Adaptive governance of aquifers with ATES
Use it or lose it (PPT)

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Use it, or lose it

Adaptive governance of aquifers with ATES

2017-05-18

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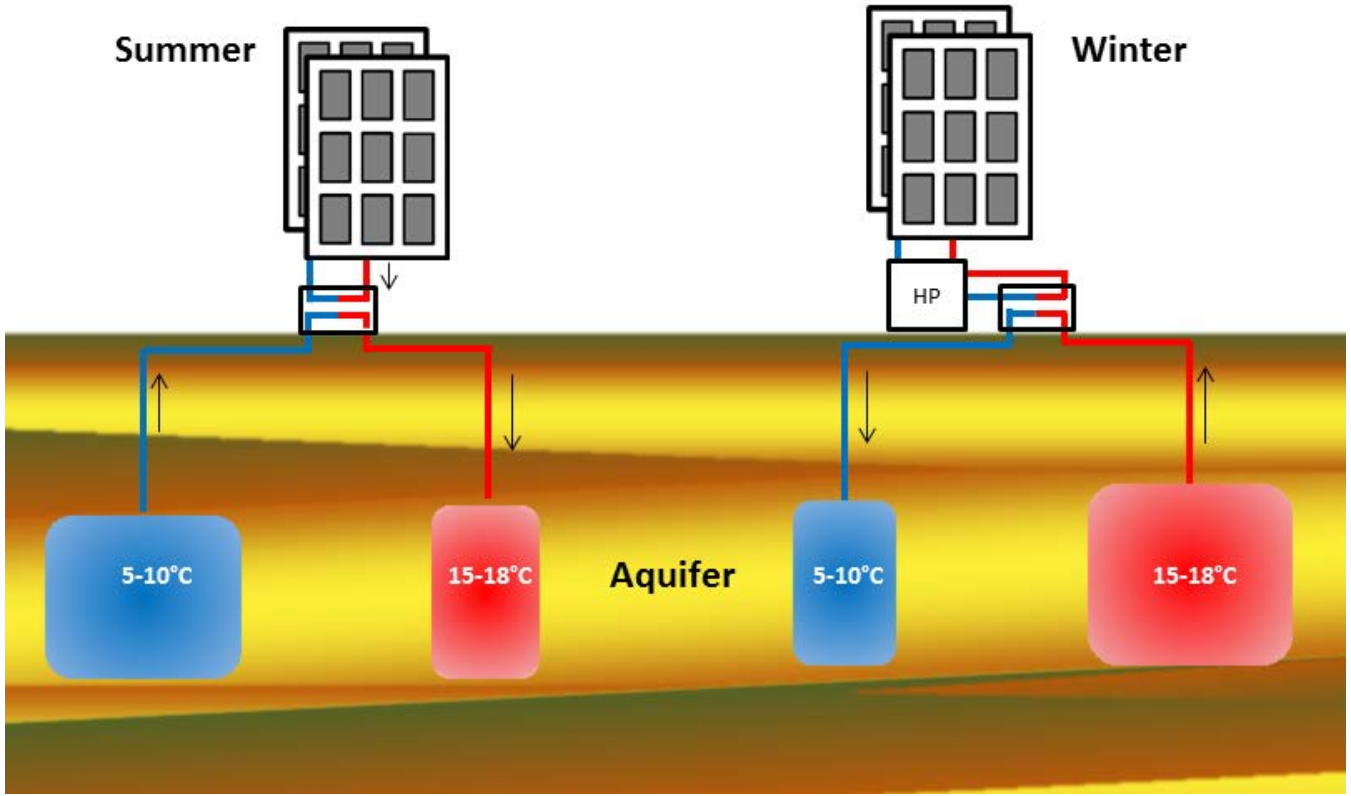
Aquifer Thermal Energy Storage



