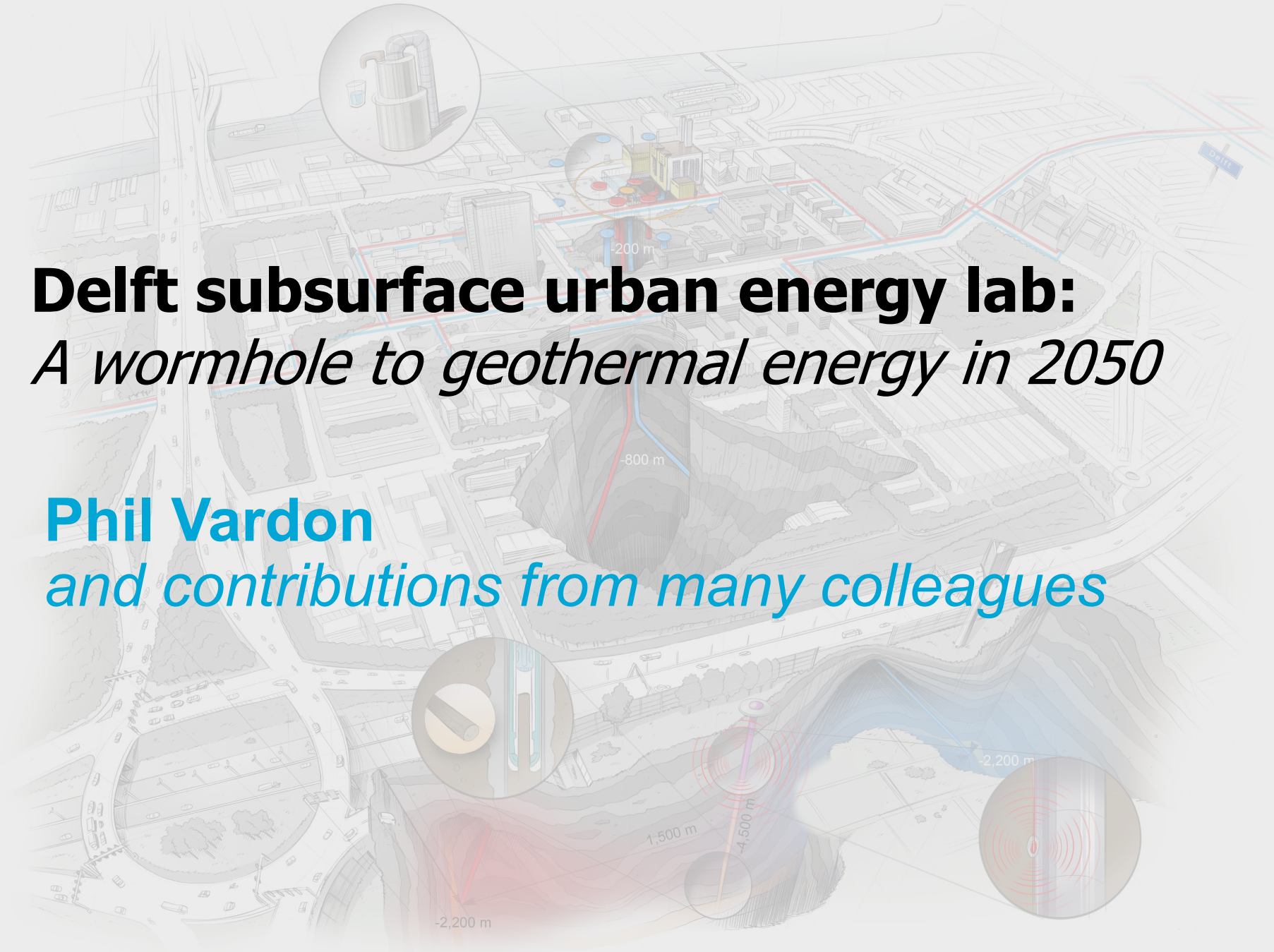
Delft subsurface urban energy lab:

A wormhole to geothermal energy in 2050

Phil Vardon

and contributions from many colleagues



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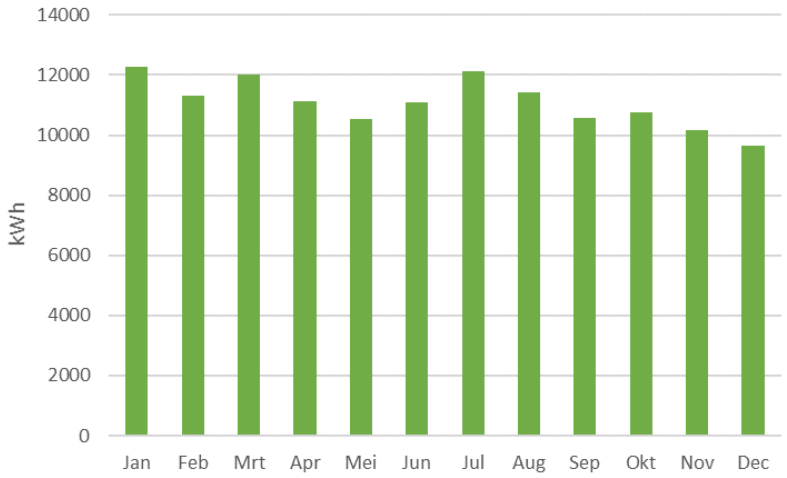
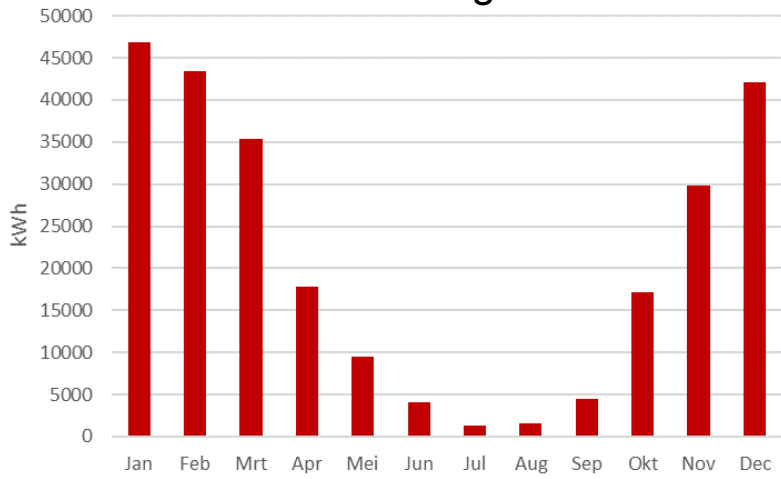
Energy usage – typical NL

