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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

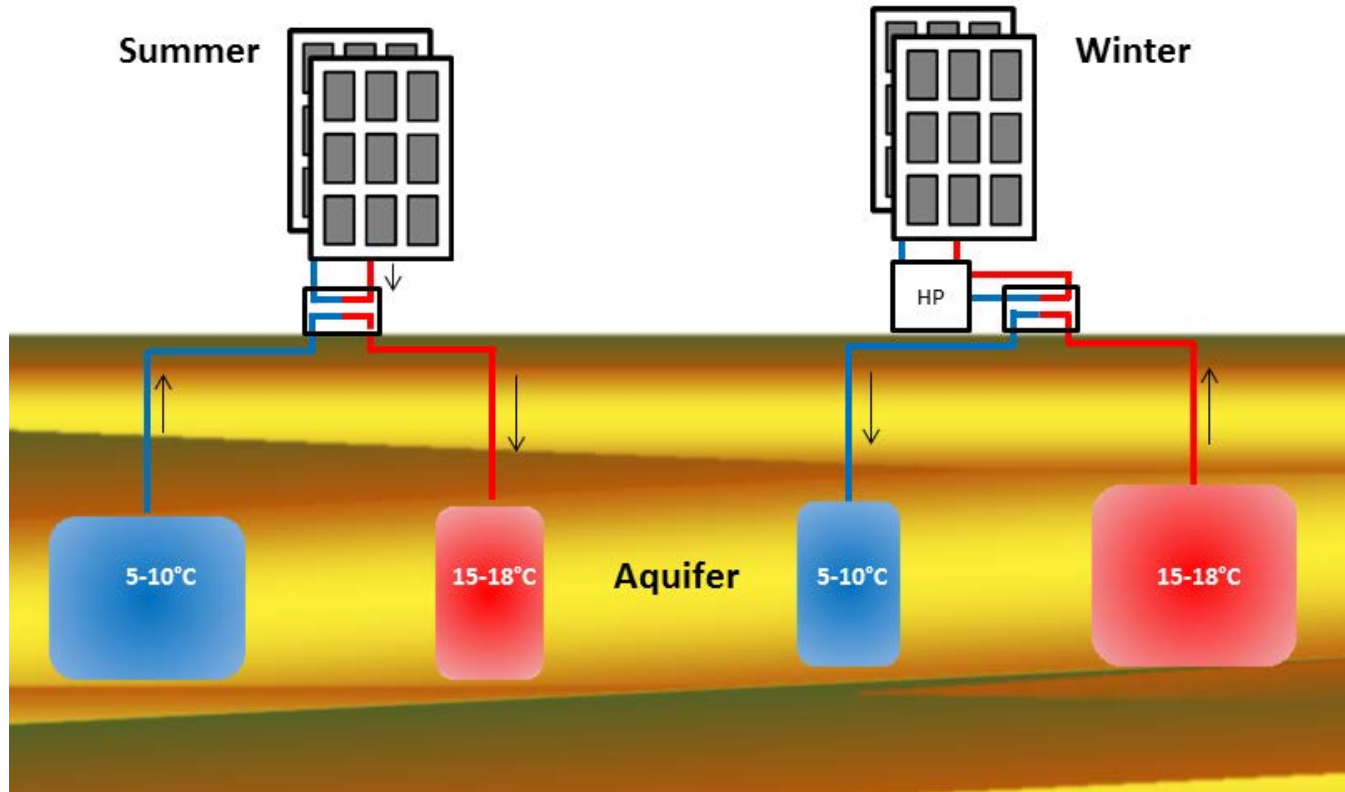
Ir. Martin Bloemendal

Ir. Marc Jaxa-Rozen

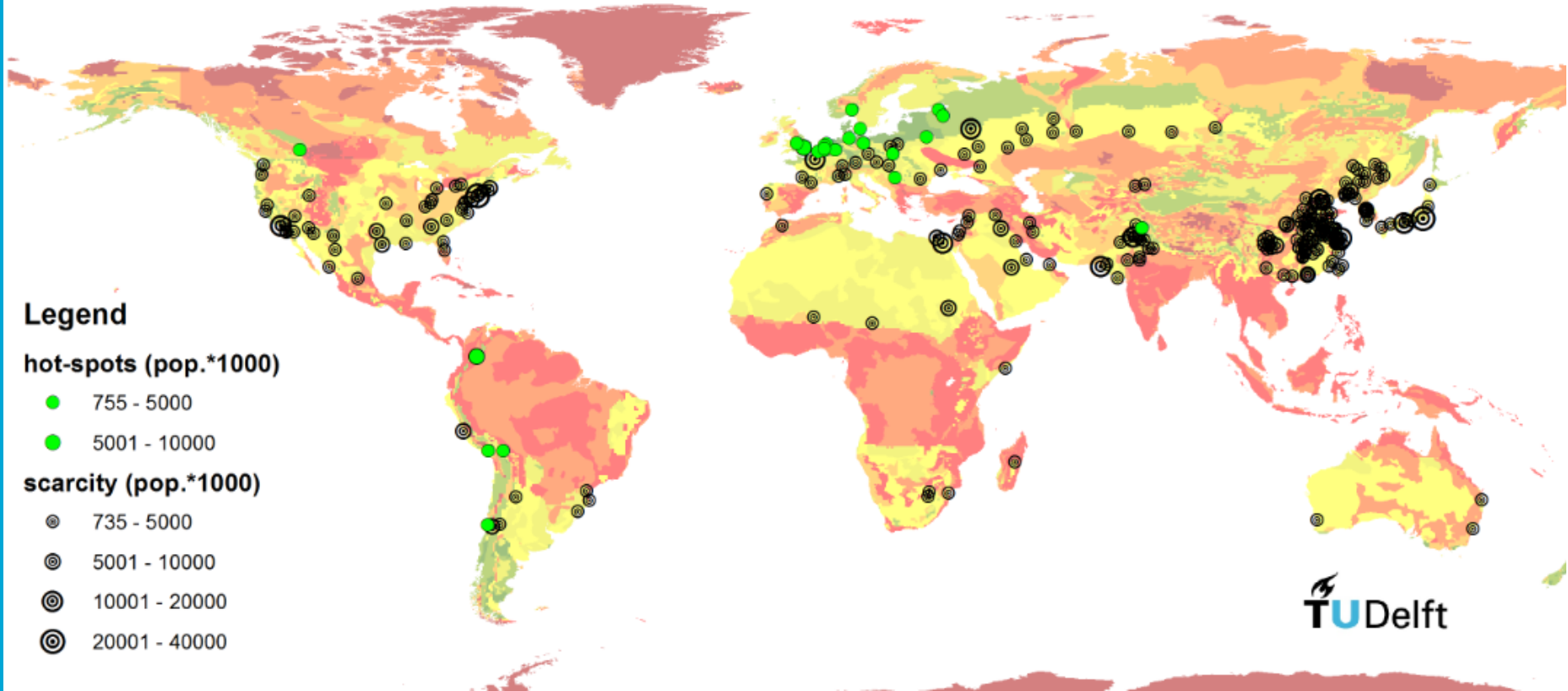
Ir. Vahab Rostampour



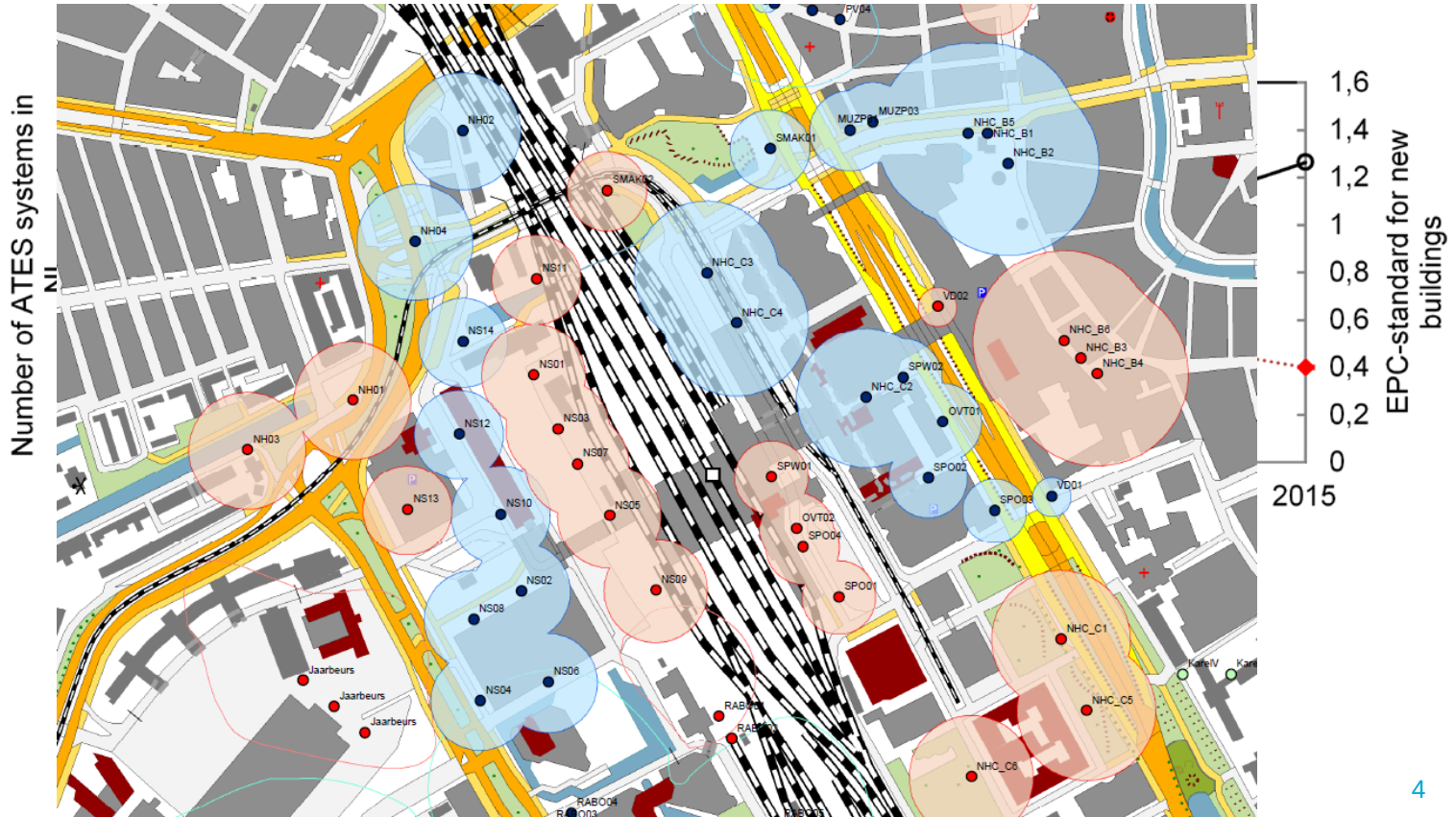
Aquifer Thermal Energy Storage



ATES Possible scarcity of space and hot spots