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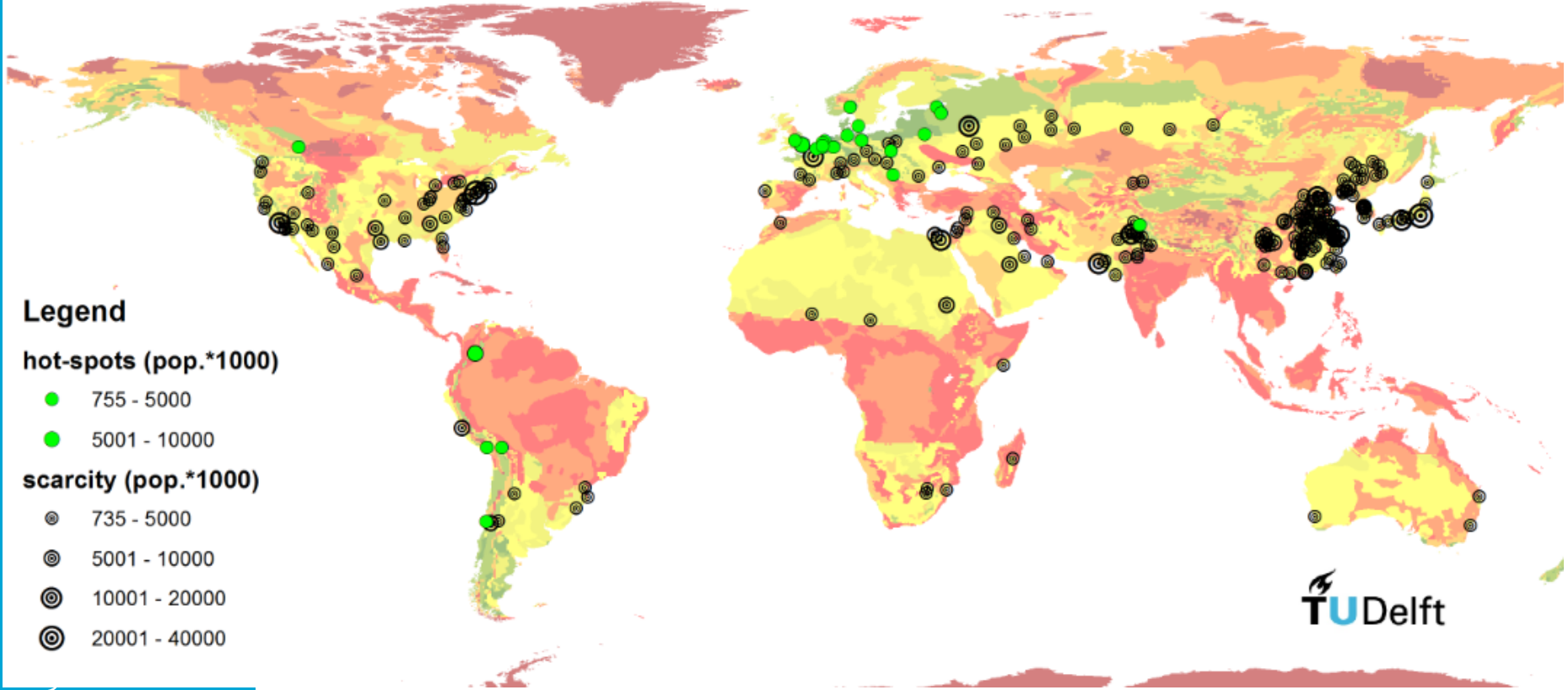
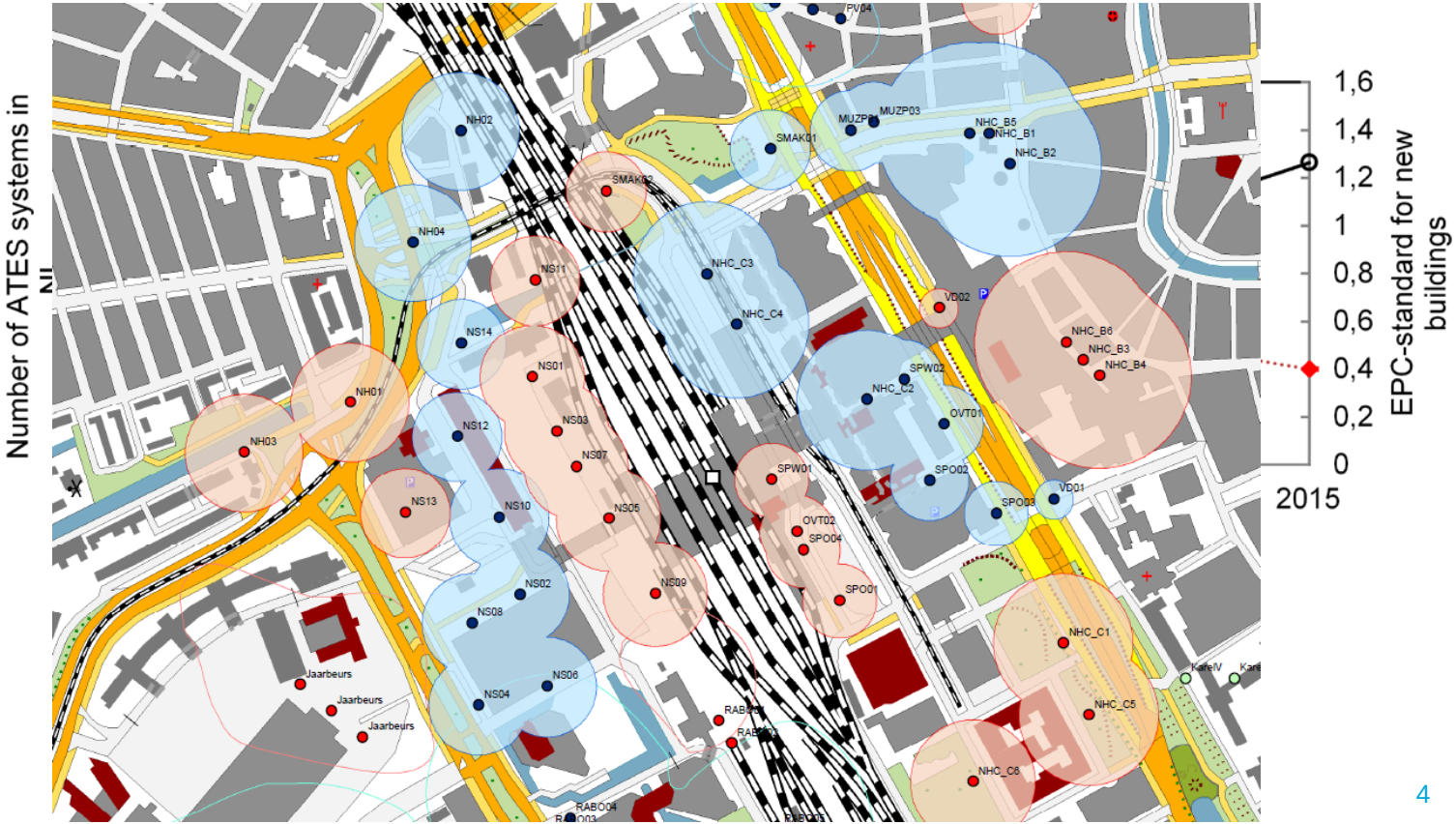
ATES Possible scarcity of space and hot spots



Bloemendal, M., Olsthoorn, T., van de Ven, F., 2015. Combining climatic and geo-hydrological preconditions as a method to determine world potential for aquifer thermal energy storage. Science of the Total Environment 538 621-633.

Aquifer Thermal Energy Storage



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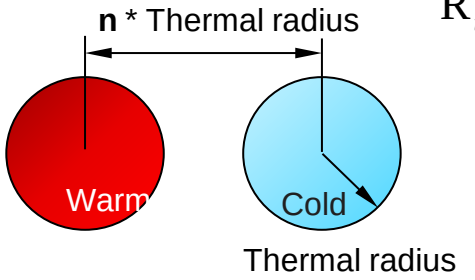
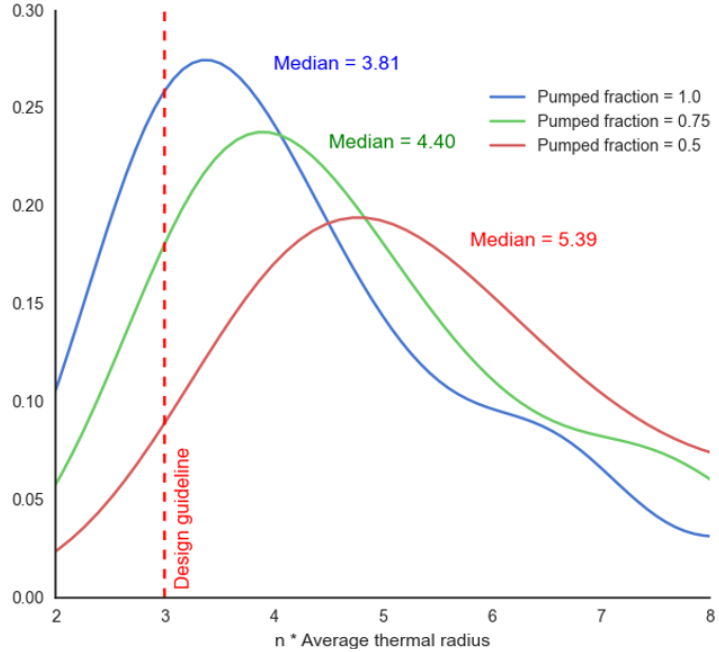
Uncertainties & Planning

