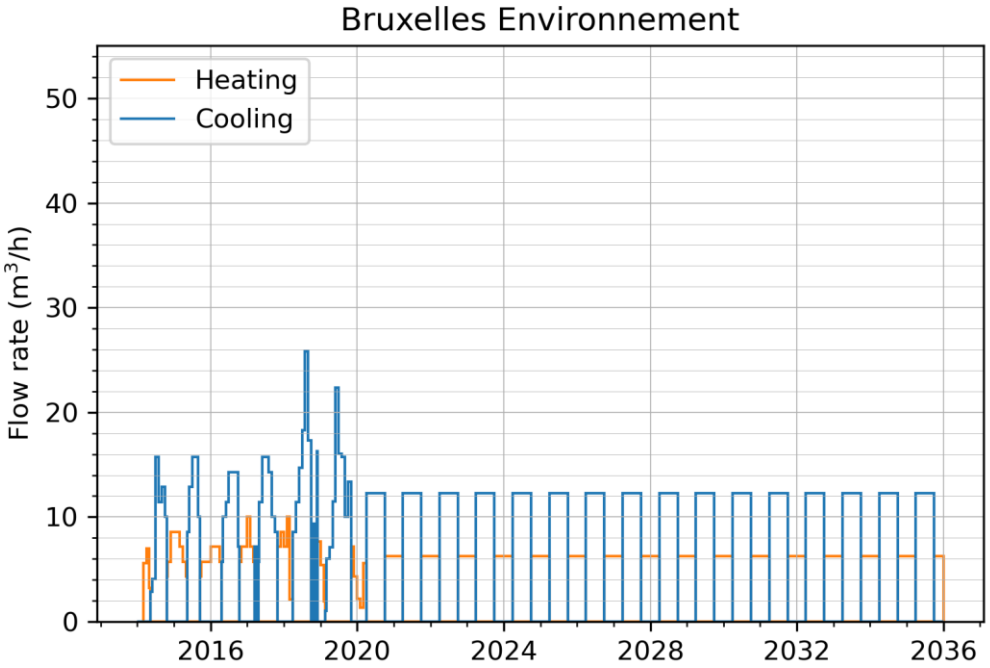


Feflow: 20 layers of 62,421 elements each



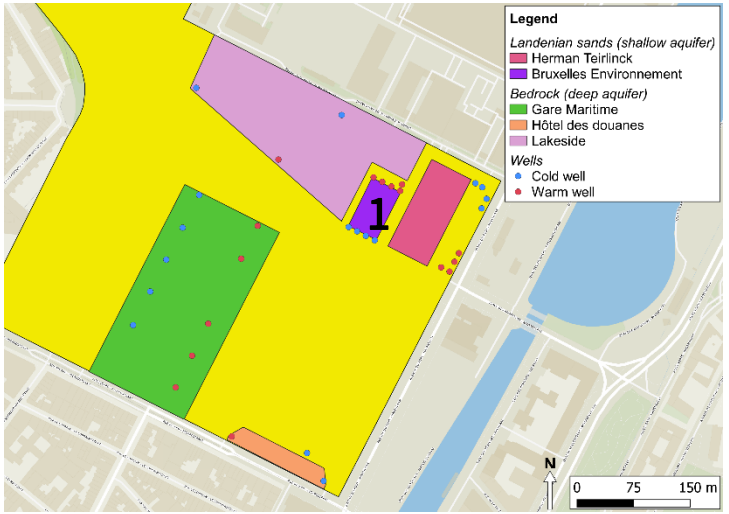


ATES main characteristics: Building 1 – based on historical data



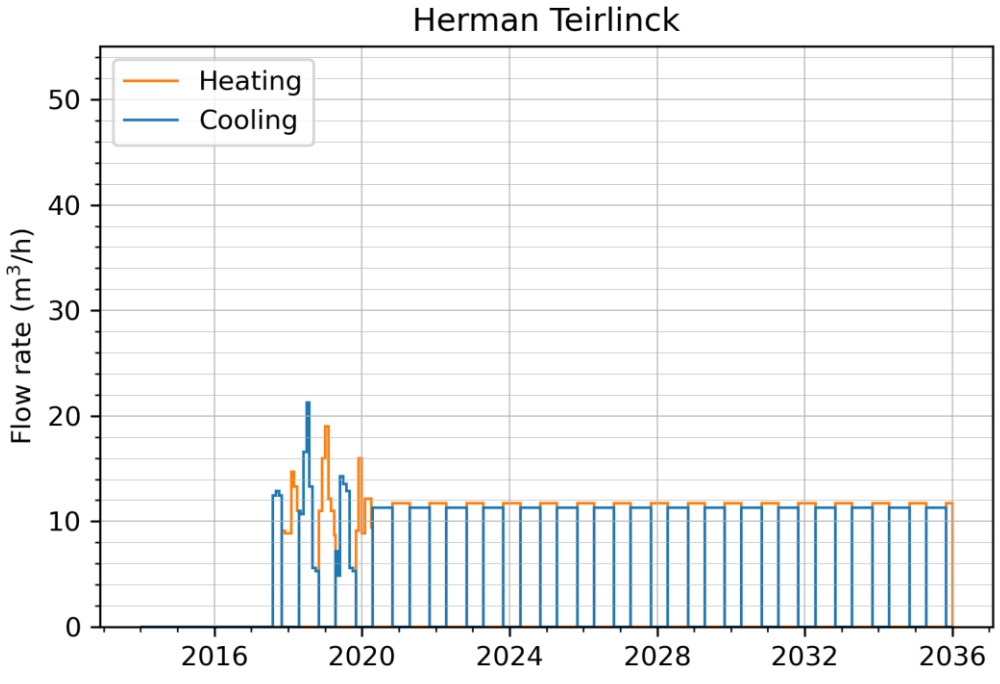
Heating : October 1st – March 31st
Cooling : April 1st – September 30th

