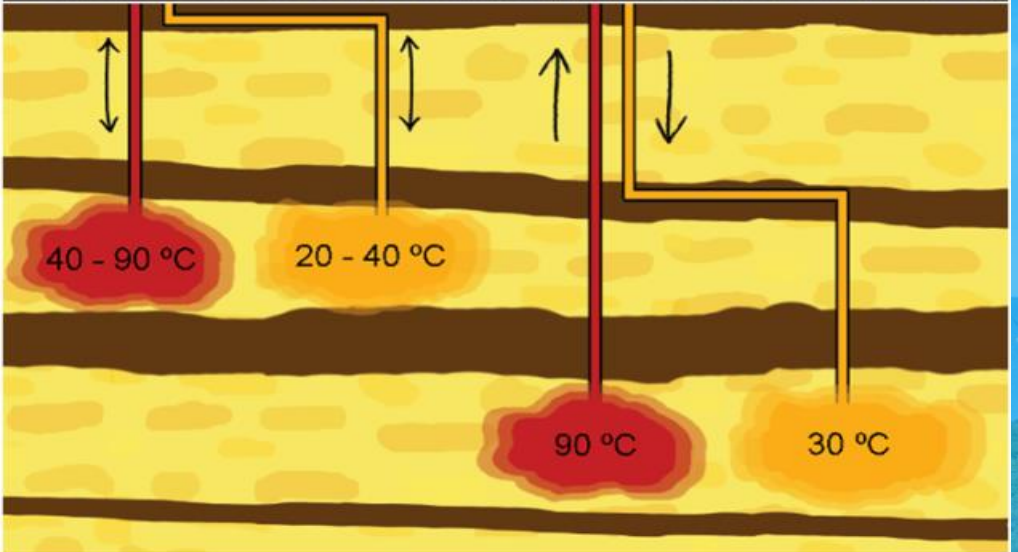


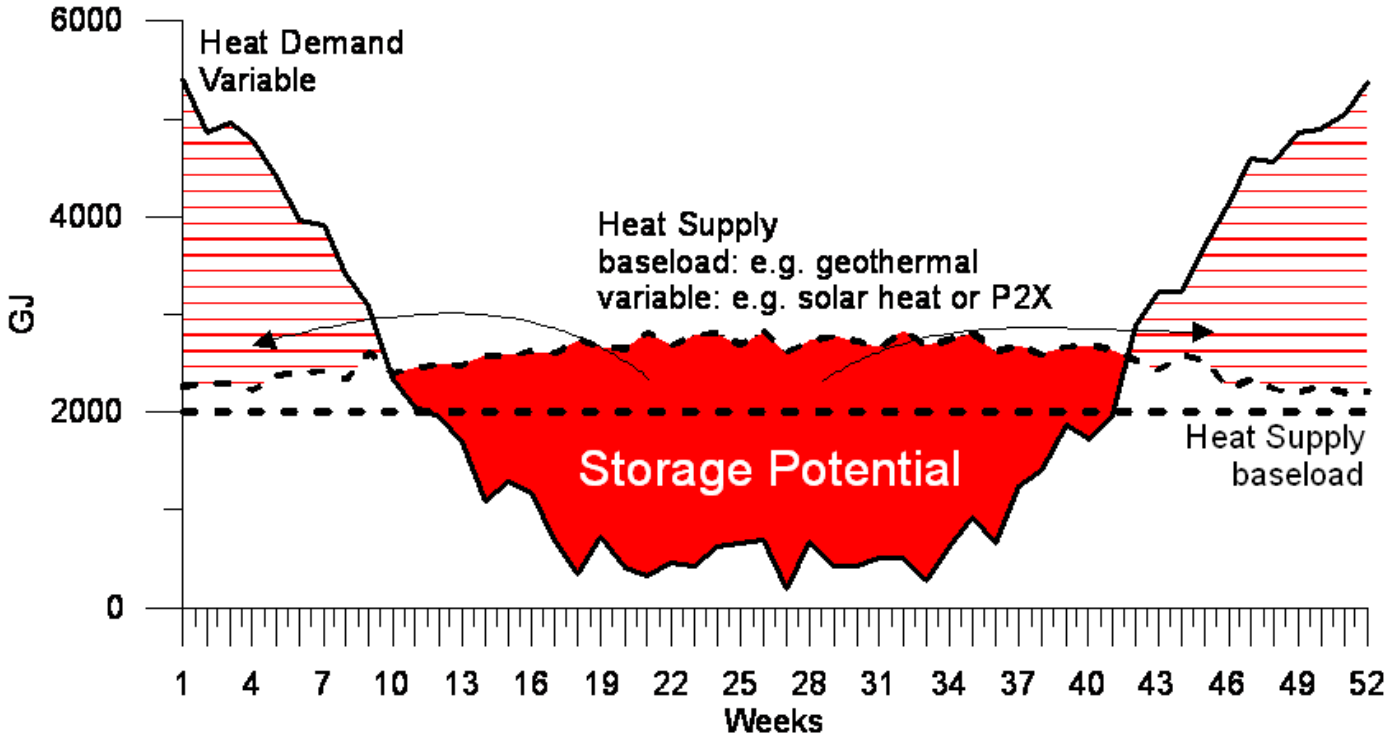
HT-ATES at the TU Delft

Feasibility of a promising technology for the future heat system

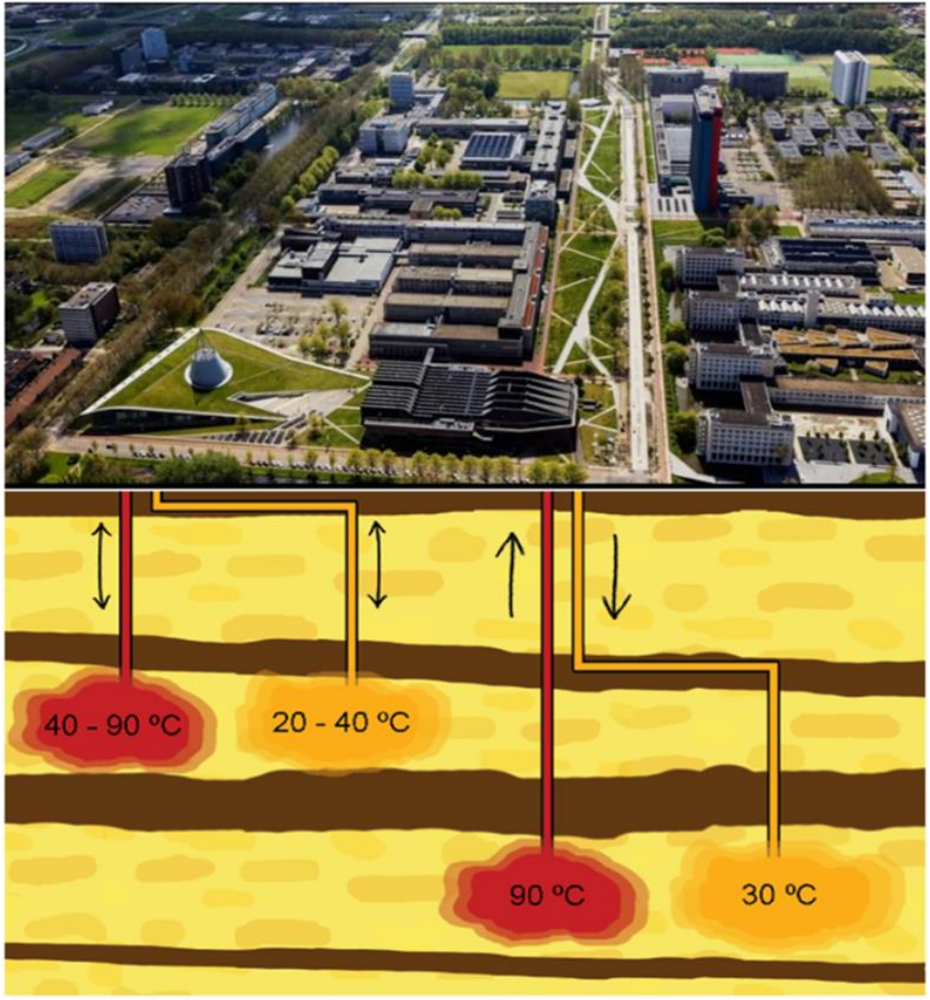
November 4, 2020

Marc Pijnenborg

Mismatch between supply and demand