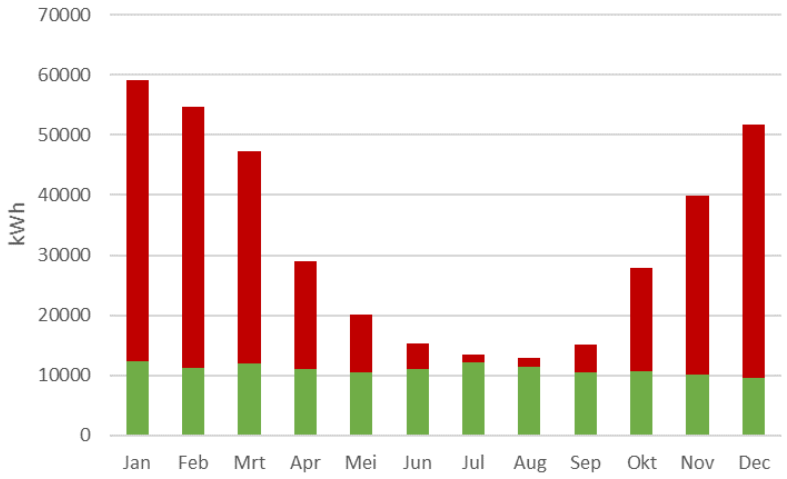
Electricity usage



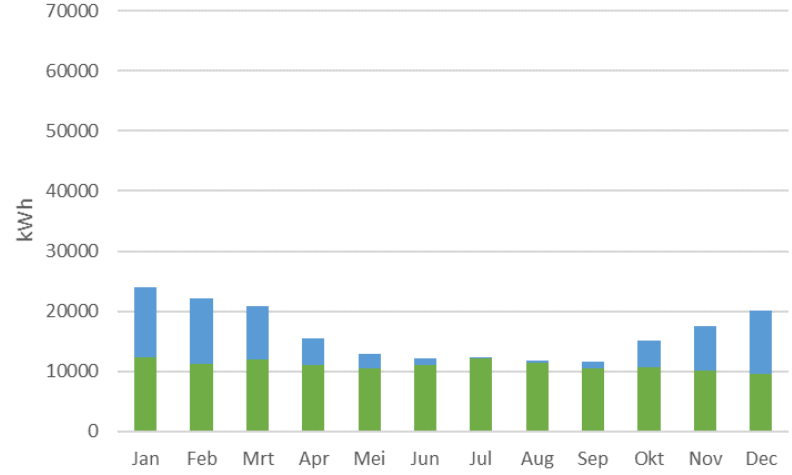
Gas usage



Electricity and gas usage



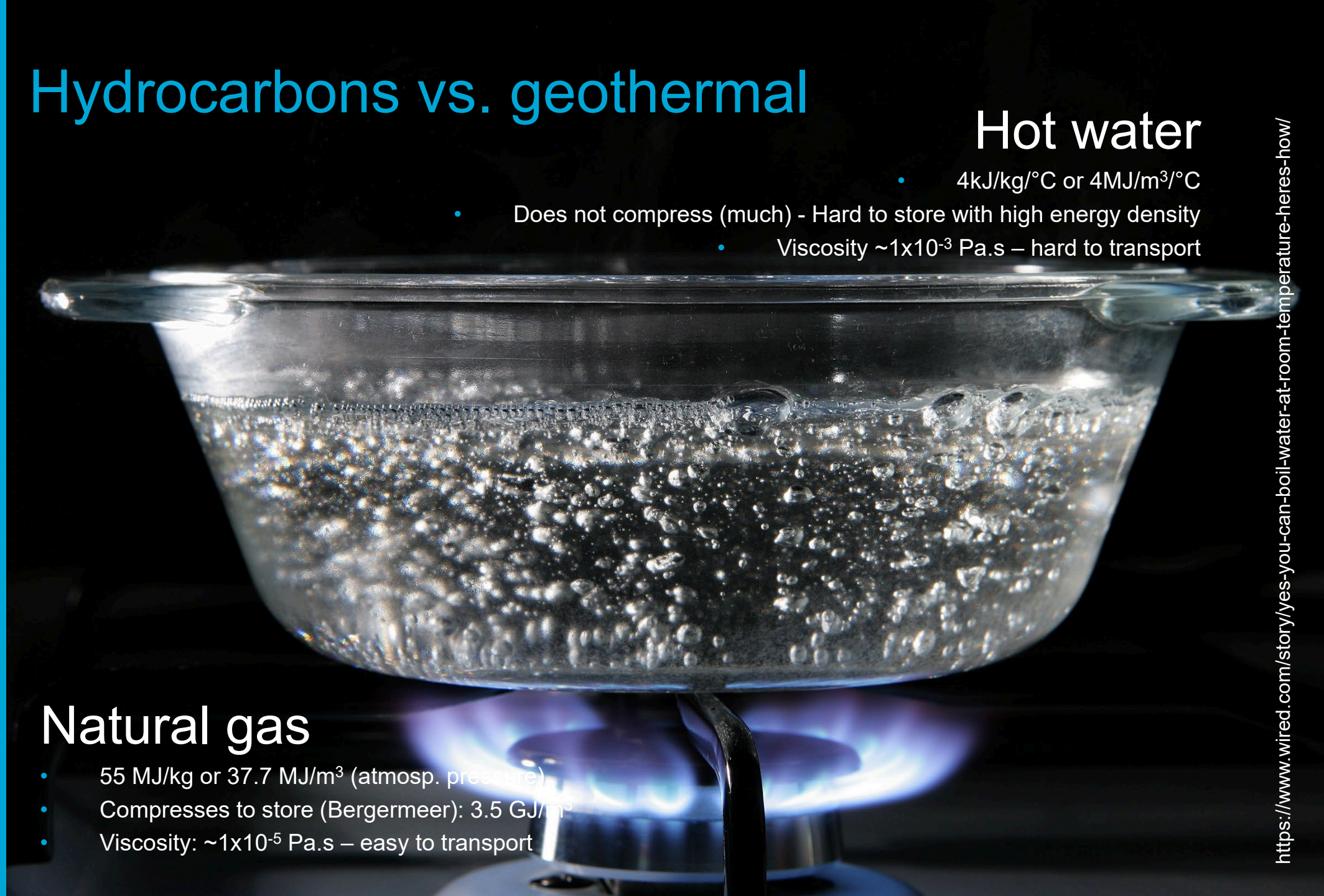
Electricity (incl. for heatpump) usage



Hydrocarbons vs. geothermal

Hot water

- 4kJ/kg/°C or 4MJ/m^3/°C
- Does not compress (much) - Hard to store with high energy density
- Viscosity ~1x10^{-3} Pa.s – hard to transport



Natural gas

- 55 MJ/kg or 37.7 MJ/m^3 (atmosp. pressure)
- Compresses to store (Bergermeer): 3.5 GJ/m^3
- Viscosity: ~1x10^{-5} Pa.s – easy to transport

https://www.wired.com/story/yes-you-can-boil-water-at-room-temperature-heres-how/