Aquifer Thermal Energy Storage

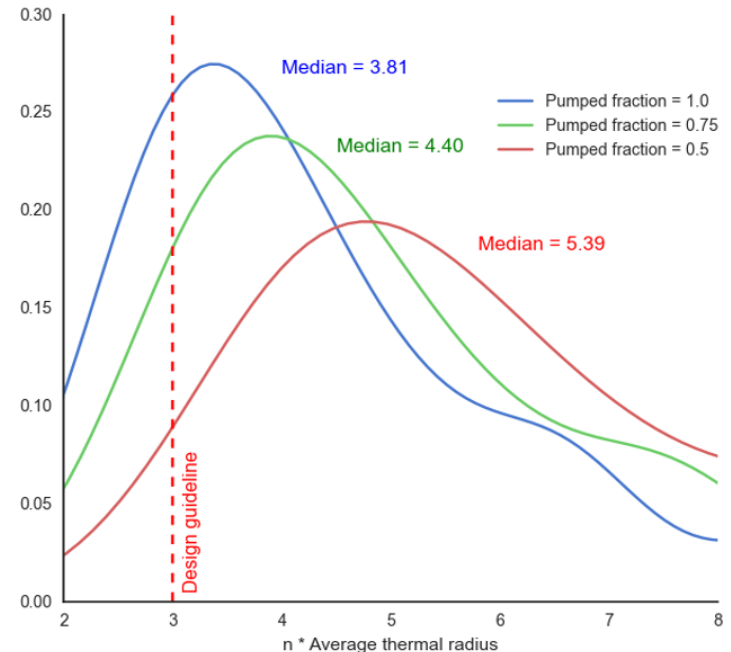
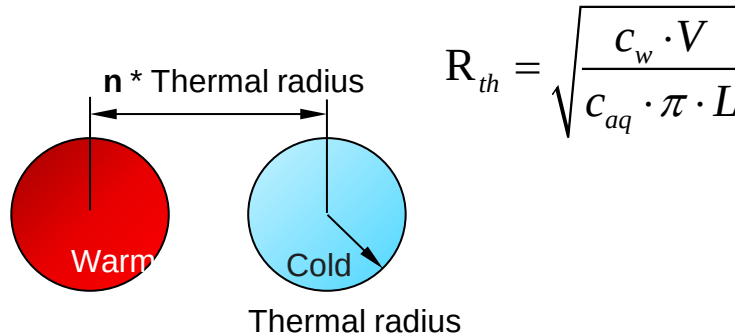


Uncertainties & Planning

Monitoring data: 40% of permit capacity is used

(Willemsen 2016, Graaf, 2016)

This leads to a waste of available space for new wells



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

Solution: adaptive permits?