HT-ATES



Goal & Consortium

Goal: Investigate the feasibility of HT-ATES and estimate the conditions this could take place:

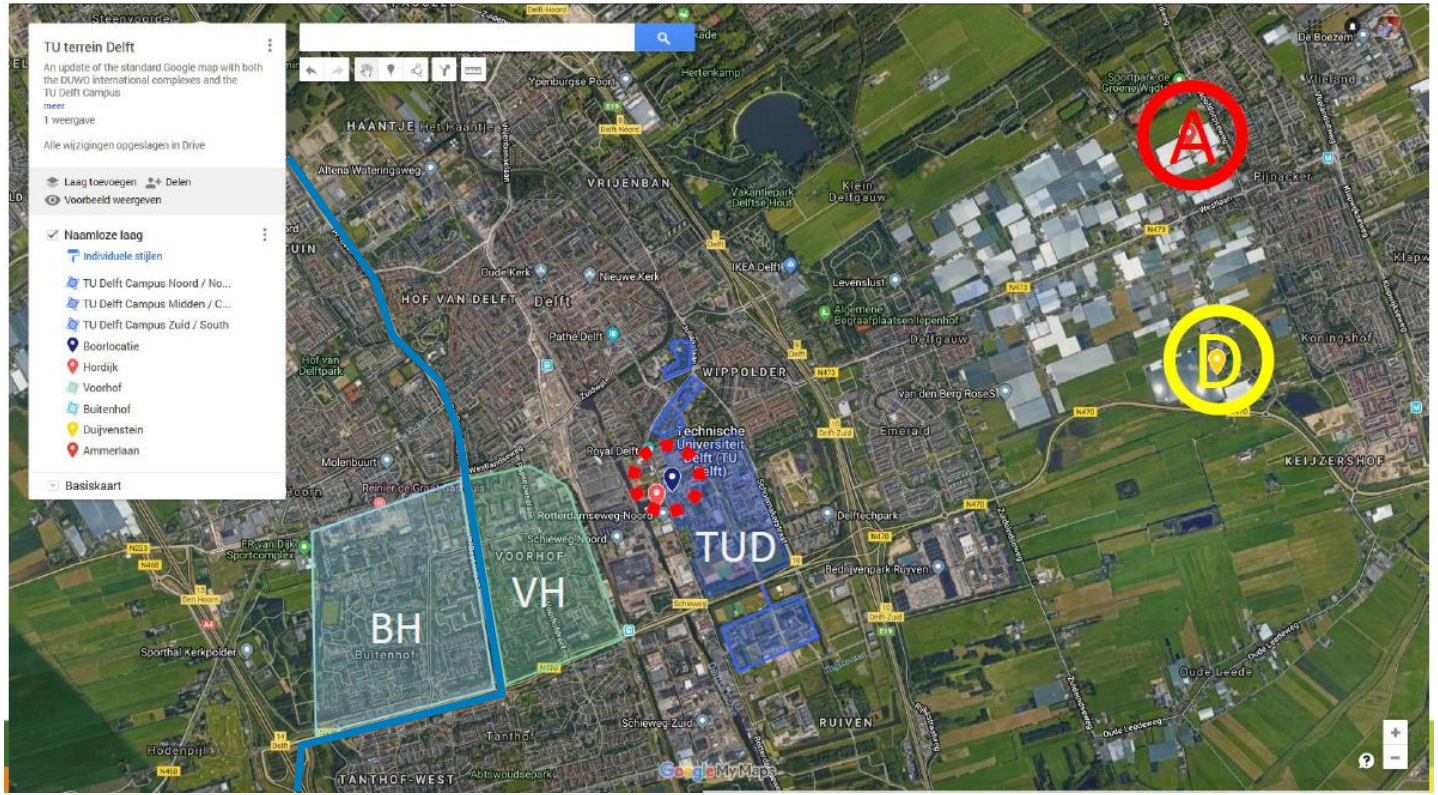
- Heat demand and availability
- Subsurface
- Preliminary design
- CO_2 savings
- Policy & permits
- Business case
- Science case