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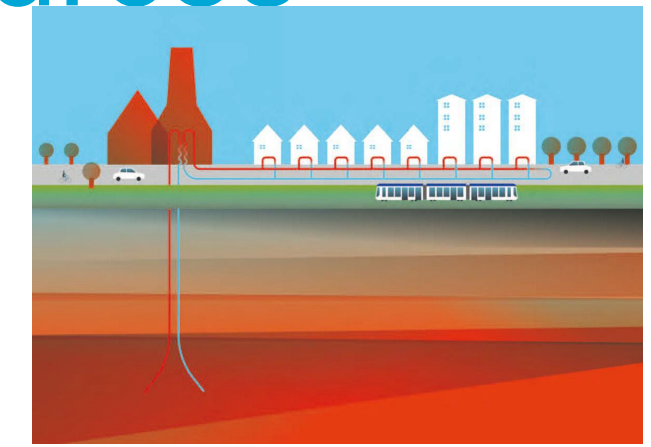
Sustainable heating sources

High/medium temperature: 50-90°C

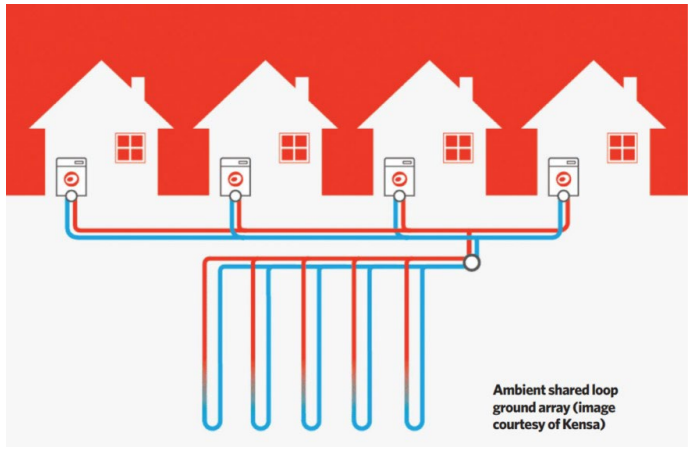
- *Geothermal*
- *Biomass*
- *Waste heat*
- *Solar thermal*



https://haagseaardwarmte.nl/aardwarmte

Low temperature: 30-50°C

- *Shallow geothermal*
- *Waste heat*
- *Solar thermal*
- *Environmental heat (soil and air)*



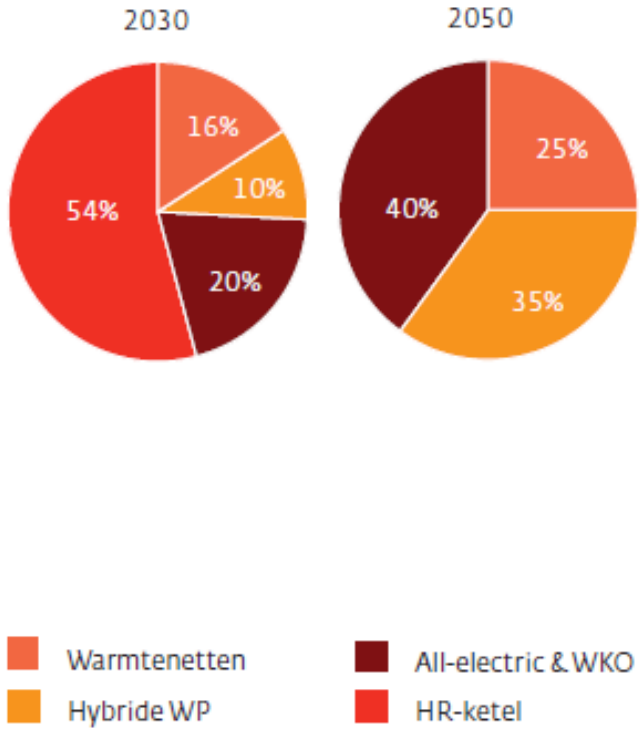
https://www.cibsejournal.com/technical/take-it-down-low/

Very low temperature: 10-20°C

- *Shallow geothermal*
- *Water*
- *Solar thermal*
- *Environmental heat (soil and air)*

In 2050….

- 700 geothermal projects in the Netherlands: there are now ~20 (EBN, 2018).
- Heat storage is needed at high temp for each project.
- Gas cannot be the peak supply.
- Heating source depends on neighbourhood and house type.