**USE IT, OR
LOSE IT**

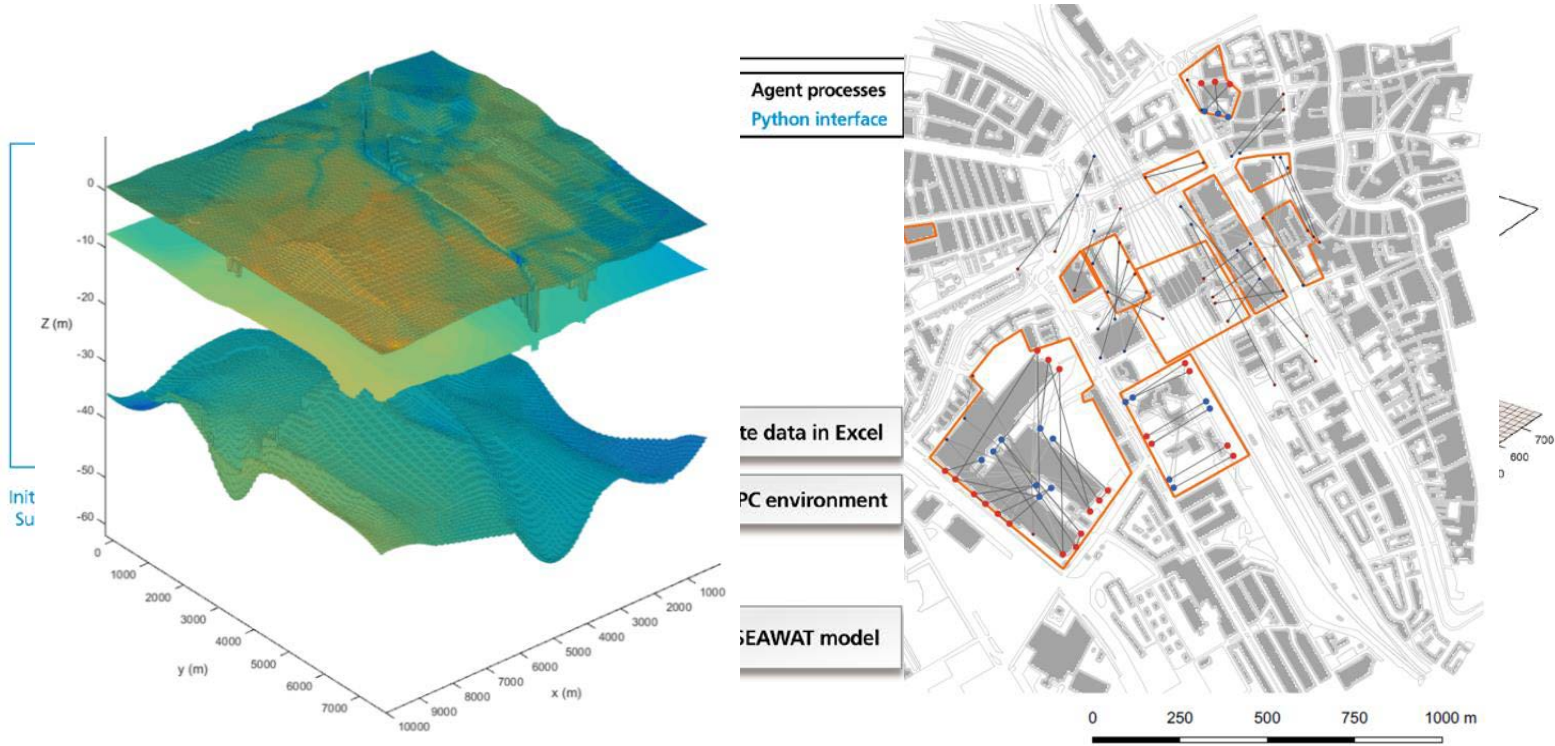
4 scenarios

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

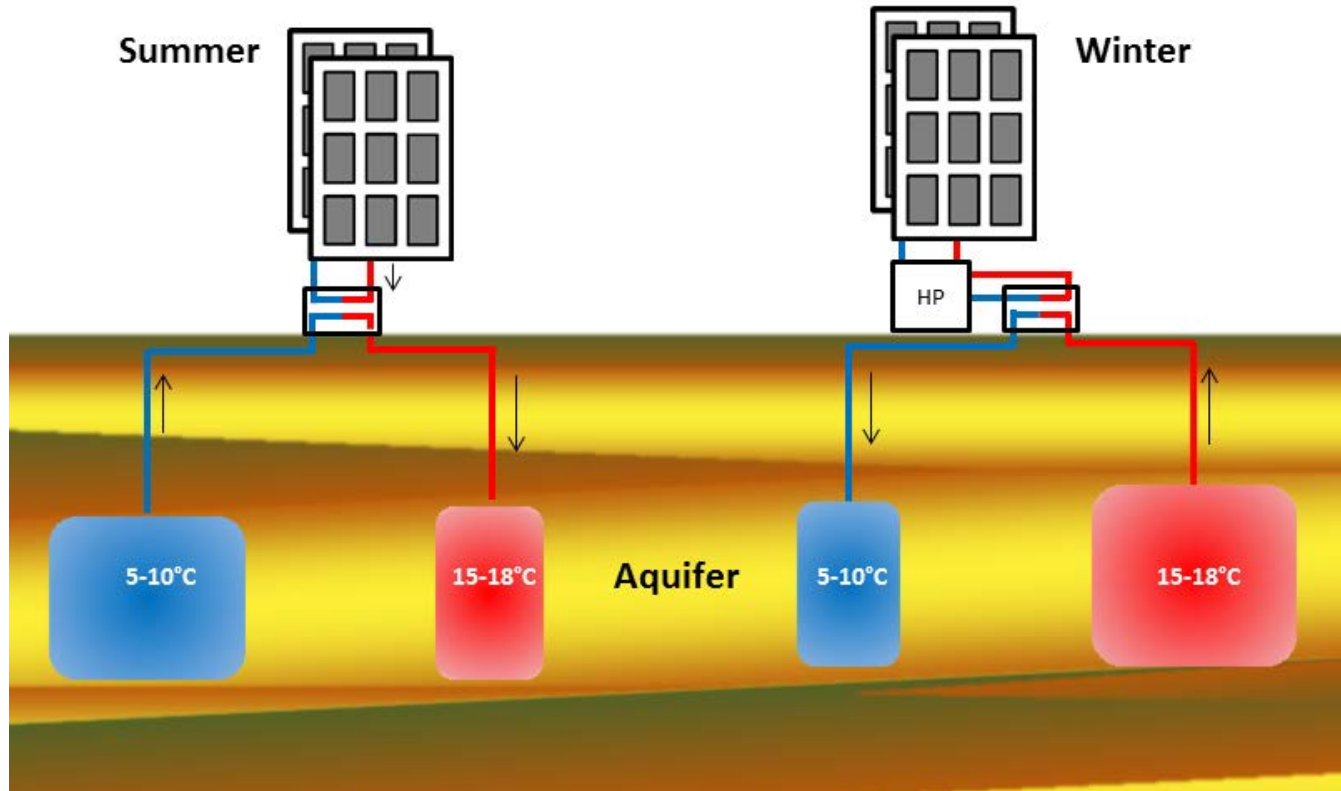
Assess