Monitoring data: 40% of permit capacity is used (Willemsen 2016, Graaf,2016)

This leads to a waste of available space for new wells



$$R_{th} = \sqrt{\frac{c_w \cdot V}{c_{aq} \cdot \pi \cdot L}}$$



Jaxa-Rozen, Bloemendal, Kwakkel, Rostampour, Hybrid modelling for ATES planning and operation in the Utrecht city centre, EGU 2016.

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Solution: adaptive permits?

4 scenarios

- static and adaptive permits
- two distance policies: 3 and 2,5 $(\cdot R_{th})$

Assess

- Cost
- CO_2 savings

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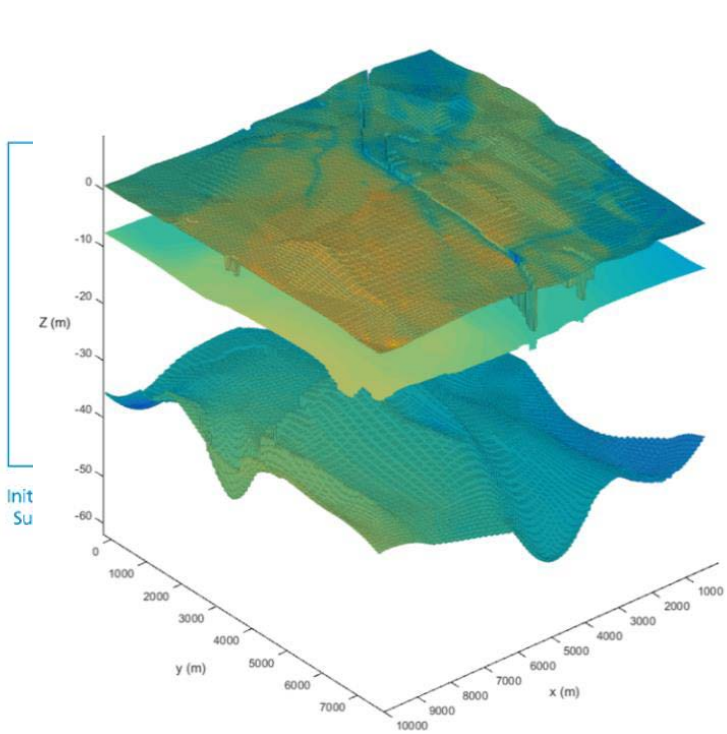
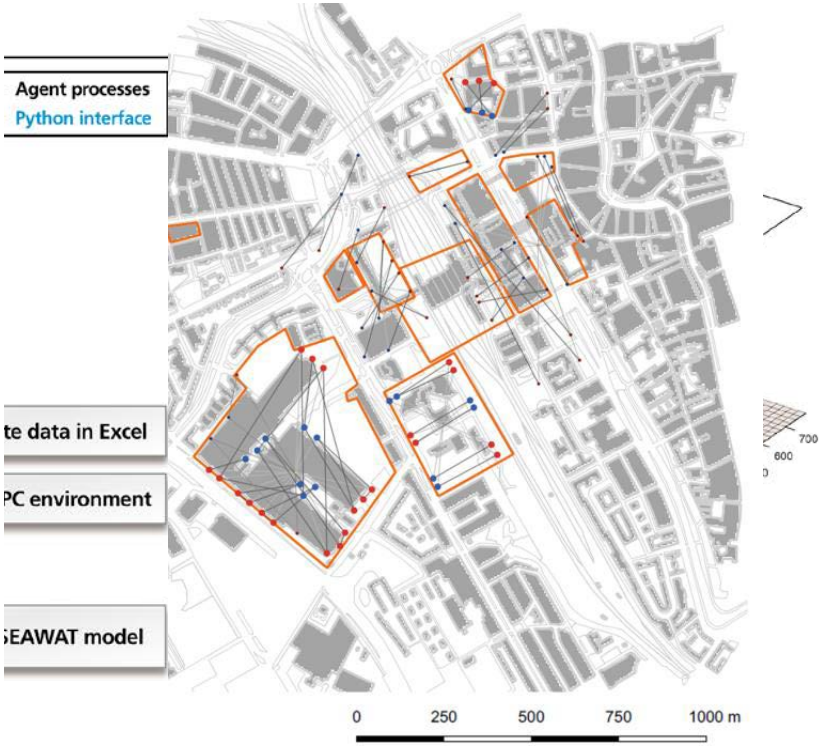
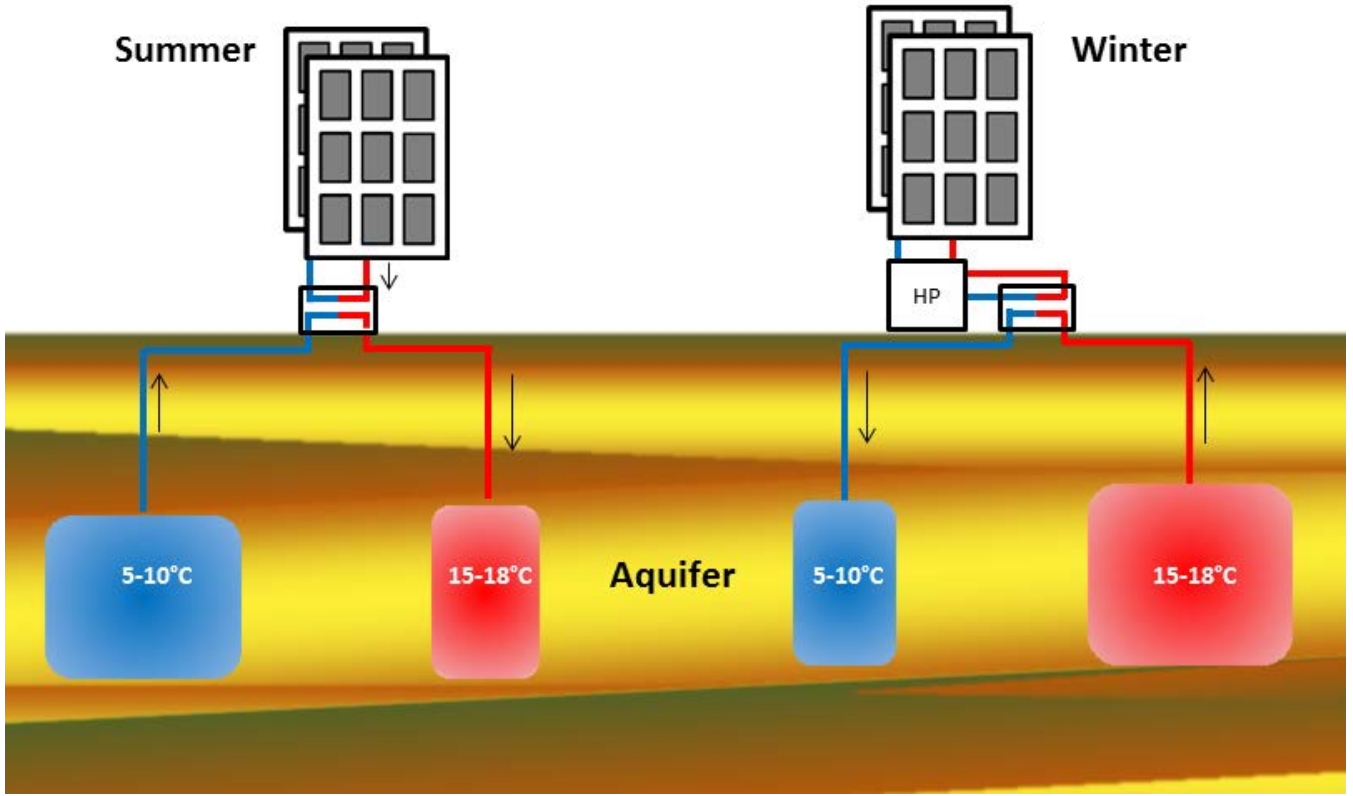
Simulation architecture