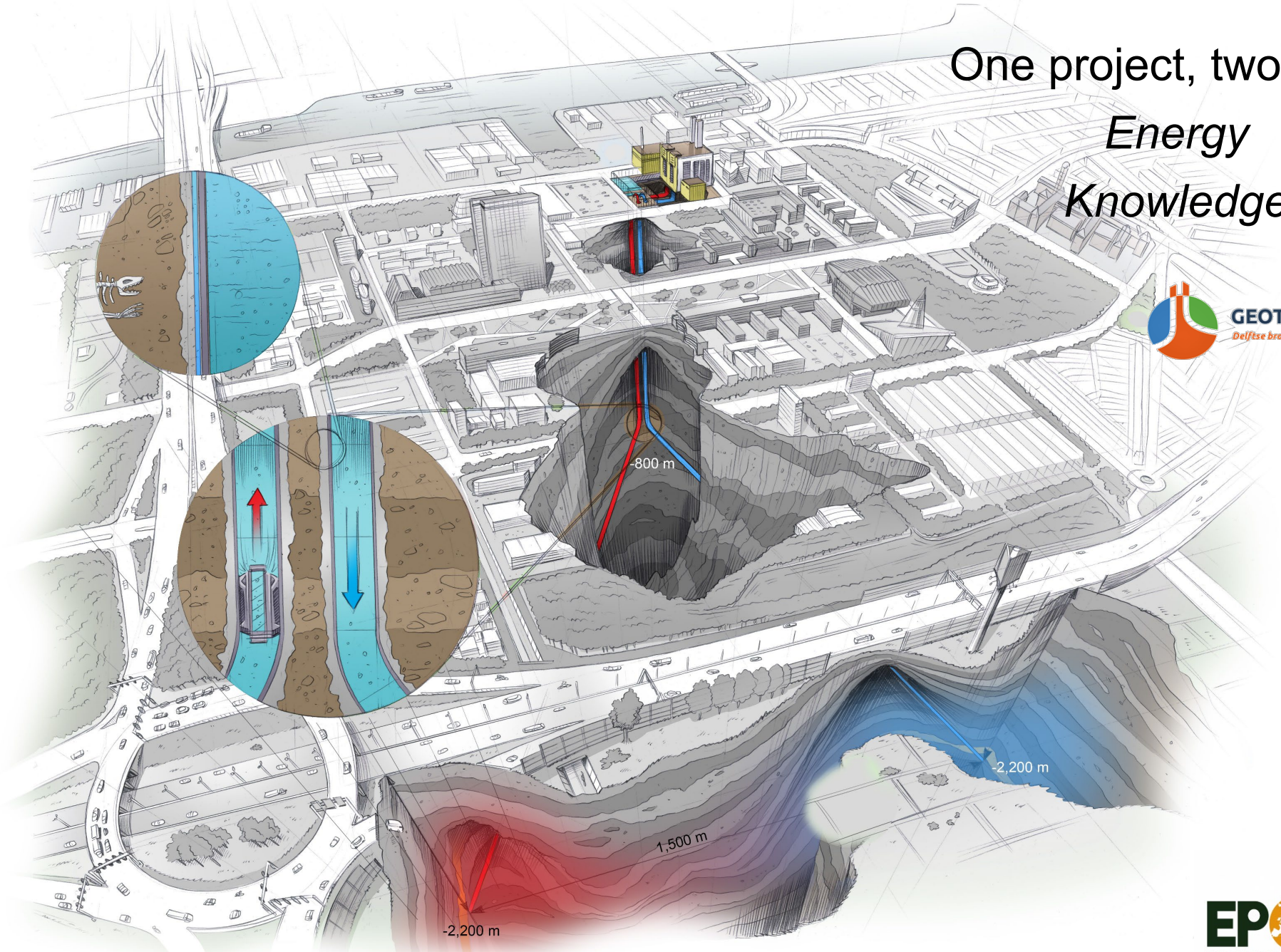


https://www.gasunie.nl/expertise/aardgas/energiemix-2050/$3170/$3171

One project, two goals

Energy

Knowledge



GEOTHERMIE DELFT
Delftse bron van duurzame energie en kennis

Aardyn
Geothermie ontwikkeling & beheer

ebn

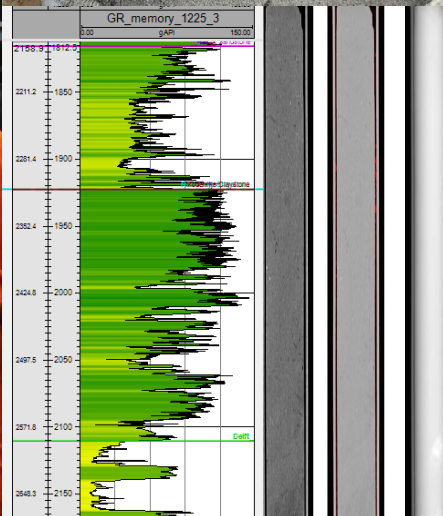
TU Delft

TU Delft

EPOS - NL
EUROPEAN PLATE OBSERVING SYSTEM NETHERLANDS

Eindsituatie Geothermie Delft


Huisman
PEINEMANN
MRT 2660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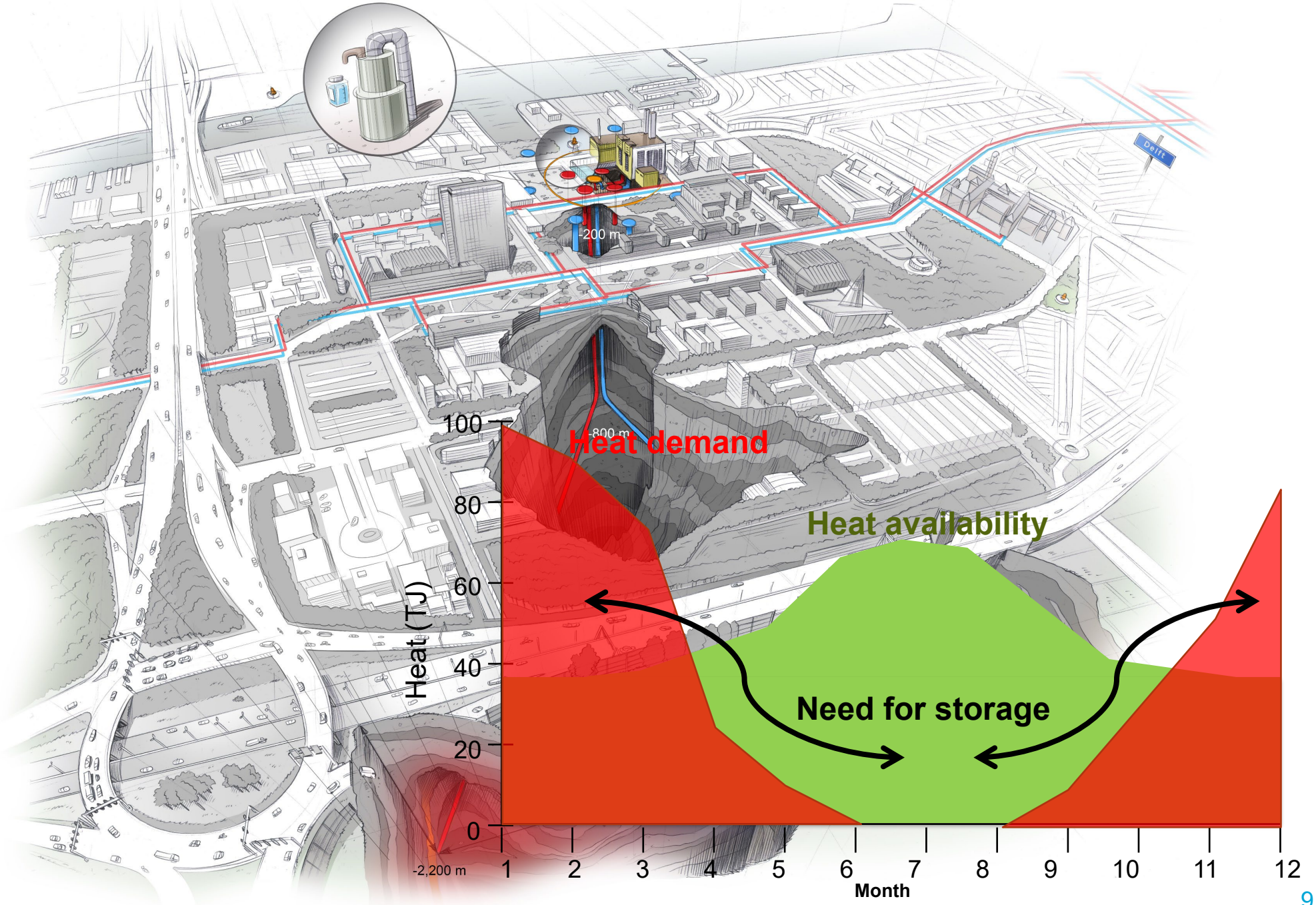


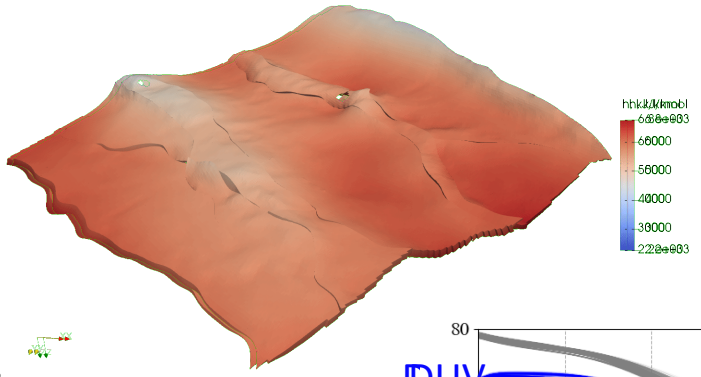
Heat demand and availability at Northern hemisphere