Consortium:

TU Delft — M. Bloemendal, P.J. Vardon, A. Medema, S. Snelleman, K. Marif, S. Beernink, F. van Veldhuizen

ENGIE — M. Pijnenborg, G. Sudintas, T. van Oort

Delft heat infrastructure developments



Heat sources of heat at the TU Delft

Boilers

- Peaks
- Capacity: 65-117MWth

Combined Heat and Power (CHP)

- Baseload
- Capacity: 4MWe, 4 MWth

DAPwell

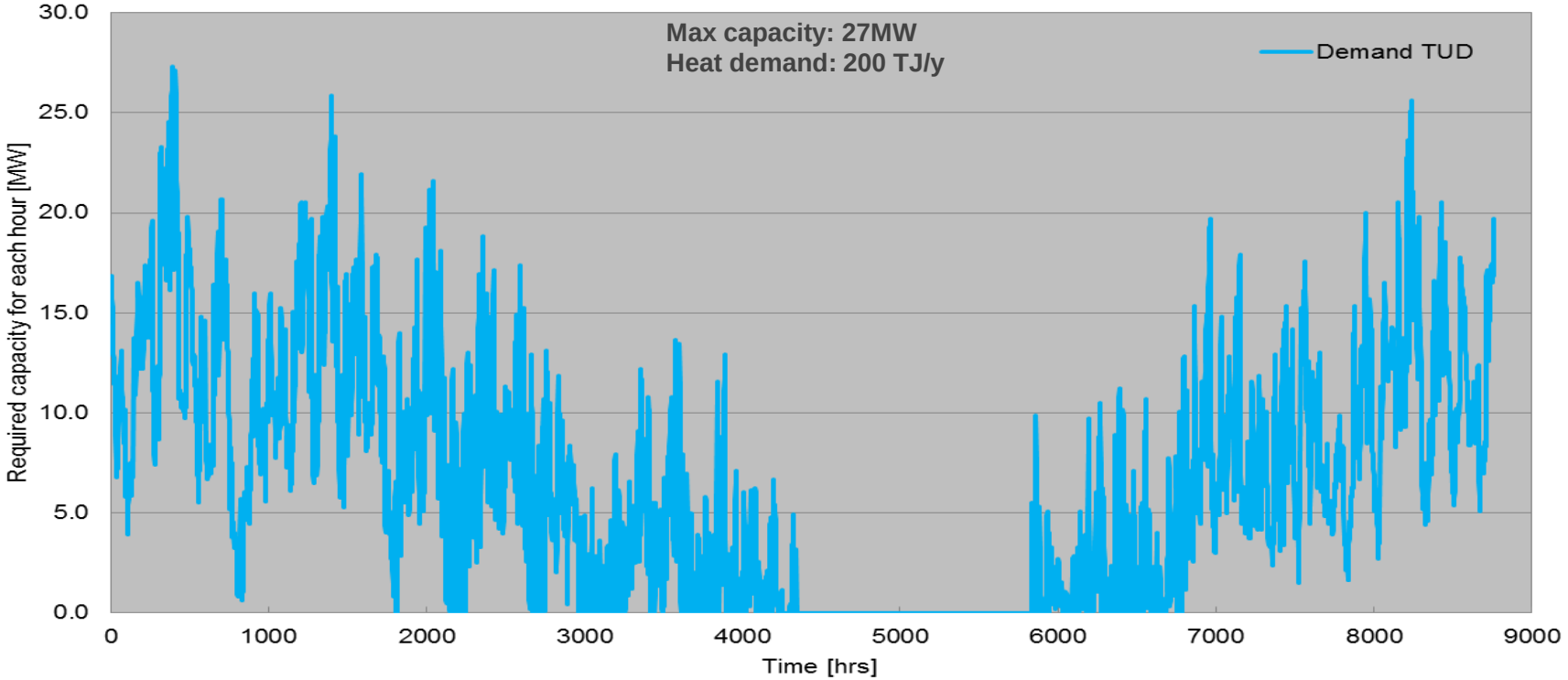
- Flow rate: ~320m3/hr
- 7.4-14.8MWth
- Production temperature: 75°C
- Heat Pump lift to 82 °C
- Project phases:
  - Drilling: End 2021
  - Heat delivery mid-2022
  - Phase I – campus only
  - Phase II – to city