Jaxa-Rozen, M., J.H. Kwakkel, and M. Bloemendal, *The Adoption and Diffusion of Common-Pool Resource-Dependent Technologies: The Case of Aquifer Thermal Energy Storage Systems*, in *PICMET*. 2015: Portland.

Assessment framework



Assessment framework

Cost and CO_2 savings

E_h

E_c

Results

Number of ATES systems → + 20%

Total cost savings → + 10%

Total GHG emission → -10%

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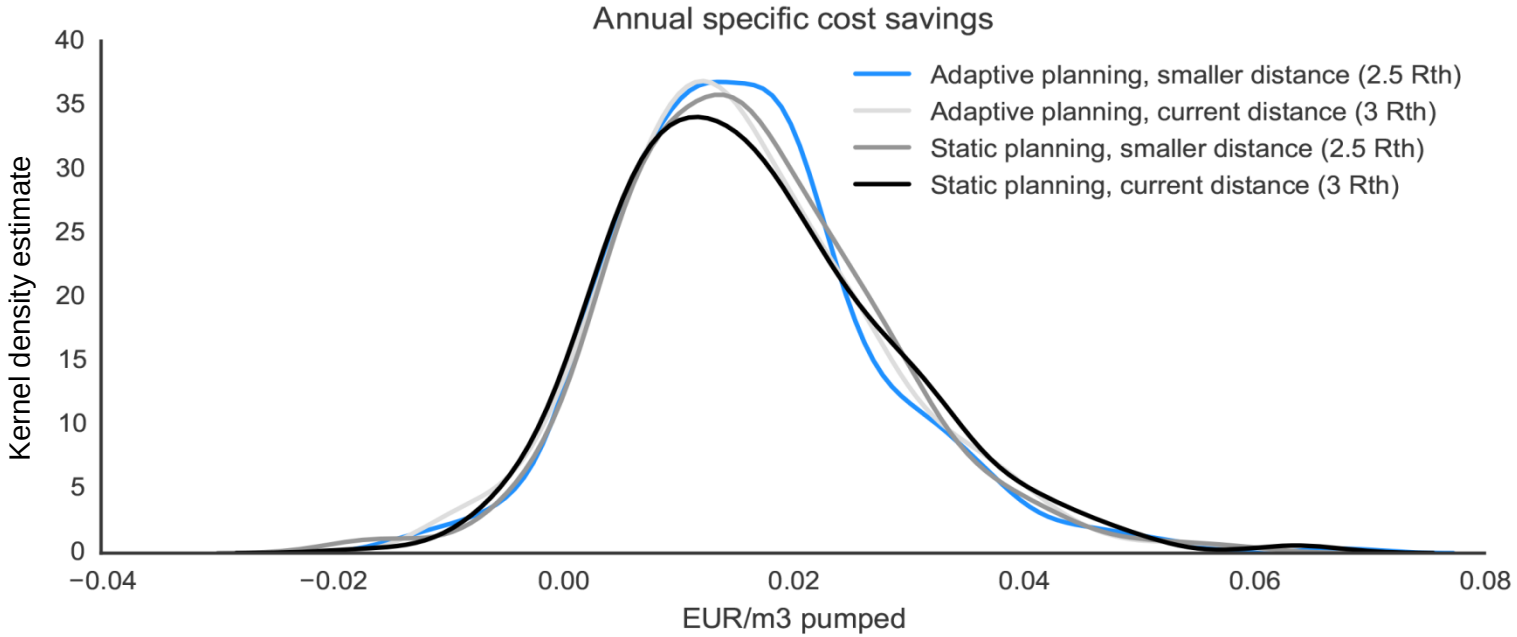
Results: Costs

Specific cost savings	Mean (EUR/m^3)
Adaptive 2.5 R_{th}	0.01583 (96.6%)
Adaptive 3.0 R_{th}	0.01579 (96.4%)
Baseline 2.5 R_{th}	0.01613 (98.5%)
Baseline 3.0 R_{th}	0.01638 (100%)