- Cost
- CO₂ savings

Simulation architecture



Assessment framework



Assessment framework

Cost and CO₂ savings

E_h

E_c

Results

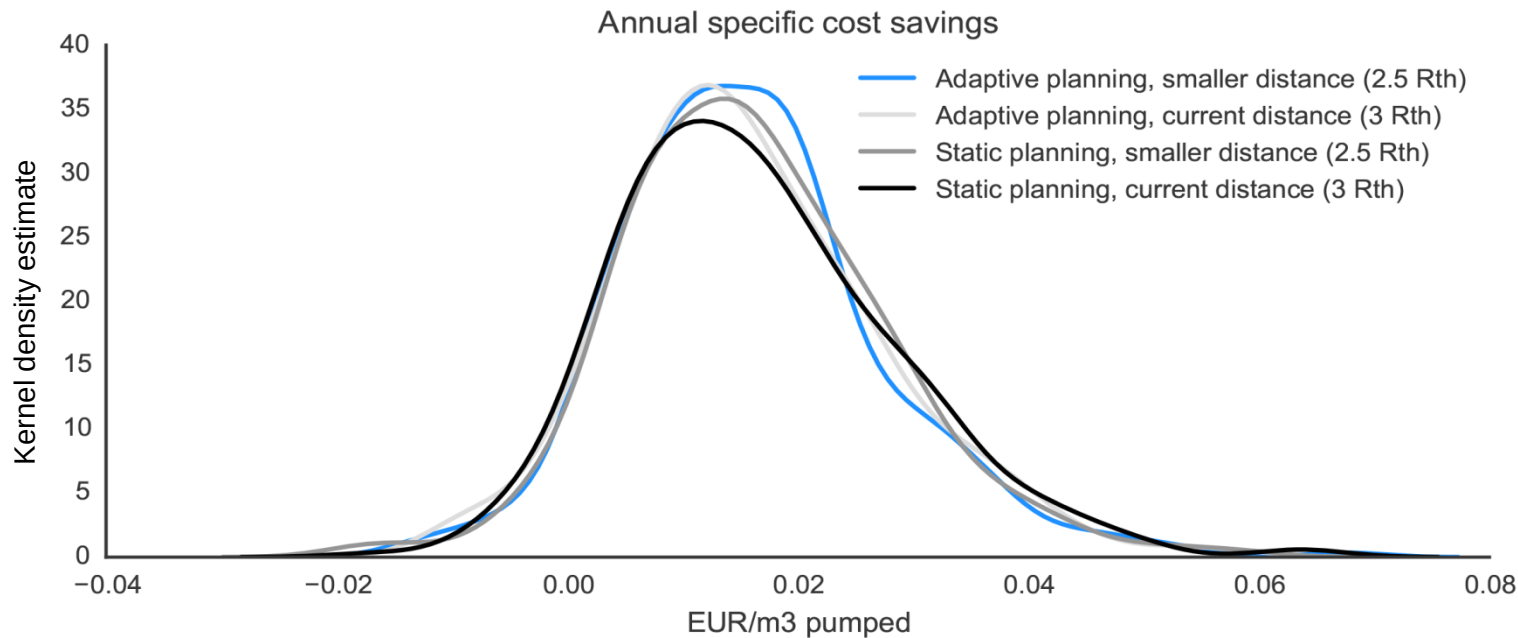