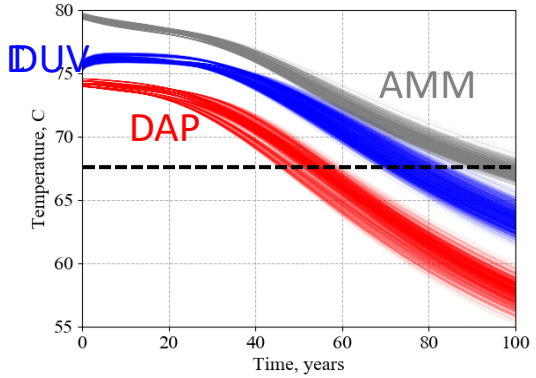
Key facts

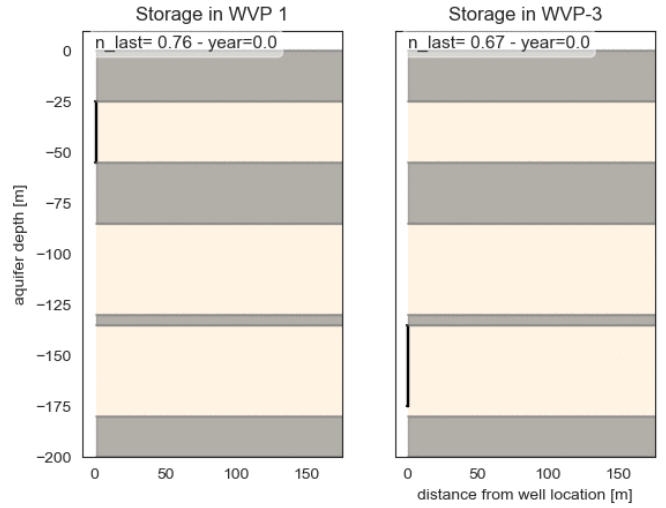
- **Energy**
  - Up to 25 MWth from geothermal source
  - Temperature ~80 °C
  - Can produce almost 365/7/24
  - Storage ~600 000m^3
  - Heating grid TU Delft: 4 tracks, 1 new track (50% of heat demand)
  - Heating grid Delft: under design (50% of heat demand)
- **System**
  - Produces brine:
    - Methane ~1 Nm^3/m^3 water (350m^3/hr)
    - Salt 10% vol
  - Heat demand in summer ~50 MW; in winter ~0 MW
  - Current heating delivery at ~110 °C

Our research questions

- **How much energy can be delivered / stored?**
  - What is the long term flow and heat flow behaviour?
  - Reliable predictions, interference, safe operating windows.
  - How does the combined system work?
- **How can we best monitor geothermal projects?**
  - For energy production / storage.
  - For surface/groundwater quality/ etc. impacts.
- **How do (new) materials / subsurface behave / perform?**
  - Reservoir variability / heterogeneity.
  - Geothermal fluids, geochemical processes, engineered materials.
- **How to improve enabling technologies?**
  - Drilling, control, testing, water treatment, model development.
- **How does society view and engage with energy projects?**
  - Perceptions, legal framework, just energy transition.