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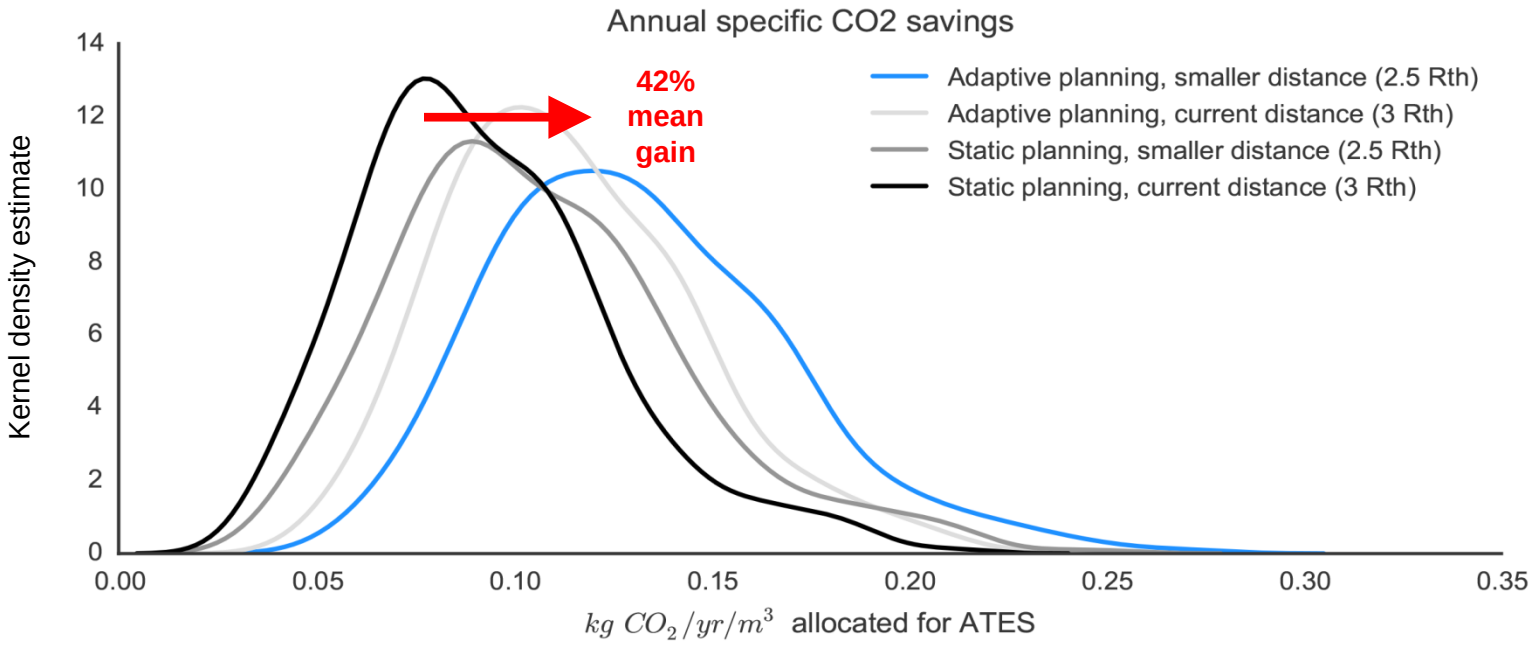
Results: GHG emissions



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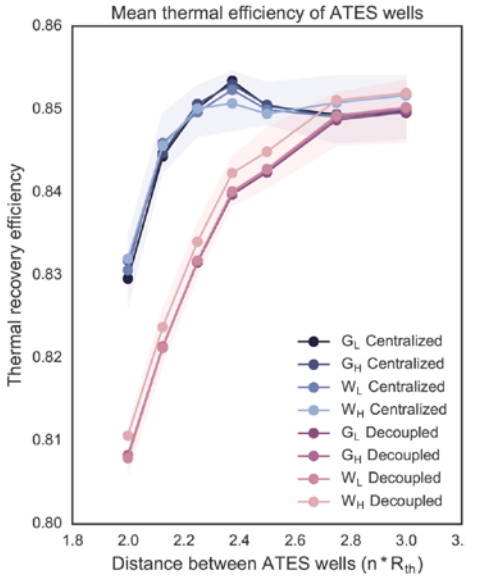
Future work

Further evaluation trade offs for increasing density of ATES systems

- Spatial lay out & well design
- Energy balance
- Different control schemes
- Negotiation among agents



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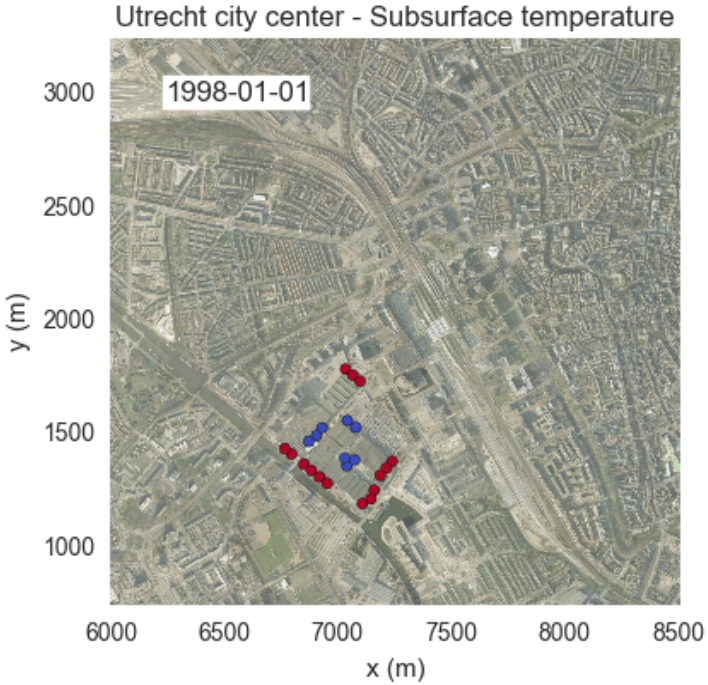