Start : 1 March 2014



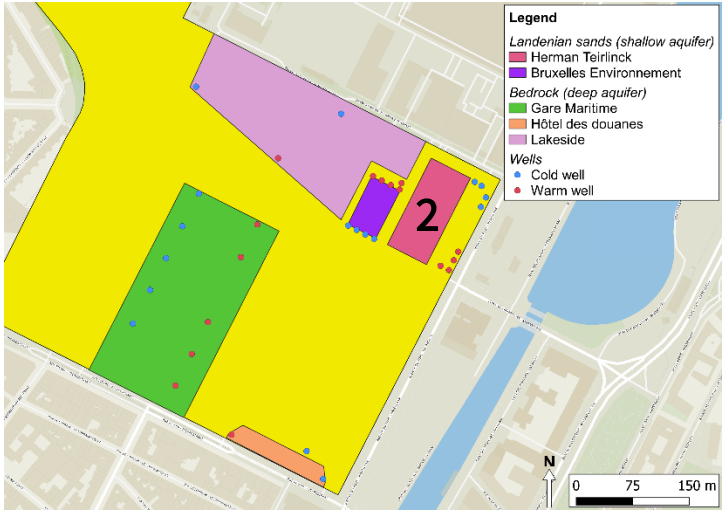
Shallow aquifer, $\Delta T = 6°C$
Cooling demand > Heating demand

ATES main characteristics: Building 2 – based on historical data



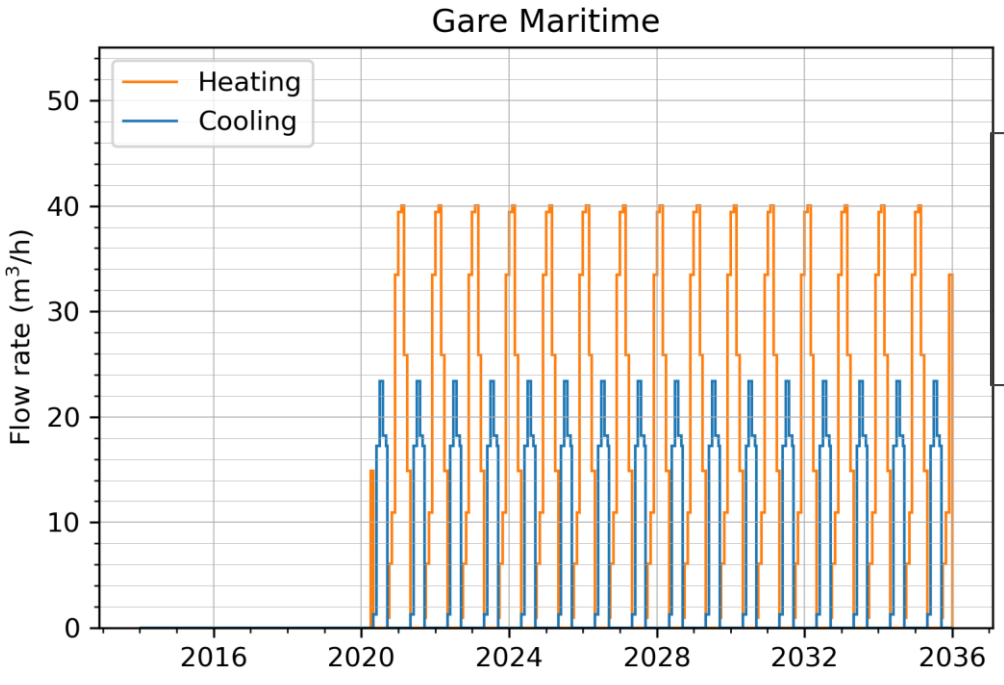
Heating : November 1st – April 15th
Cooling : April 16th – October 31st