Number of ATES systems → + 20%

Total cost savings → + 10%

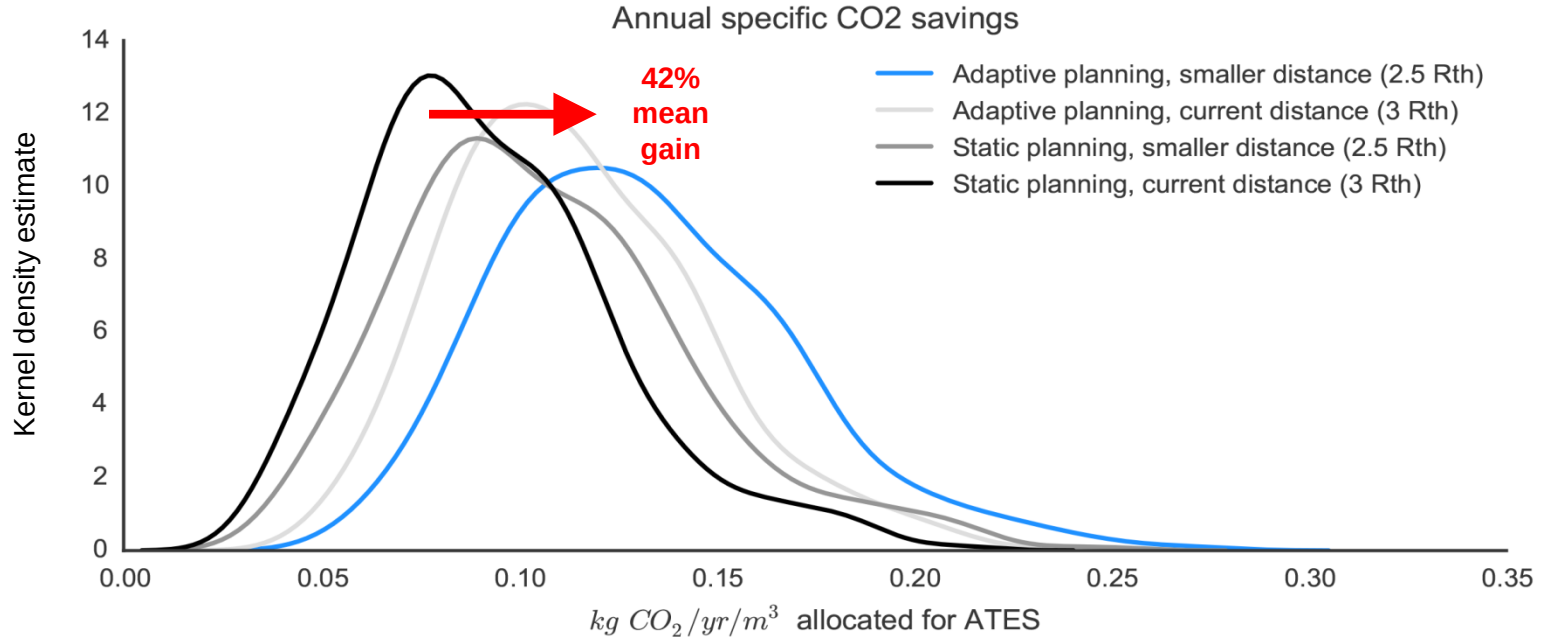
Total GHG emission → -10%

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%)