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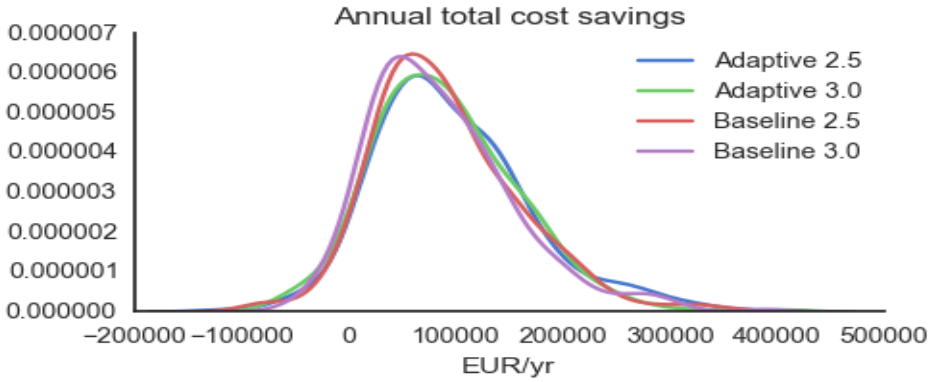
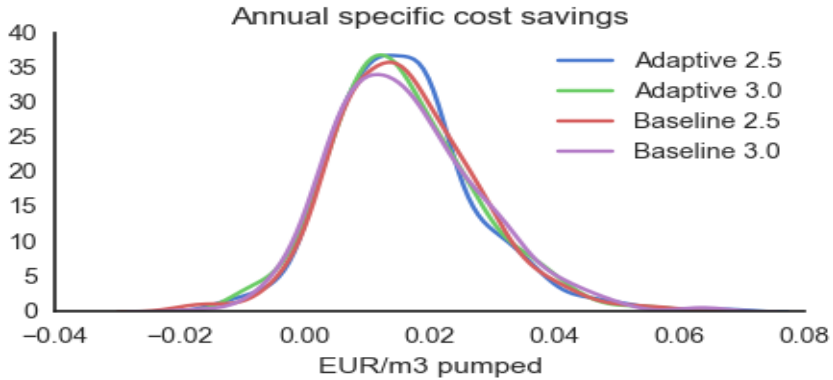
Economic performance



Total cost savings	Mean (EUR/yr)
Adaptive 2.5 R_{th}	96 614 (112%)
Adaptive 3.0 R_{th}	90 017 (104.5%)
Baseline 2.5 R_{th}	90 127 (104.6%)
Baseline 3.0 R_{th}	86 152 (100%)

Sensitivity

Rank	Variable	Estimated importance
1	*Gas price*	0.5727
2	Q_{mult}	0.1302
3	ΔT	0.0965
4	*Elec. price*	0.0474
5	COP_{hp}	0.0428

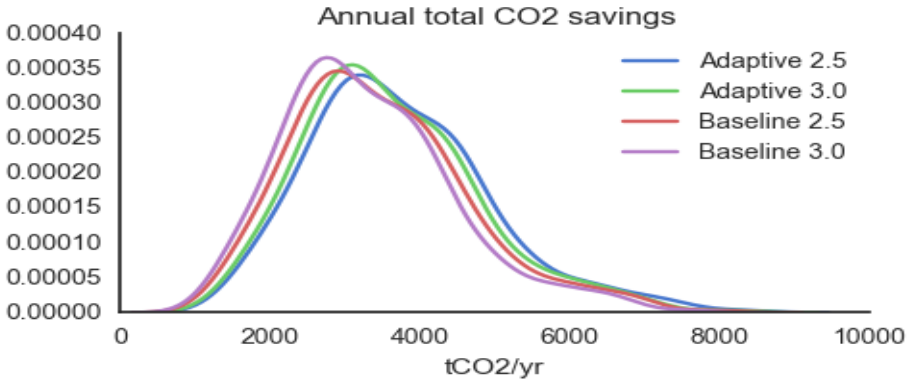


Specific cost savings	Mean (EUR/m^3)
Adaptive 2.5 R_{th}	0.01583 (96.6%)
Adaptive 3.0 R_{th}	0.01579 (96.4%)
Baseline 2.5 R_{th}	0.01613 (98.5%)
Baseline 3.0 R_{th}	0.01638 (100%)

Sensitivity

Rank	Variable	Estimated importance
1	*Gas price*	0.6674
2	ΔT	0.1132
3	*Elec. price*	0.0517
4	COP_{hp}	0.0451
5	COP_C	0.0293

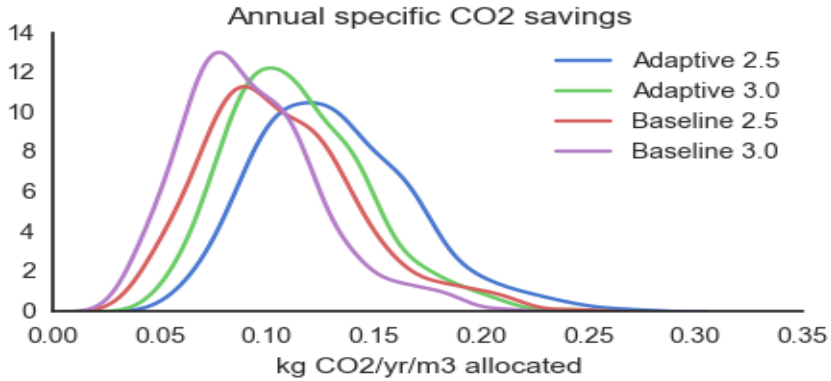
GHG savings



Total CO_2 savings	**Mean (tCO_2/yr)**
Adaptive 2.5 R_{th}	3739 (113%)
Adaptive 3.0 R_{th}	3615 (109%)
Baseline 2.5 R_{th}	3472 (104%)
Baseline 3.0 R_{th}	3314 (100%)