Start : 1 August 2017



Shallow aquifer, $\Delta T = 6°C$
Cooling demand = Heating demand

ATES main characteristics: Building 3 – based on historical data



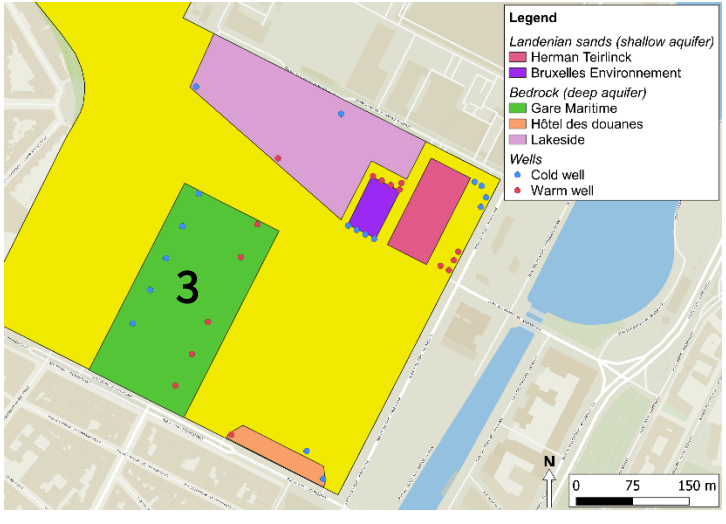
Deep aquifer, $\Delta T = 6°C$

Demand for cooling < Demand for heating

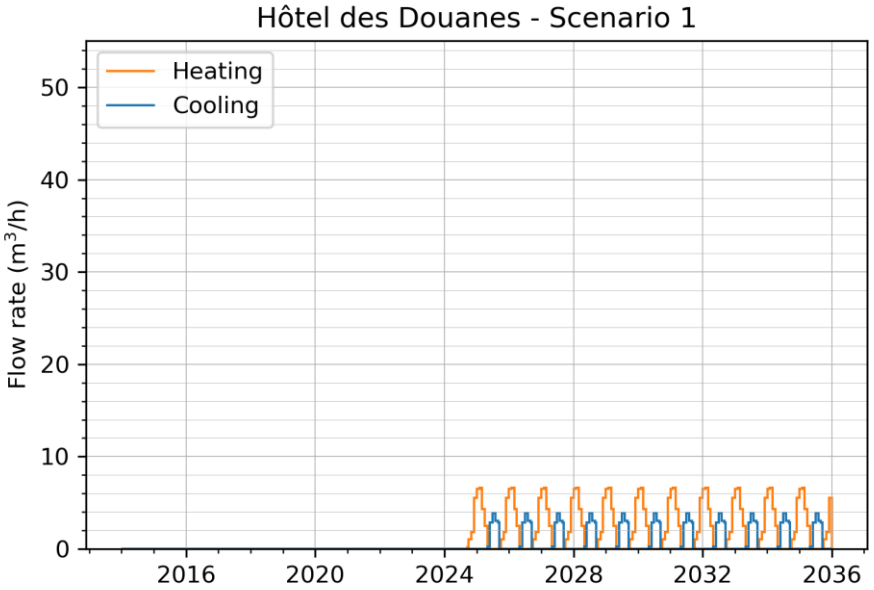
Heating : September 15th – March 31st

Cooling : April 1st – September 14th

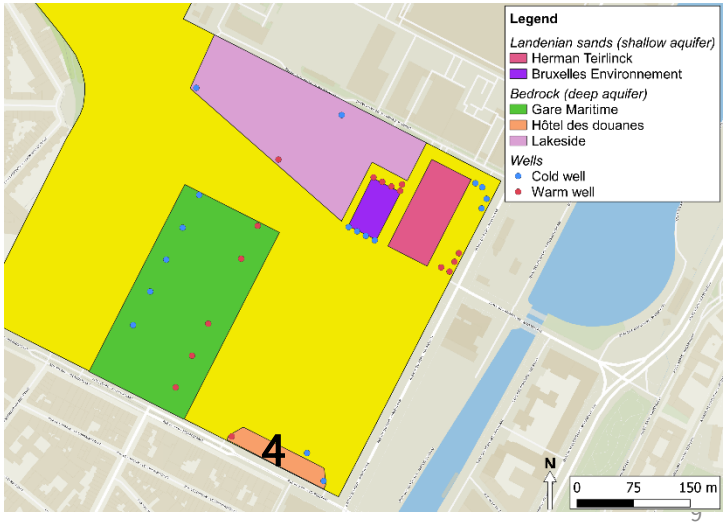
Start : 1 April 2020



ATES main characteristics: Building 4 – Scenario 1

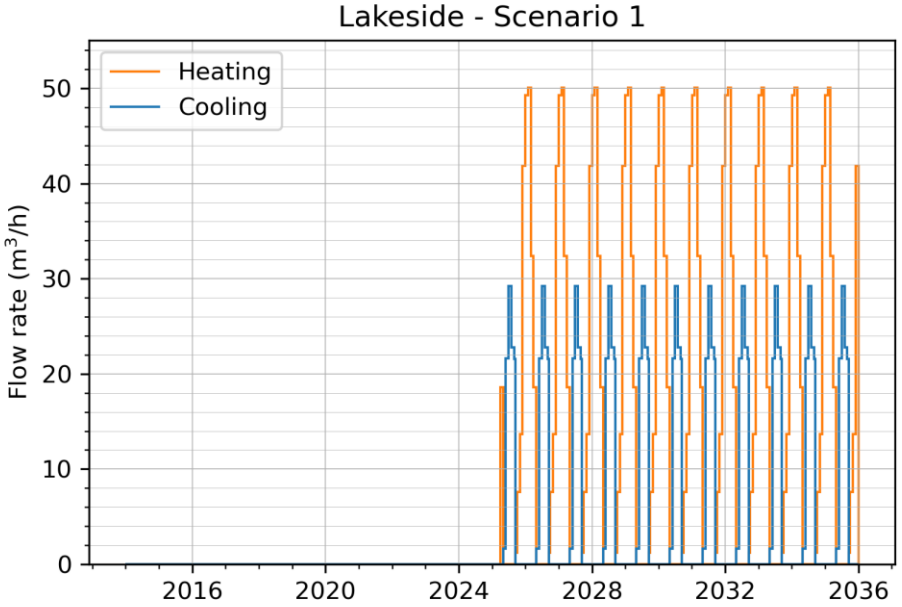


Heating : September 15th – March 31st
Cooling : April 1st – September 14th
Scenario1 : Same demand/surface as building 3
Start : 1st October 2024