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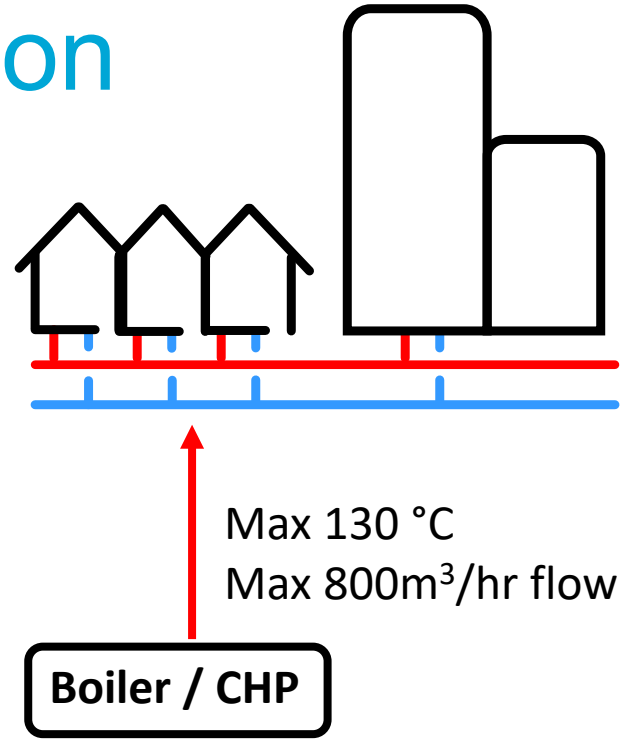
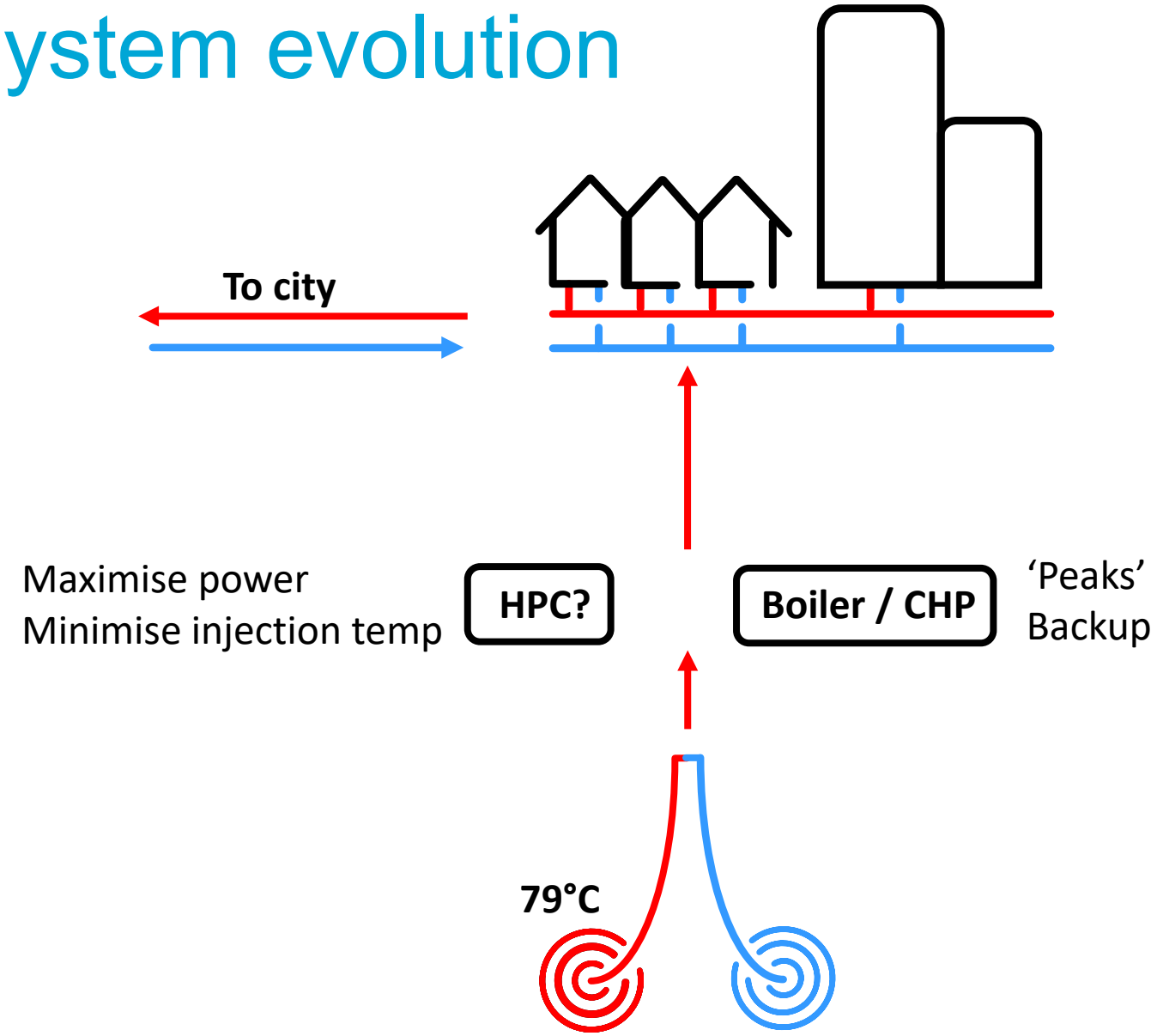
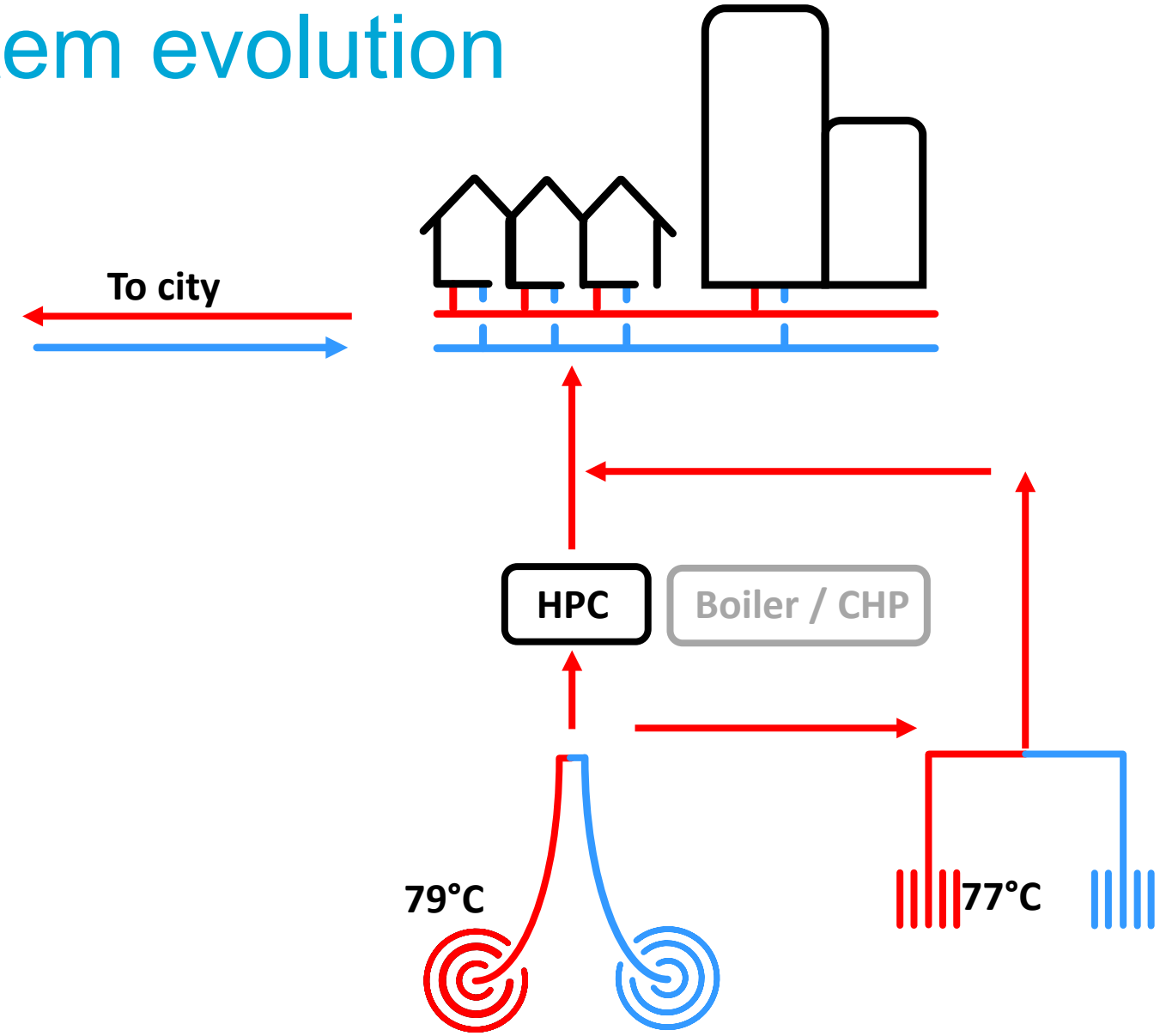
System evolution