2 scenarios are investigated

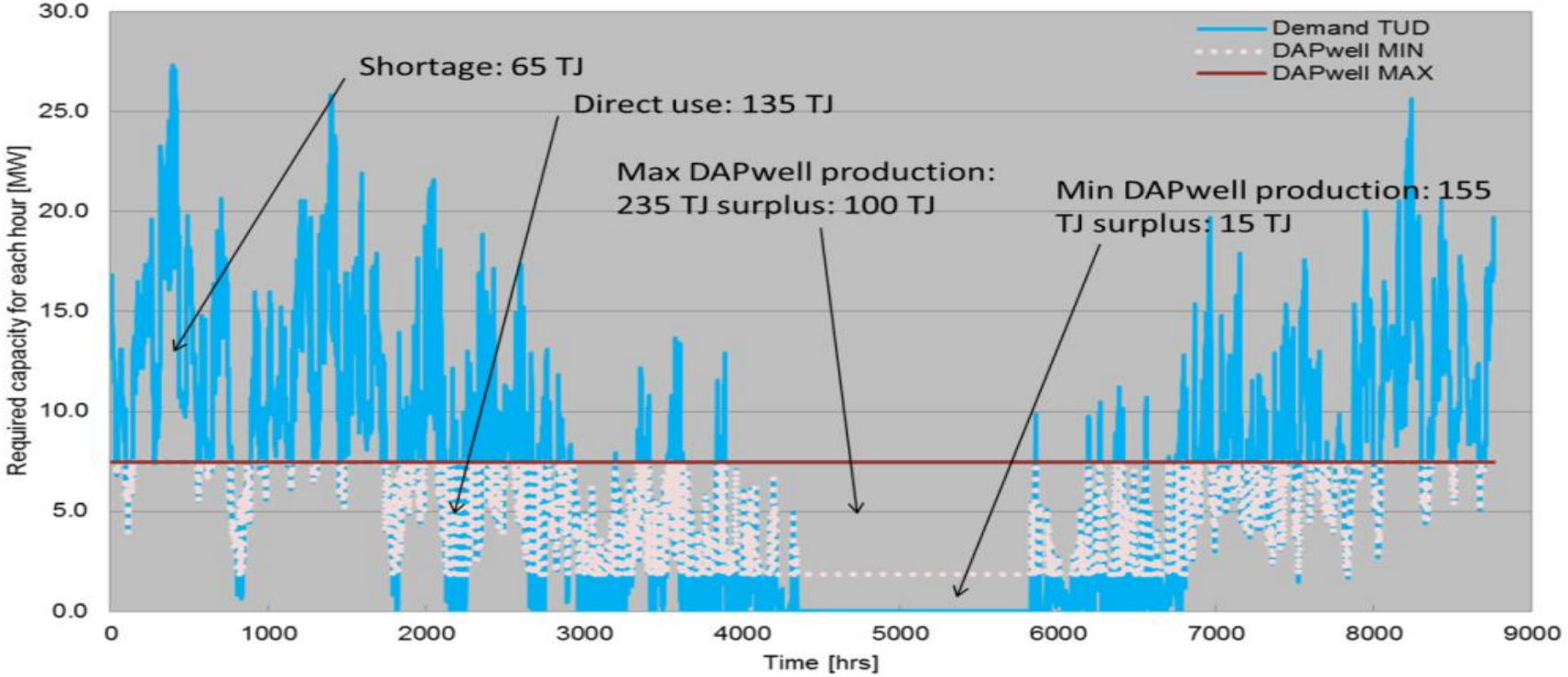
1. Heat for TU Delft campus
    - Supply 75-90 °C and return at 55-65°C

2. Heat for TU Delft campus and city of Delft
    - Return of campus is supply to the city with 55 °C and return at 35 °C
    - city follows the heat supply to the campus