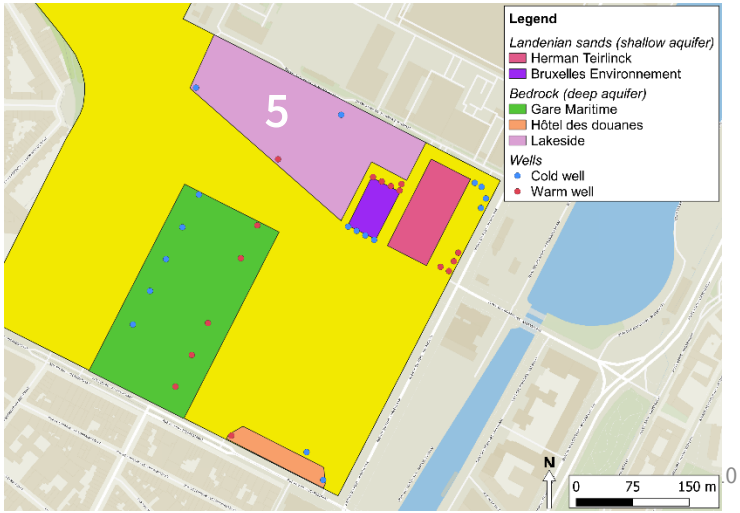


Deep aquifer, $\Delta T = 6°C$
Scenario 1 : Cooling demand < Heating demand

ATES main characteristics: Building 4 – Scenario 1



Heating : September 15th – March 31st
Cooling : April 1st – September 14th
Scenario1 : Same demand/surface as building 3
Start : 1st April 2025

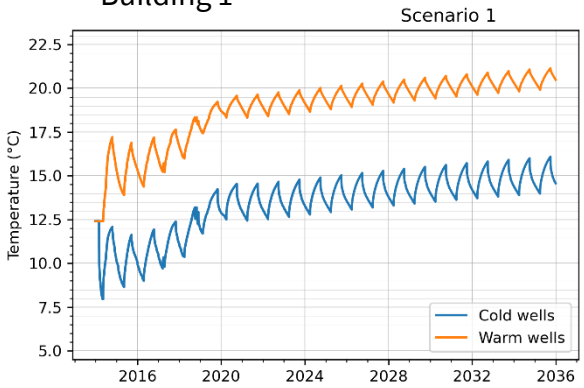


Deep aquifer, $\Delta T = 6°C$
Scenario 1 : Cooling demand < Heating demand

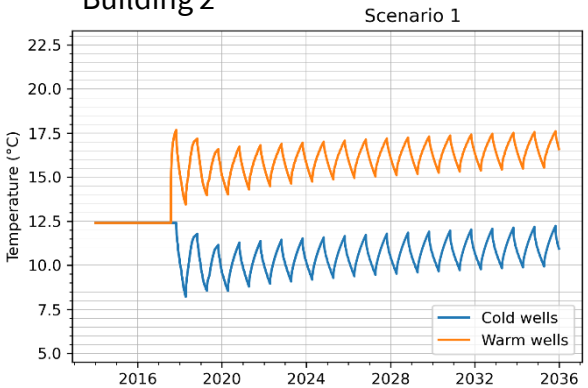
Temperature evolution in the hot and cold wells