System evolution

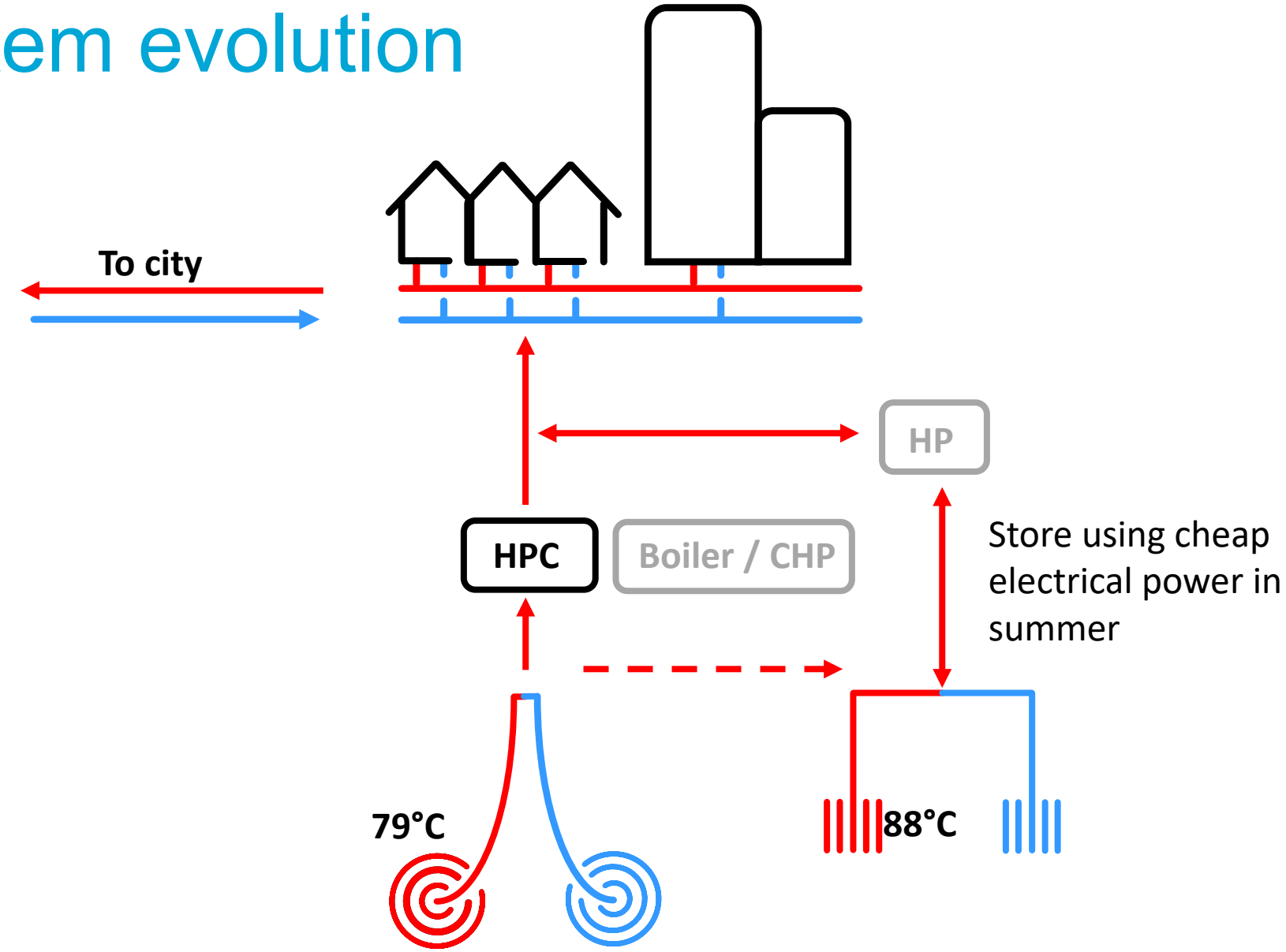


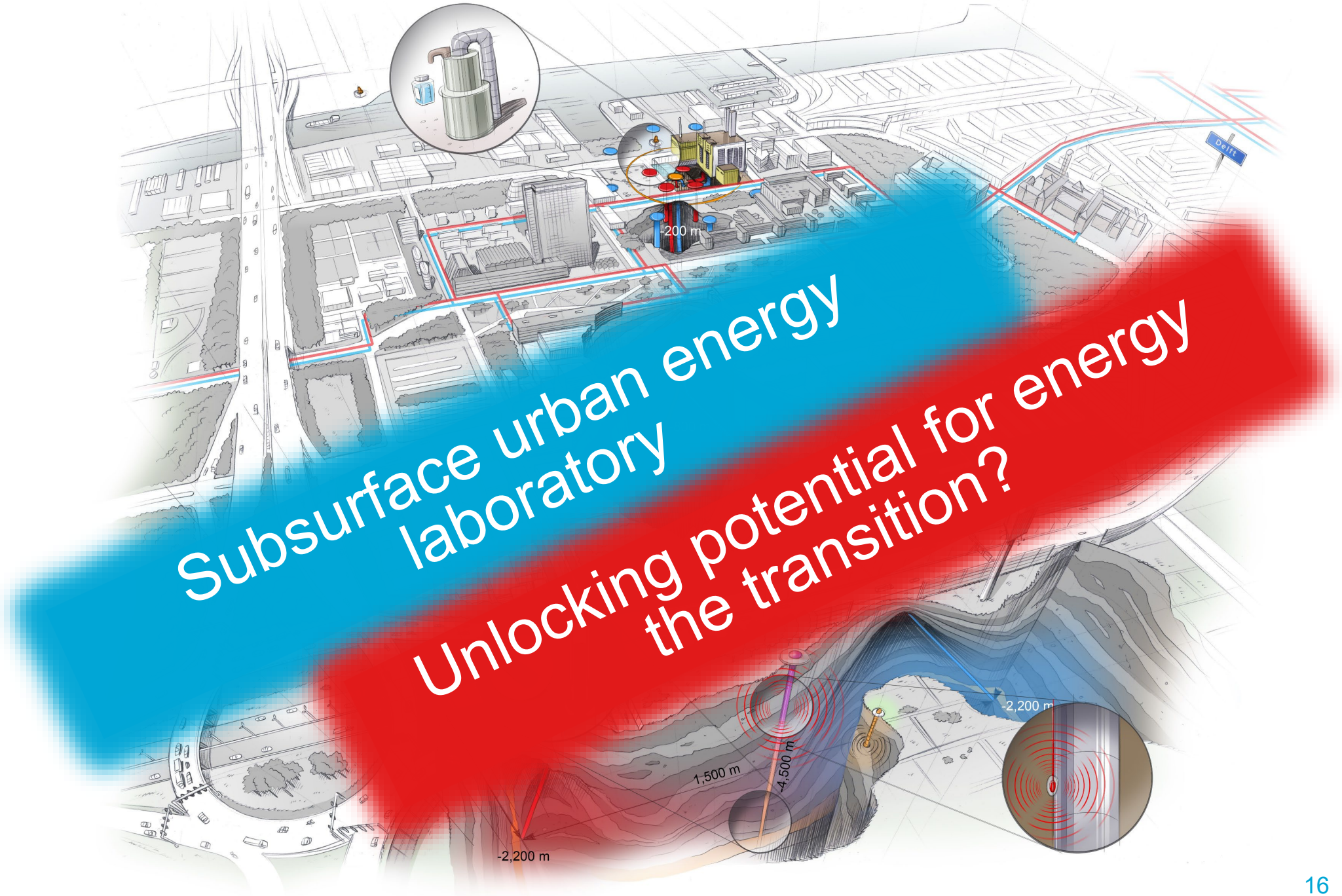
System evolution



Boiler ‘Peaks’ are much fewer

System evolution





Subsurface urban energy laboratory

Unlocking potential for energy the transition?