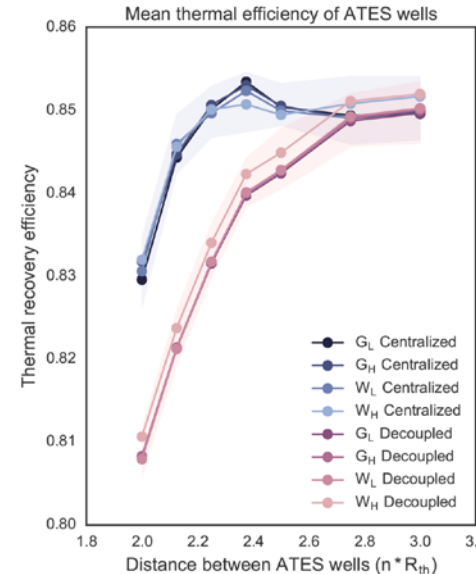
Results: GHG emissions



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

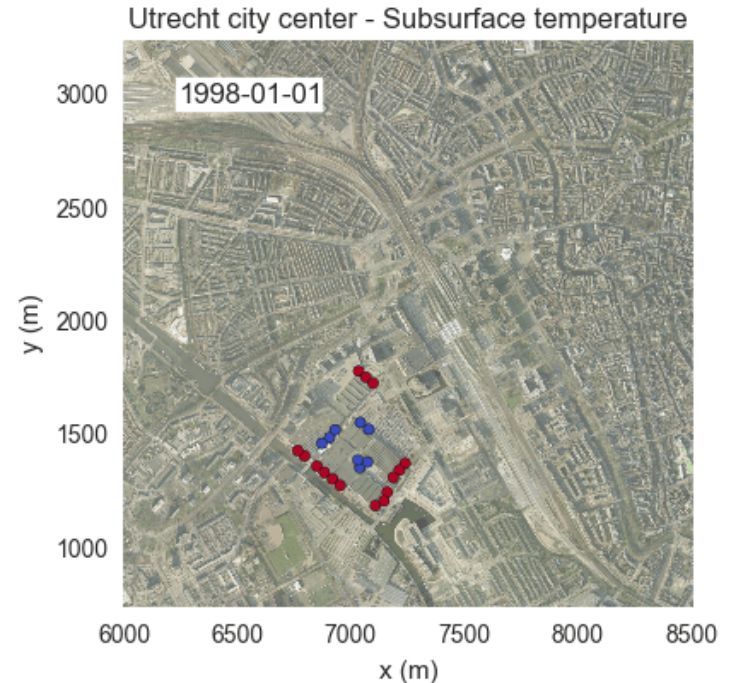


Use it, or lose it

Adaptive governance of aquifers with ATEs

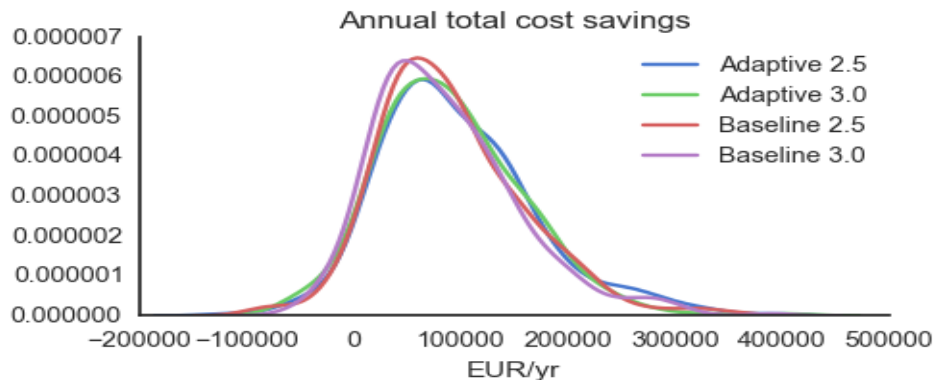
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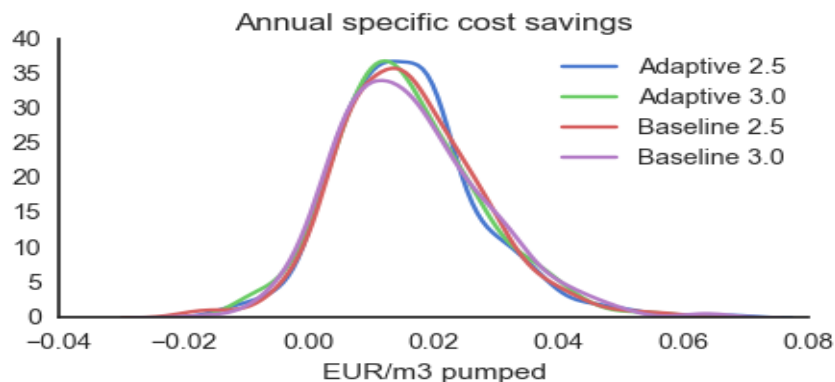
3. Utrecht case study