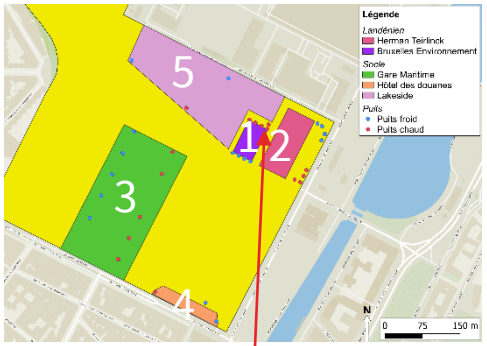
Scenario 1: shallow aquifer

Building 1



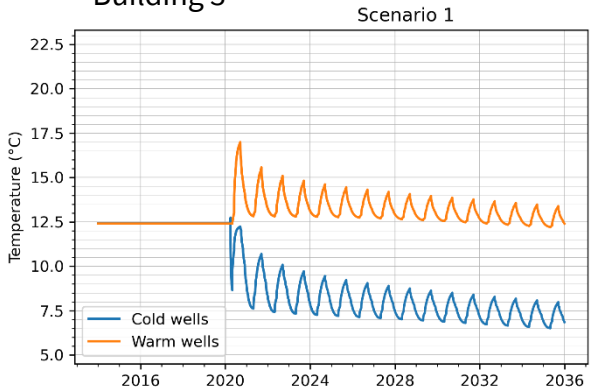
Building 2



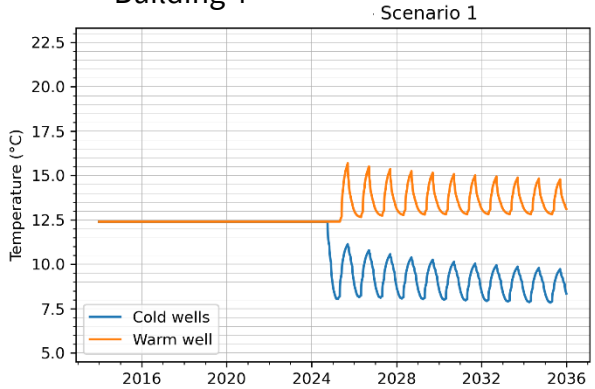


Scenario 1: deep aquifer

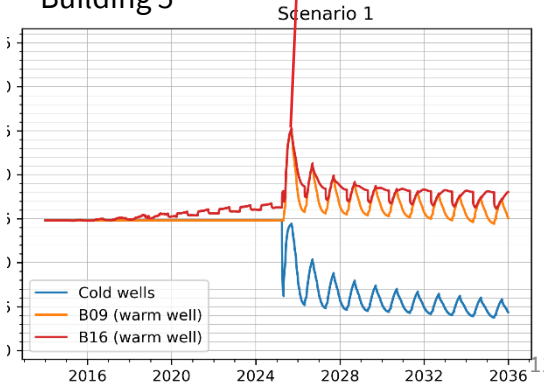
Building 3



Building 4

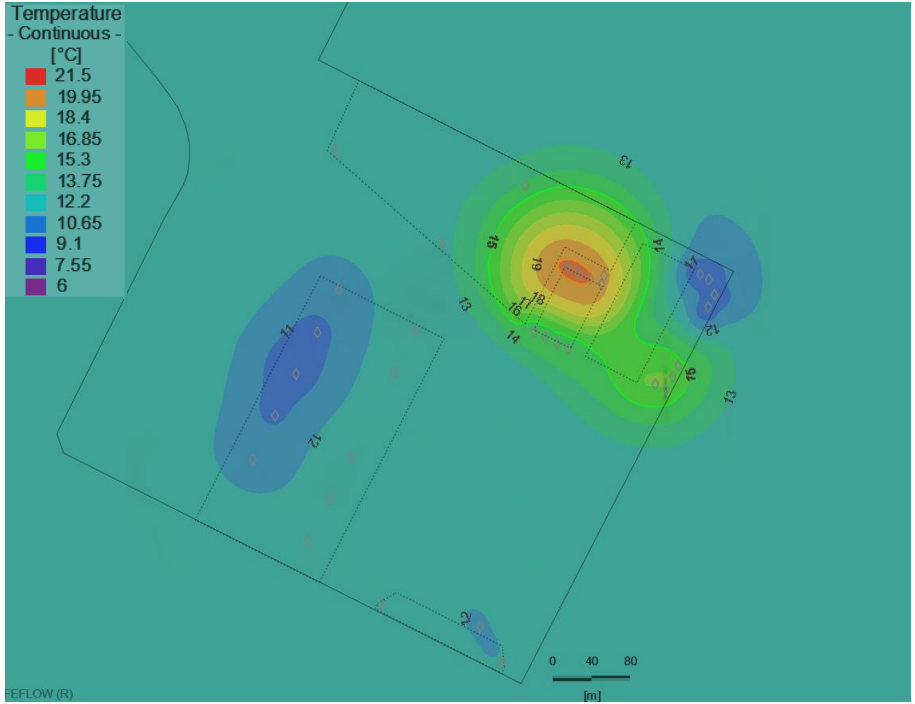


Building 5

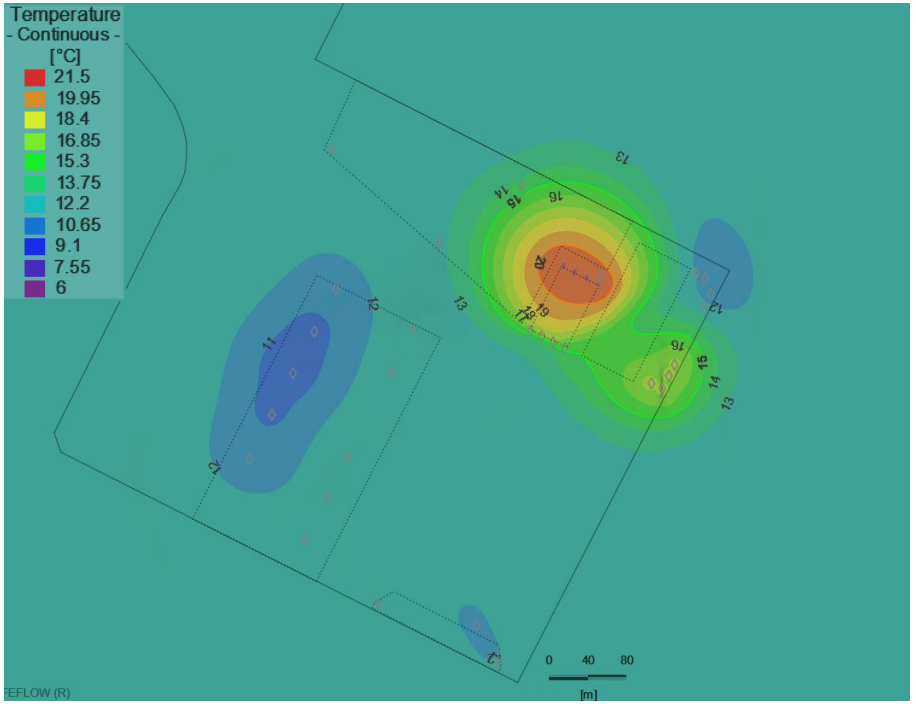


Hot and cold plumes in the shallow aquifer – Scenario 1 after 10 years of operating building 5 (2035)