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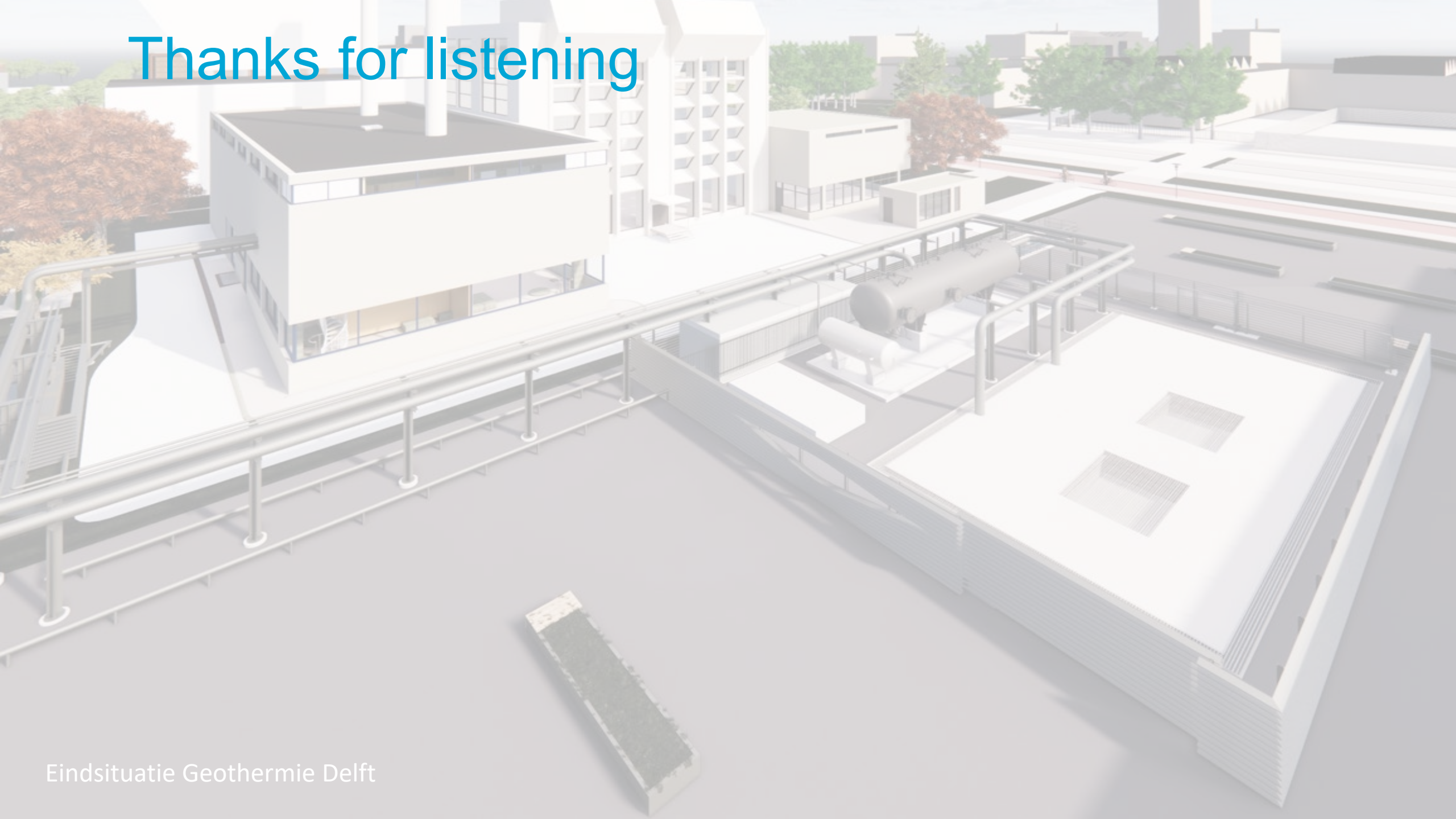
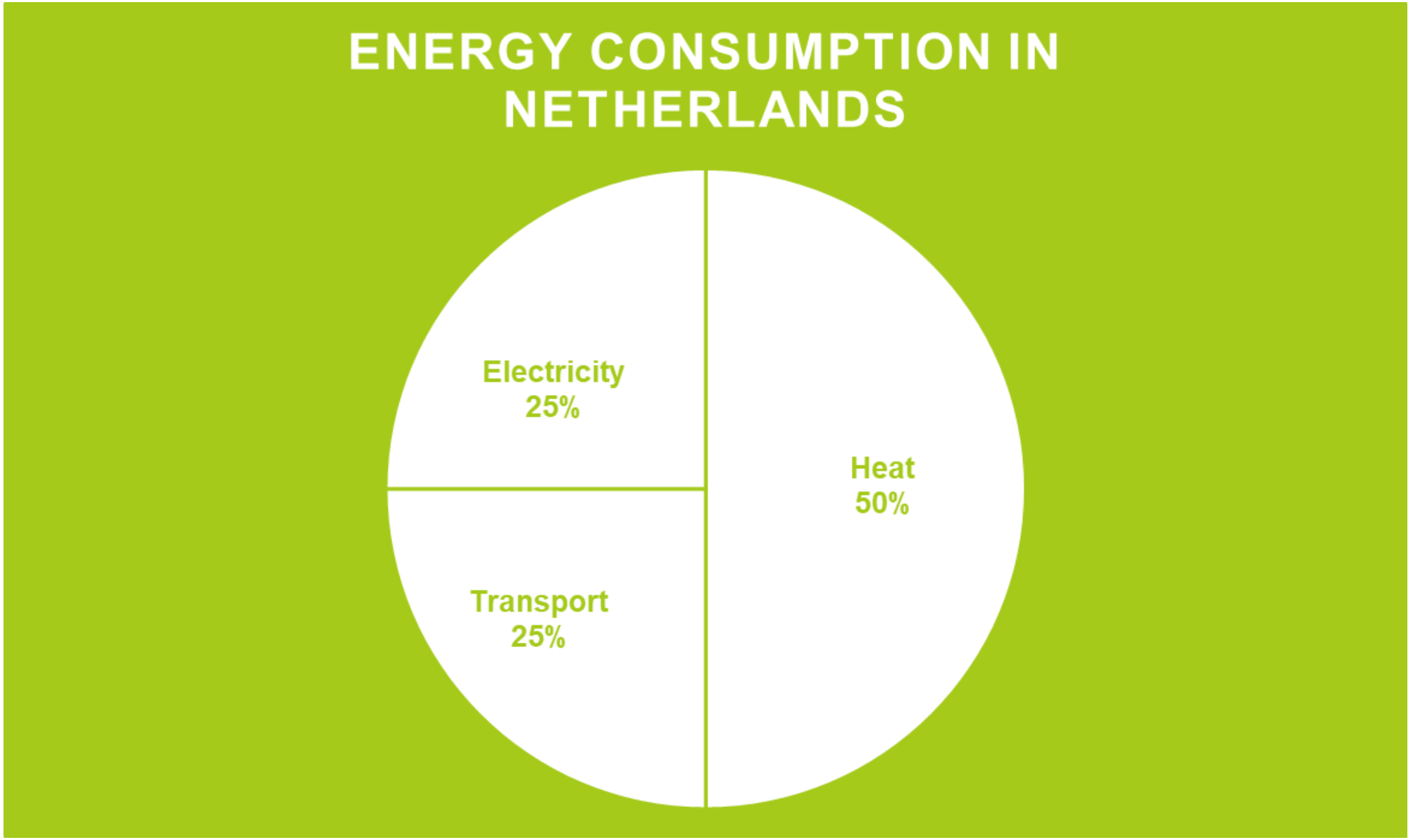
Thanks for listening



Eindsituatie Geothermie Delft



Source: CBS, 2019. Figures slightly simplified.