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

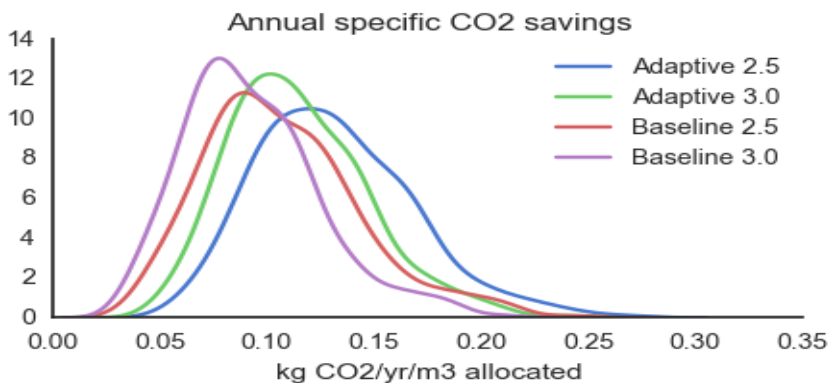
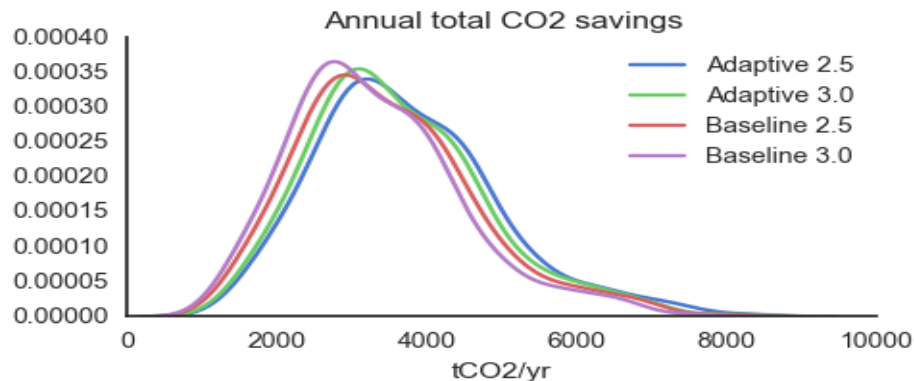


Specific cost savings	Mean (EUR/m ³)
Adaptive 2.5 R_{th}	0.01583 (96.6%)
Adaptive 3.0 R_{th}	0.01579 (96.4%)
Baseline 2.5 R_{th}	0.01613 (98.5%)
Baseline 3.0 R_{th}	0.01638 (100%)