End of winter

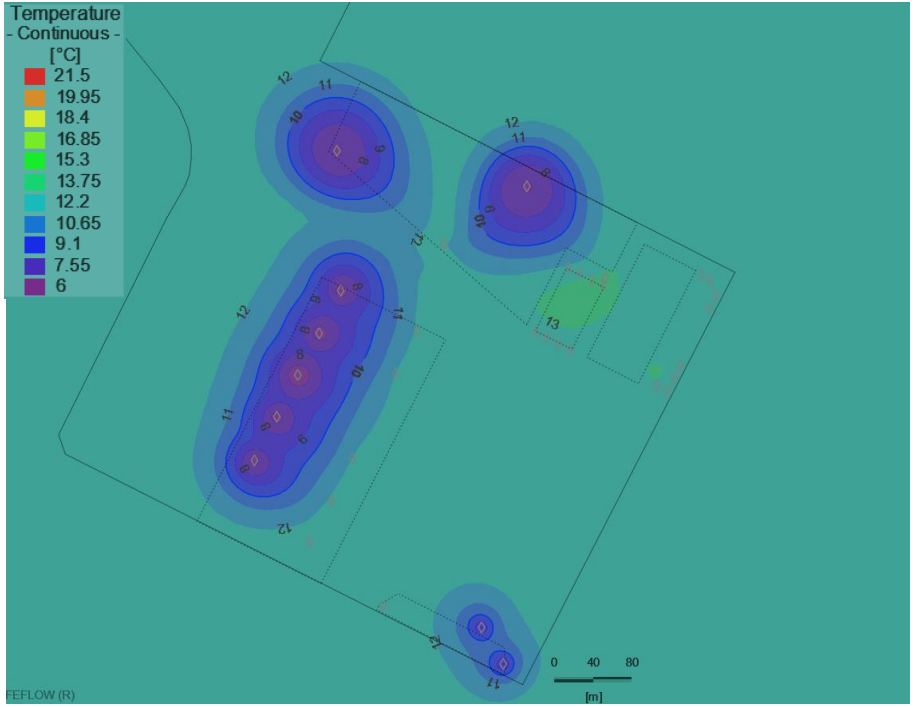


End of summer

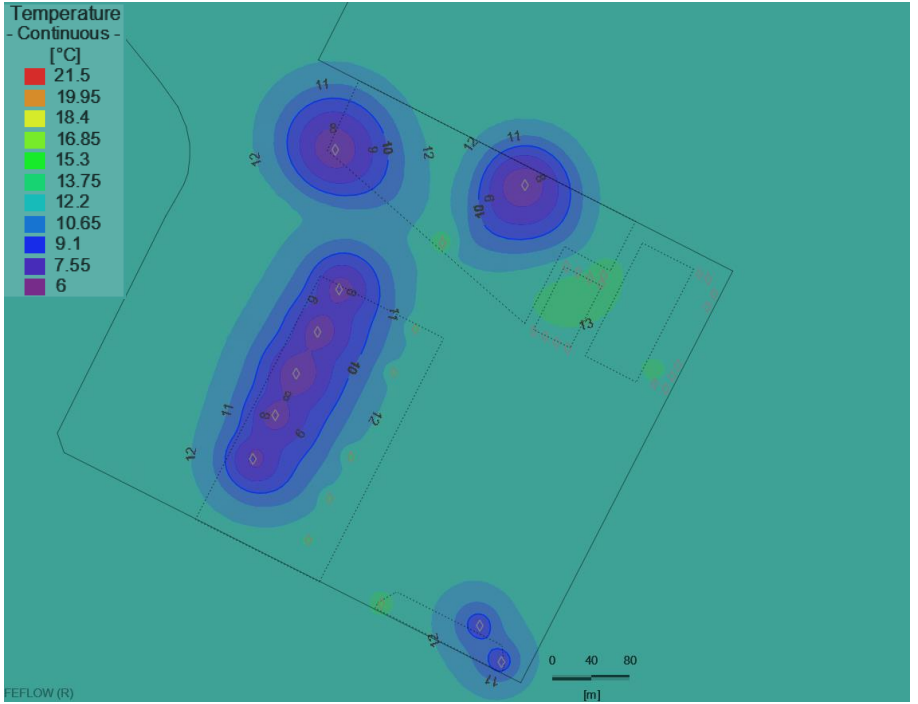


Hot and cold plumes in the deep aquifer – Scenario 1 after 10,5 years of operating building 5 (2035)