Heat demand profile



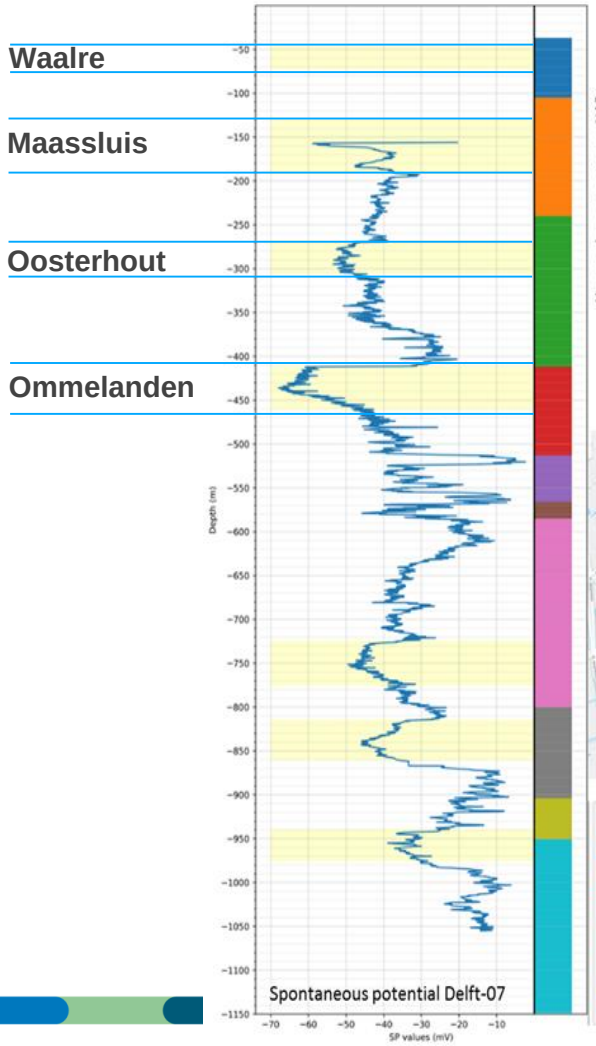
Matching demand profile

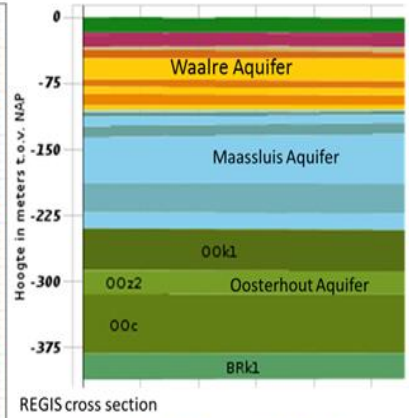


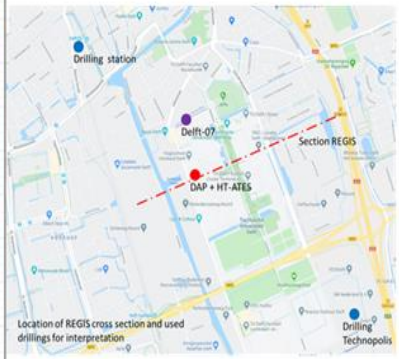
Subsurface conditions

Criteria for suitable aquifers

- Thickness
- Hydraulic conductivity (horizontal and vertical)
- Confining layers
- Risk of clogging (geochemistry / microbiology)
- Depth
- Environmental impact







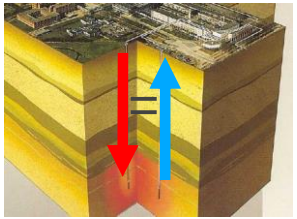
Results multi-criteria analysis

	Waalre	Maassluis	Oosterhout	Ommelanden
Thickness	*1*	*3*	*1*	*3*
Hydraulic conductivity k_v	*2*	*3*	*3*	*2*
Confining layers	*1*	*2*	*2*	*3*
TOTAL for losses	**5.3**	**9.3**	**8.0**	**9.3**
Thickness	*1*	*3*	*1*	*2*
Hydraulic conductivity k_h	*3*	*2*	*2*	*3*
Risk of clogging	*1*	*2*	*2*	*1*
Depth	*3*	*3*	*2*	*2*
TOTAL for costs	**8.0**	**10.0**	**7.0**	**8.0**
Environmental impact	*1*	*1*	*2*	*2*
TOTAL for env. impact	**4.0**	**4.0**	**8.0**	**8.0**
Total score	**17.3**	**24.7**	**23.0**	**26.7**
Percentage of maximum score	**48%**	**69%**	**64%**	**74%**

Preliminary Design

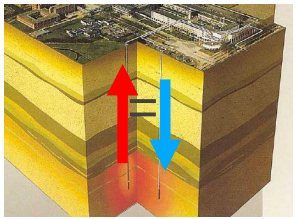
INPUTS	Maassluis	Ommelanden	Unit
Thickness / screen length	50	50	m
Hydraulic conductivity k_h	10	15	m/d
Hydraulic conductivity kv	2	5	m/d
Depth	130	410	m
Flow capacity – heat delivery	535	535	m^3/hr
Flow capacity – loading	320	320	m^3/hr
Storage volume	1	1	Mm^3/y