Sensitivity

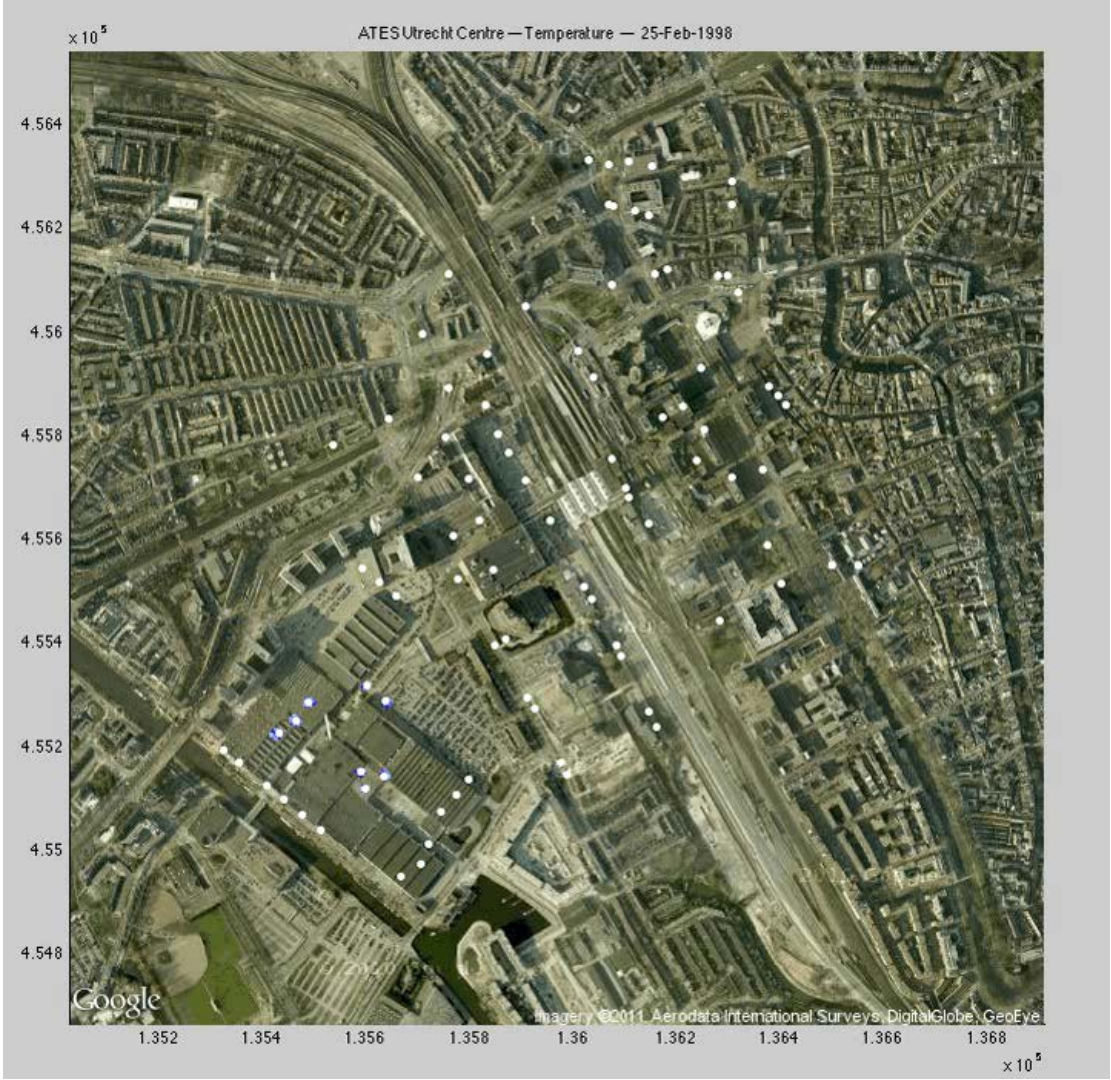
Rank	**Variable**	**Estimated importance**
1	Q_{mult}	0.4598
2	ΔT	0.3851
3	COP_{hp}	0.0525
4	COP_C	0.0492
5	Policy	0.0299



Specific CO_2 savings	**Mean (kg CO2/yr/m^3)**
Adaptive 2.5 R_{th}	0.1316 (142%)
Adaptive 3.0 R_{th}	0.1144 (123%)
Baseline 2.5 R_{th}	0.1067 (115%)
Baseline 3.0 R_{th}	0.0927 (100%)

Sensitivity

Rank	**Variable**	**Estimated importance**
1	ΔT	0.3910
2	Q_{mult}	0.3336
3	Policy	0.1604
4	COP_{hp}	0.0478
5	COP_C	0.0451


ATES Utrecht Centre — Temperature — 25-Feb-1998
x 10^5
4.564
4.562
4.56
4.558
4.556
4.554
4.552
4.55
4.548
1.352
1.354
1.356
1.358
1.36
1.362
1.364
1.366
1.368
x 10^5
Google
Imagery ©2011 Aerodata International Surveys, DigitalGlobe, GeoEye