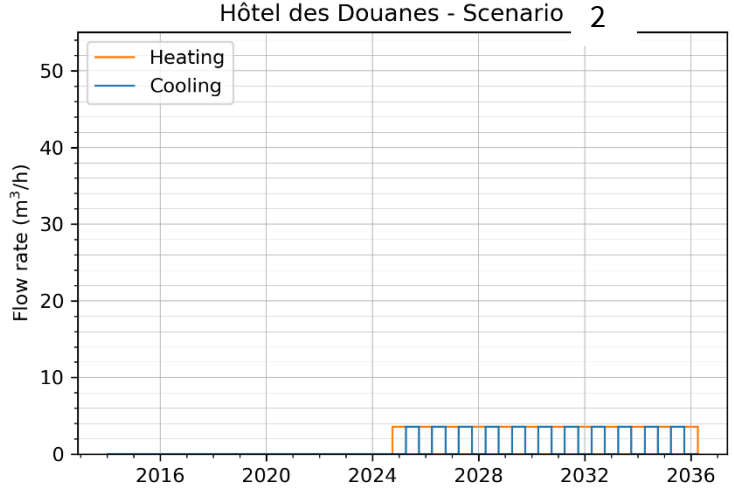
End of winter



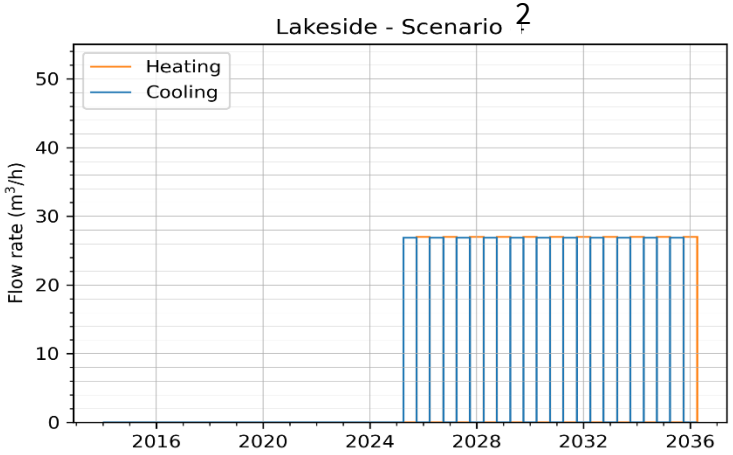
End of summer



ATES main characteristics : Building 4 and 5



Heating : October 1st – March 31st
Cooling : April 1st – September 30th
Start : 1st November 2024

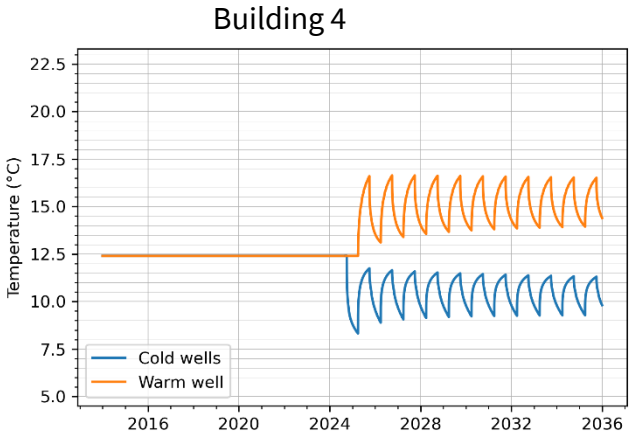


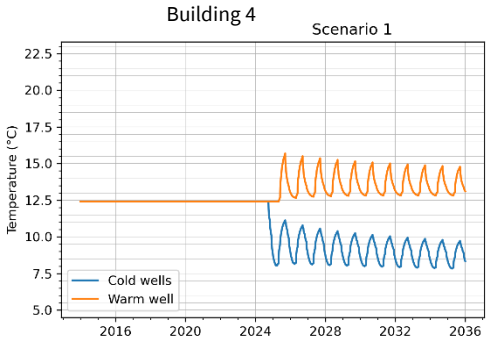
Heating : October 1st – March 31st
Cooling : April 1st – September 30th
Start : 1st April 2025

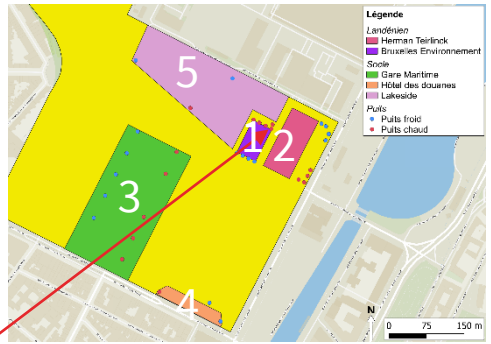
Deep aquifer, $\Delta T = 6°C$
Cooling demand = Heating demand

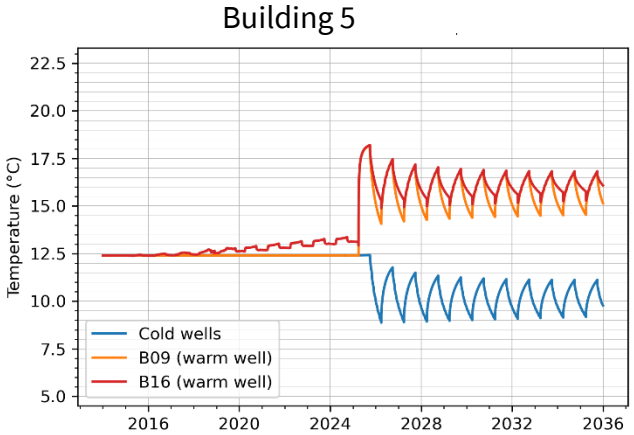
Temperature evolution in the hot and cold wells