Operating modes



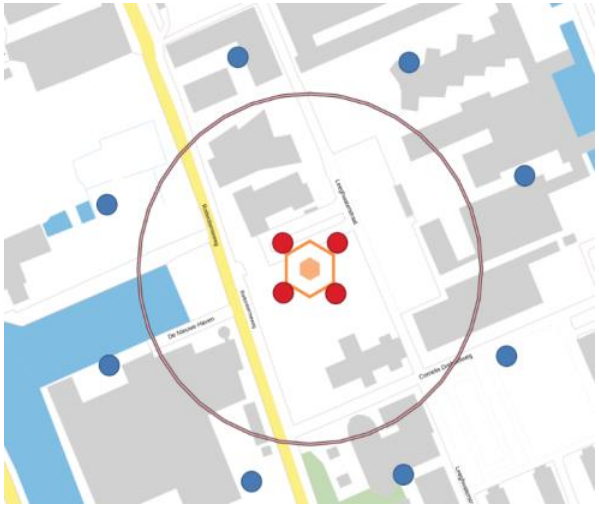
Loading 320m3/hr
→ 4 hot wells

Loading



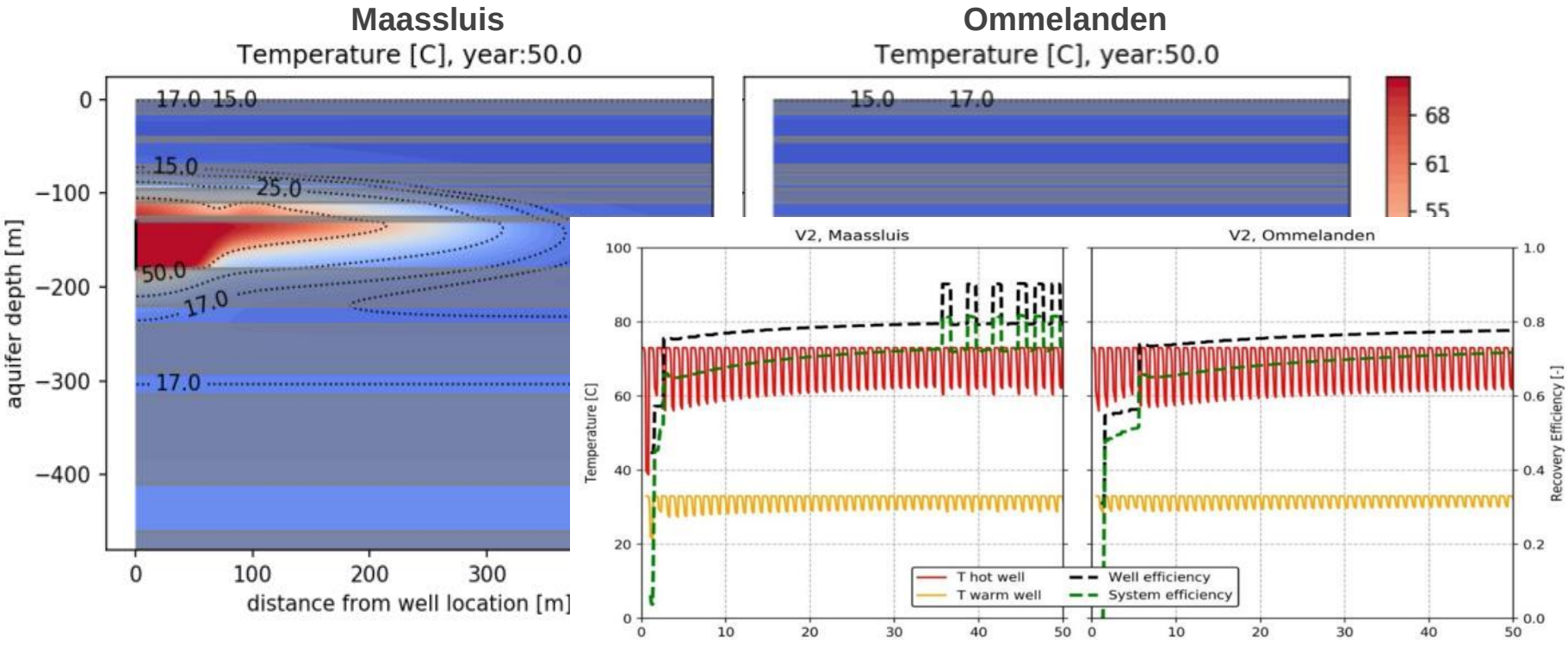
Capacity 535 m3/hr
→ 6 warm wells Ommelanden
→ 8 warm wells Maassluis