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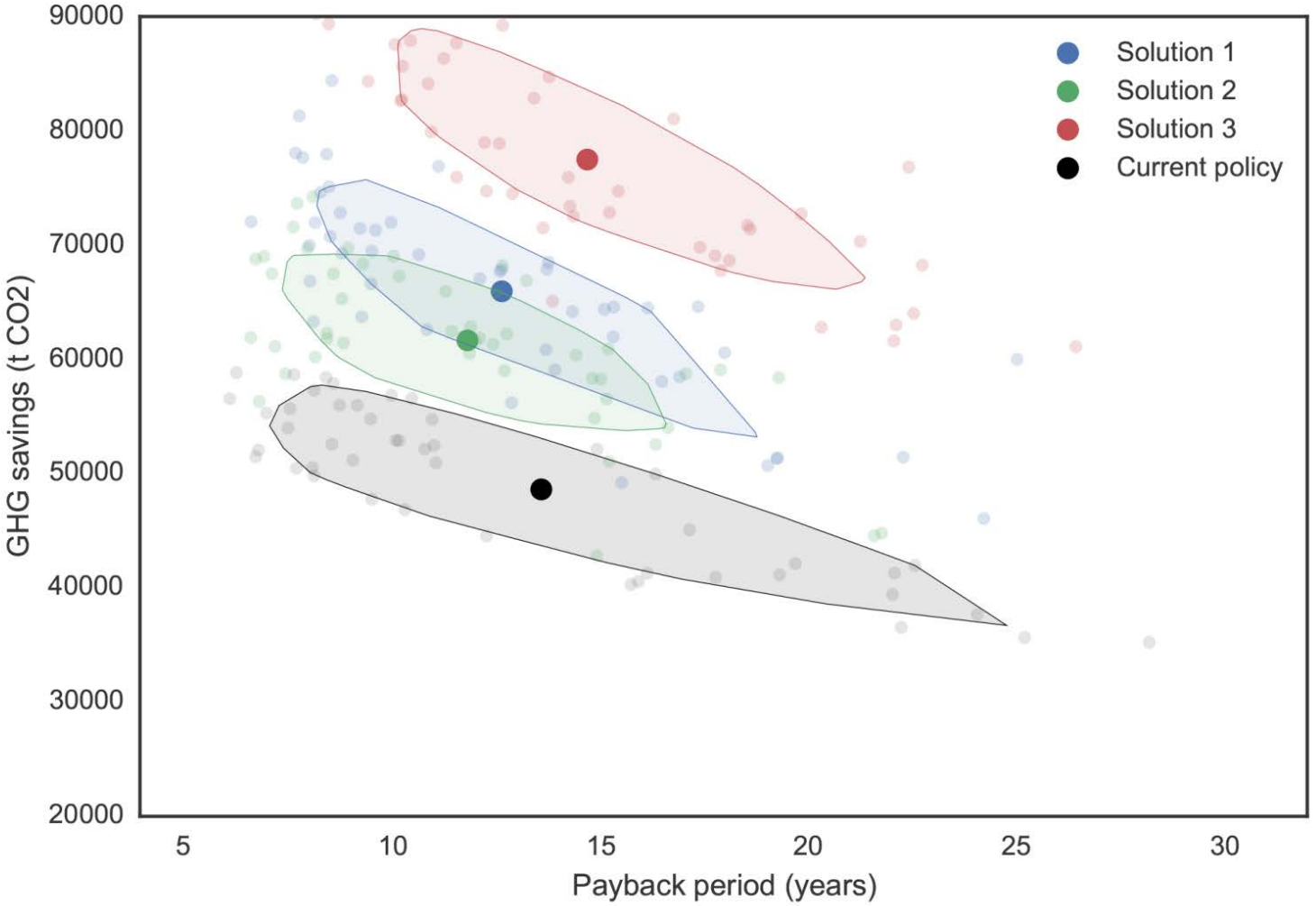
90000
80000
70000
60000
50000
40000
30000
20000
GHG savings (t CO2)
5
10
15
20
25
30
Payback period (years)
Solution 1
Solution 2
Solution 3
Current policy

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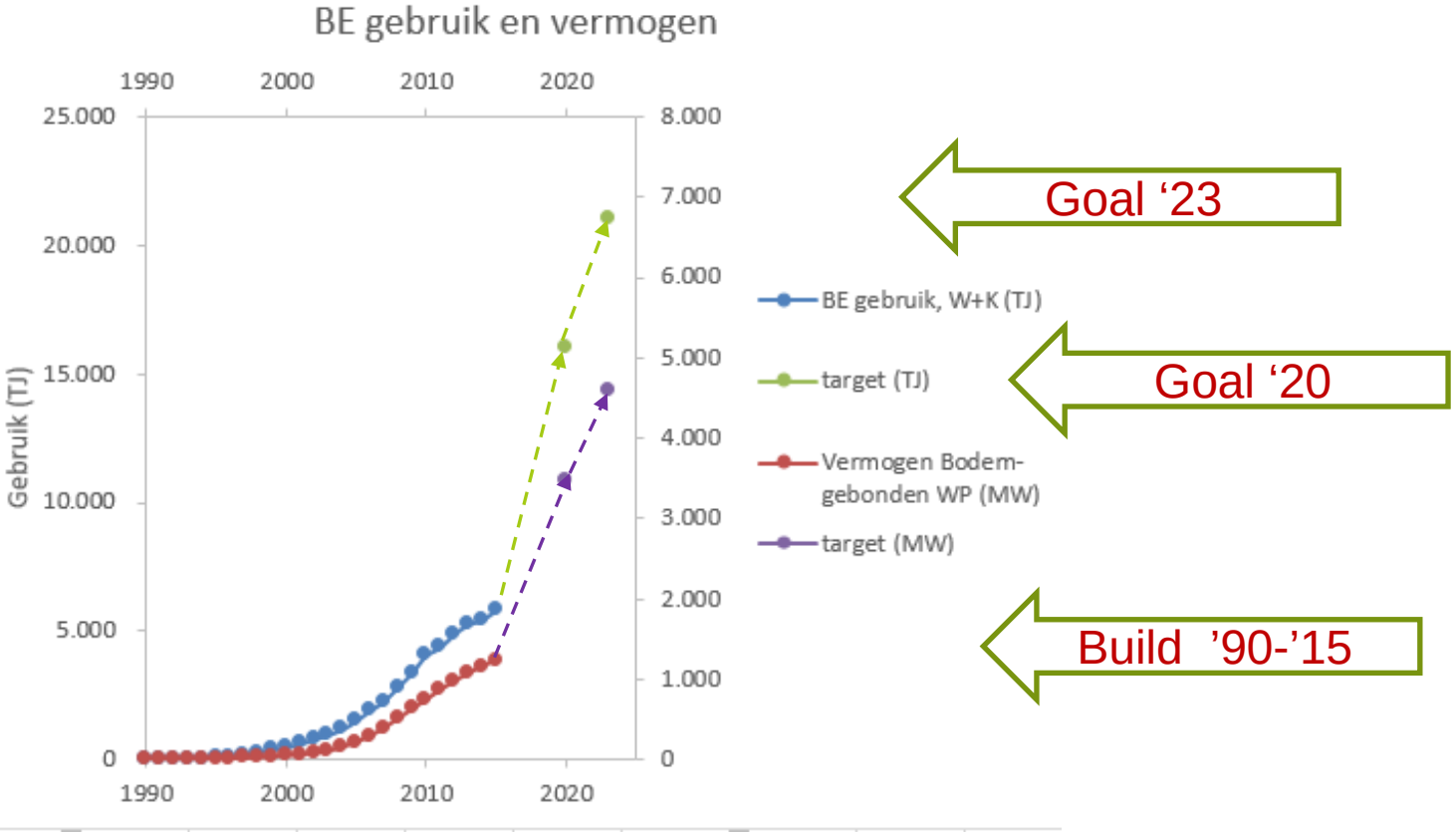
SER / Paris Agreement



Phase change materials

Thermo Chemical materials

Bovengrondse buffertank

Ondergrondse buffertank

bodemenergie WKO

bodemenergie HTO

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