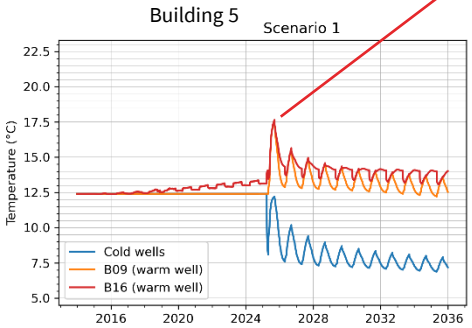
Scenario 2: deep aquifer





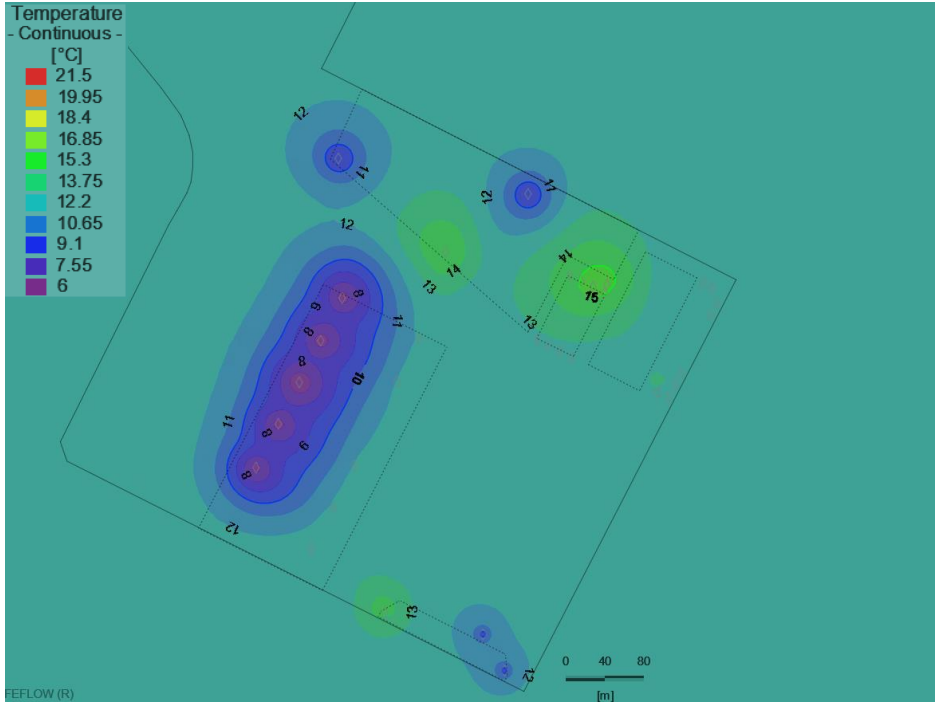




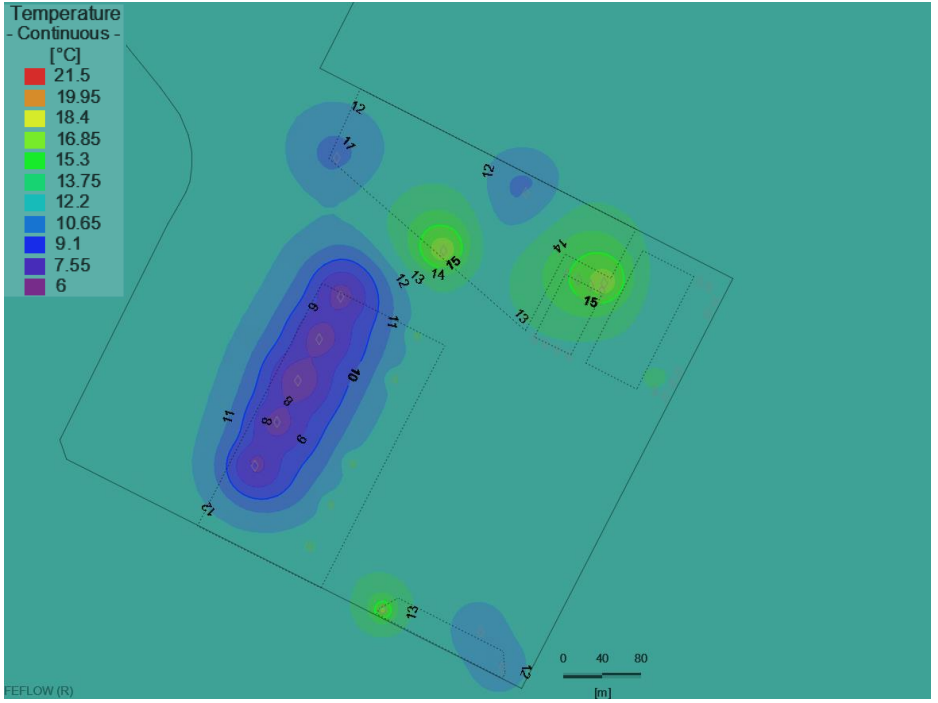


Hot and cold plumes in the deep aquifer – Scenario 2 after 10,5 years of operating building 5 (2035)

End of winter



End of summer



Conclusions, lessons …

- Advection remains limited and the storage is efficient but the cool and heat demands have to be balanced

- Limited heat transfers simulated between the two aquifers through the aquitard and no significant impact on the efficiency of the individual systems

- New data should be collected (pressure and temperature in the wells) but also temperature in the aquifer

- Data on the real heating and cooling demands of the buildings are needed to improve the model

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