Unloading

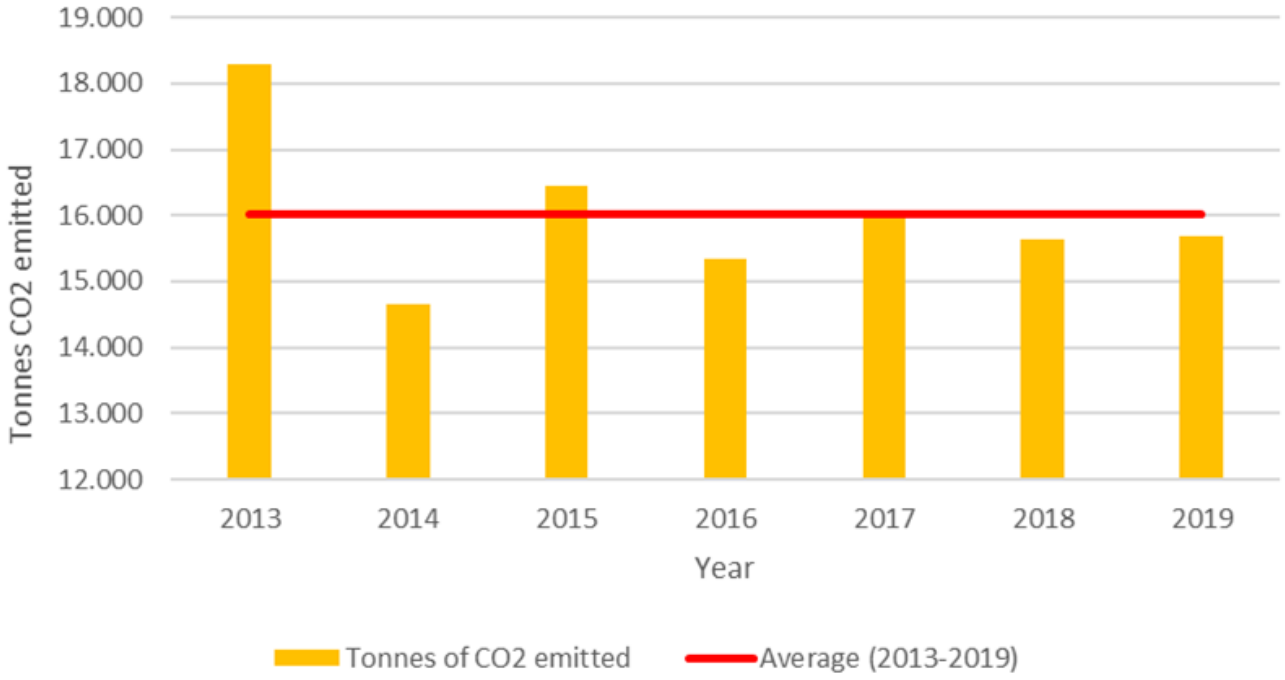


Well configuration Maassluis

Simulations - Temperature distribution after 50 years



Impact of HT-ATES on CO_2 Emissions is significant

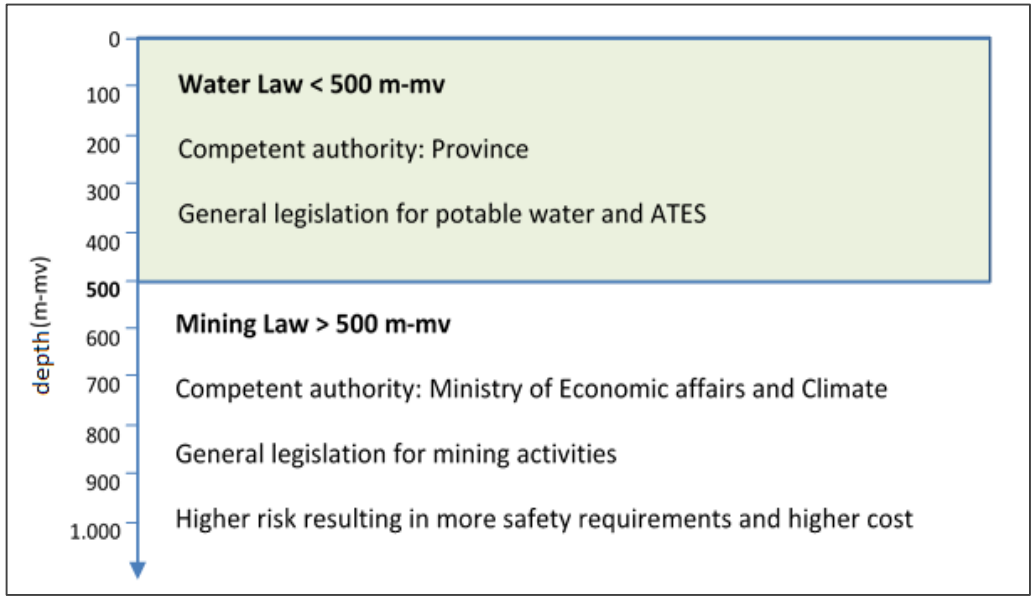


Savings HT-ATES

Scenario 1: 5000 tonnes CO_2

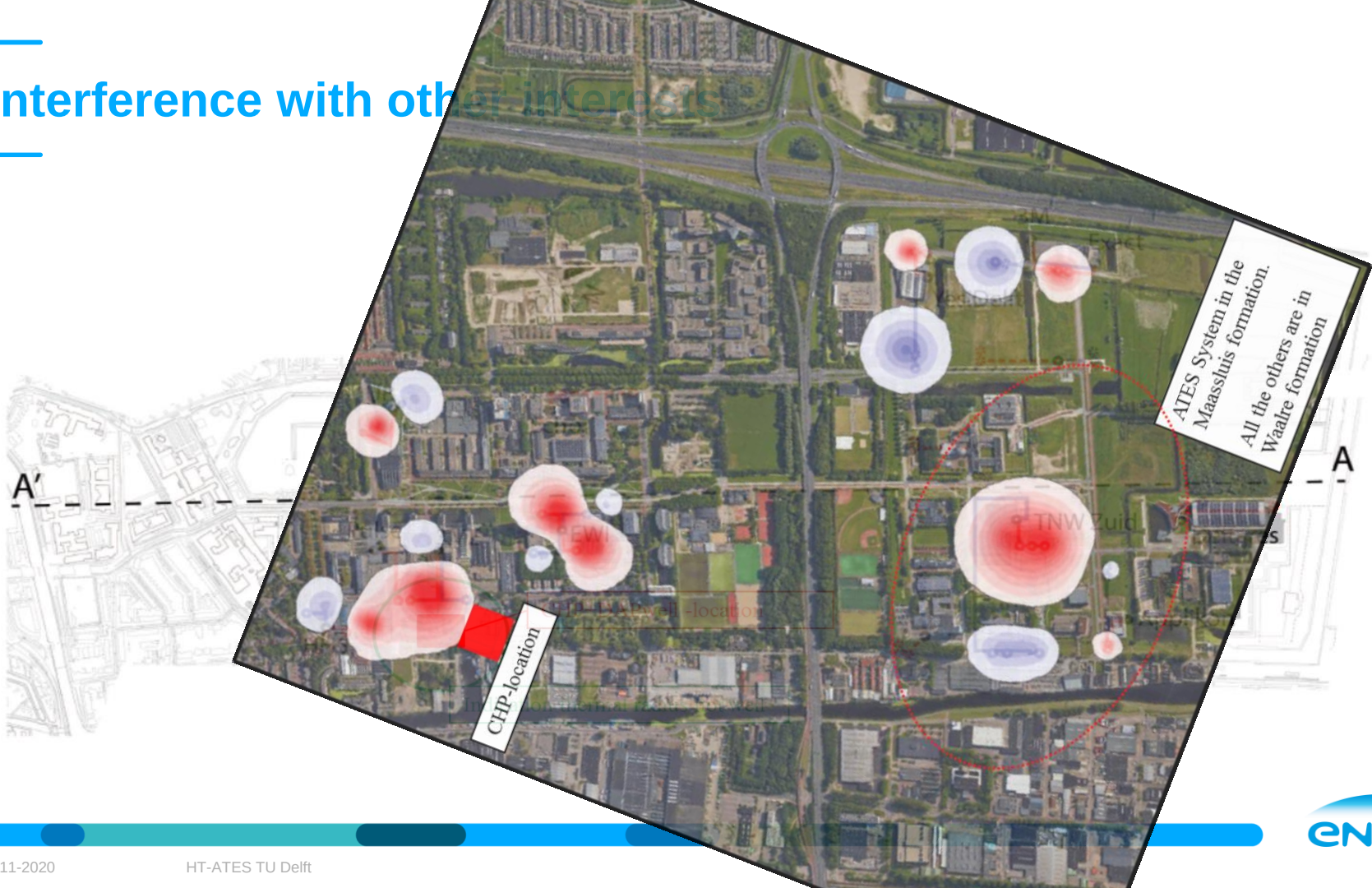
Scenario 2: 8000 tonnes CO_2

Policy & permits



- Maassluis / Ommelanden < 500m-mv
- HT-ATES does not meet the standard regulations as the infiltration temperature exceeding 25 °C and the long-term heat surplus in the soil → Exception
- Province is willing to allow pilot projects
- Water License
- Impact study to quantify the effects

Interference with other interests



Financial feasibility

System Costs

CAPEX	Maassluis	Ommelanden	Unit
HT-ATES wells	1 880	3 288	k€
Surface plant	960	900	k€
Permits, Engineering & construction	284	419	k€
Contingency	284	419	k€
Total	3 408	5 026	k€

OPEX	Maassluis	Ommelanden	Unit
Maintenance of the wells	200	238	k€
Maintenance of the surface plant	40	40	k€
Water treatment	31	31	k€
Monitoring and reporting	30	30	k€
Total	245	293	k€

Revenues

- Subsidy - SDE+
- Heat sales TU Delft
- Heat sales City

Combined Business case HT-ATES and DAPwell

Assumptions

- Operating time 30 years
- Indexation rate of 1.5%
- SDE+ subsidy for 15 years (+1 yr banking)
- Heat sales revenues over 30 years
- Discount rate on future cash flows is 5.5%
- ESP's are replaced every 5 years
- Large maintenance on the DAPwell is scheduled in the year 2037

Results

Business cases	Maassluis		Ommelanden	
	NPV k€	IRR	NPV k€	IRR
1a TUD	(11 801)	0.00%	(11 801)	0.00%
1b TUD + HT-ATES	(2 963)	3.94%	(4 364)	3.31%
2a TUD + City	1 992	6.48%	1 992	6.48%
2b TUD + City + HT-ATES	6 933	8.62%	5 121	7.73%

Conclusion
Connect the city and HT-ATES with preference for the Maassluis formation

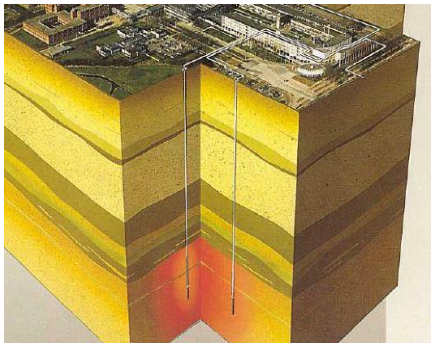
Conclusions

Heat demand and availability

- There is potential for HT-ATES to significantly contribute to the sustainable heat delivery to the TU Delft and City

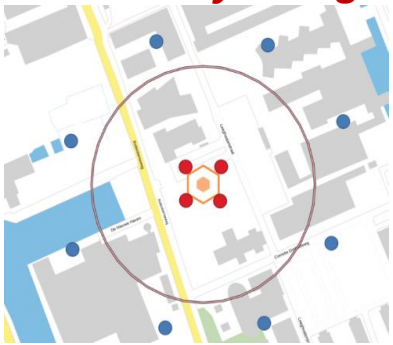
CO2 savings

Subsurface



Potential suitable layers; Maassluis & Ommelanden

Preliminary design



1Mm3, 4 hot wells, 6-8 warm wells

Policy & permits

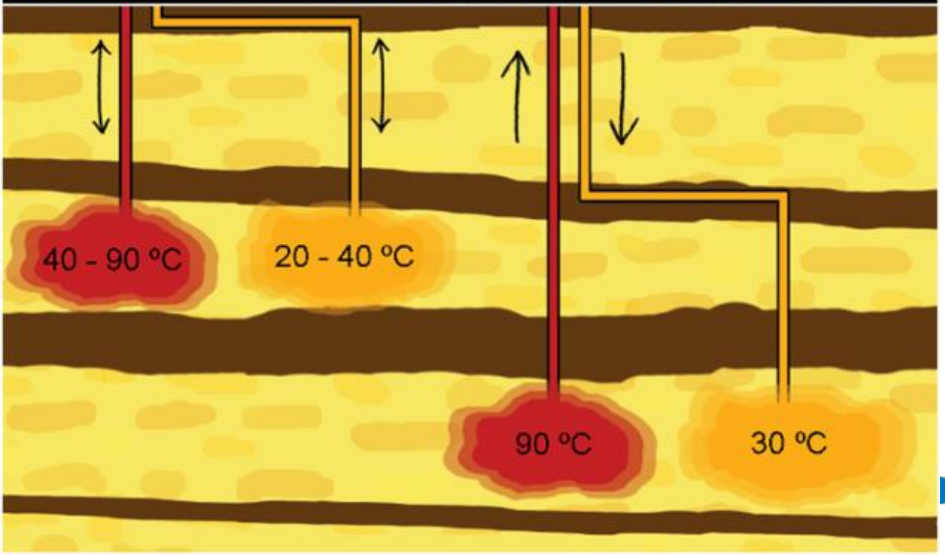
- No showstoppers

Business Case

- Connect the city and HT-ATES with preference for the Maassluis formation

Next steps

- Selection process between TU Delft and WINDOW locations
- Next phase in WarmingUp program
- Increasing level of detail of assumptions and current design
- Uncertainty reduction of Maassluis and Ommelanden formations → DAPwell and montoring well
- Quantify the effects
- Optimise the financial feasibility


40 - 90 ºC
20 - 40 ºC
90 ºC
30 ºC

?