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

3. Utrecht case study

GHG savings

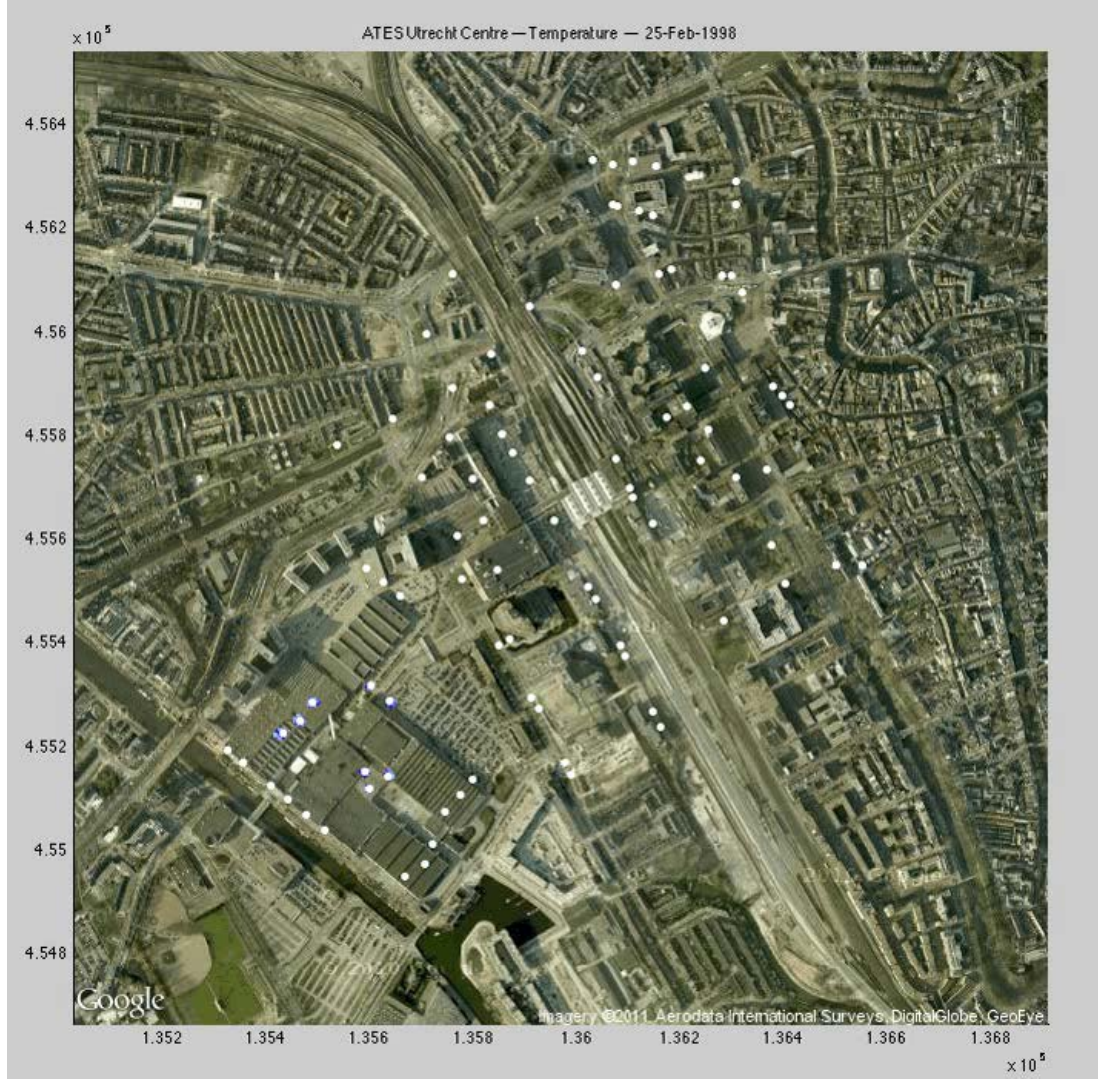


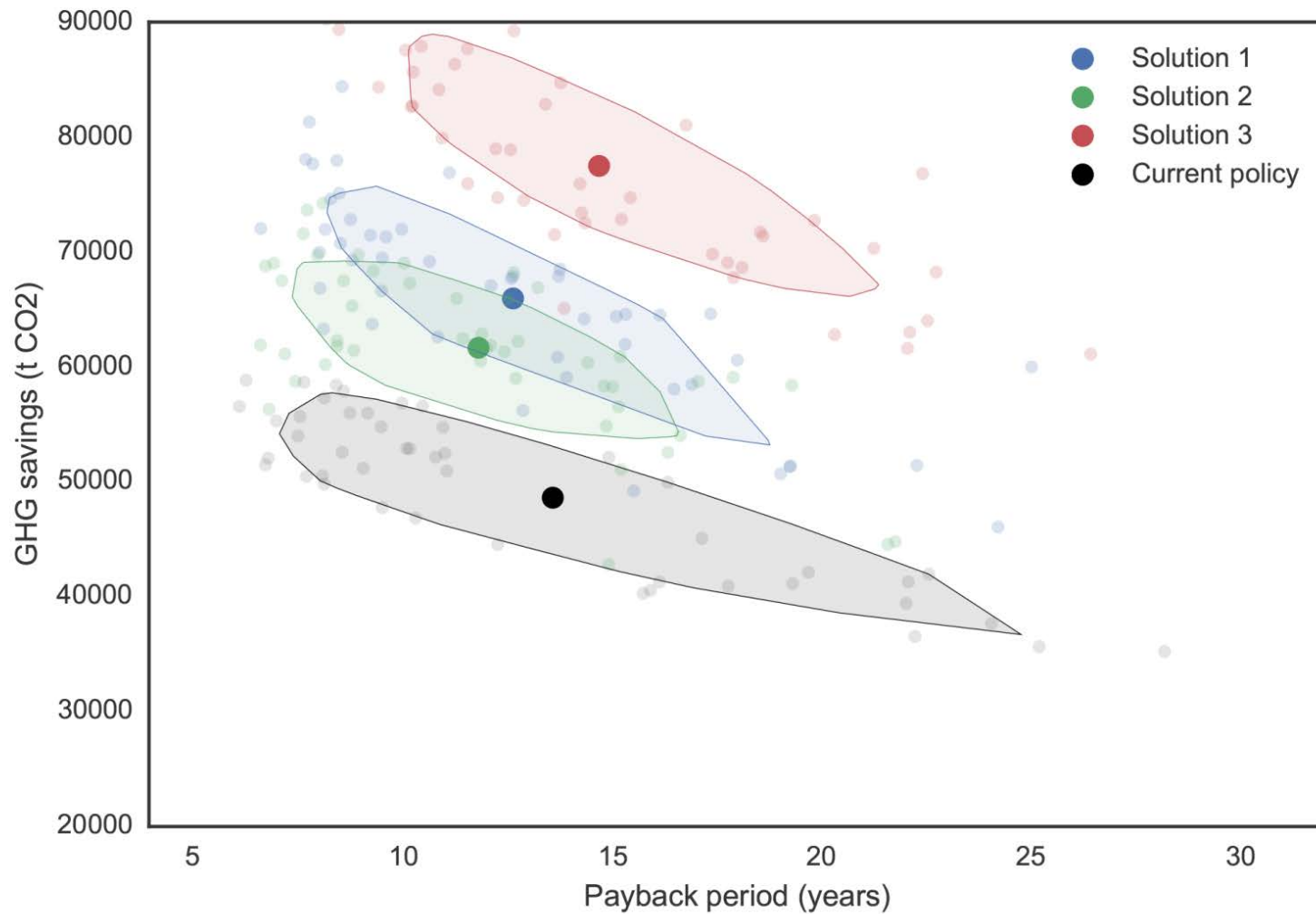
Total CO ₂ savings	Mean (tCO ₂ /yr)
Adaptive 2.5 R _{th}	3739 (113%)
Adaptive 3.0 R _{th}	3615 (109%)
Baseline 2.5 R _{th}	3472 (104%)
Baseline 3.0 R _{th}	3314 (100%)

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 CO ₂ /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%)

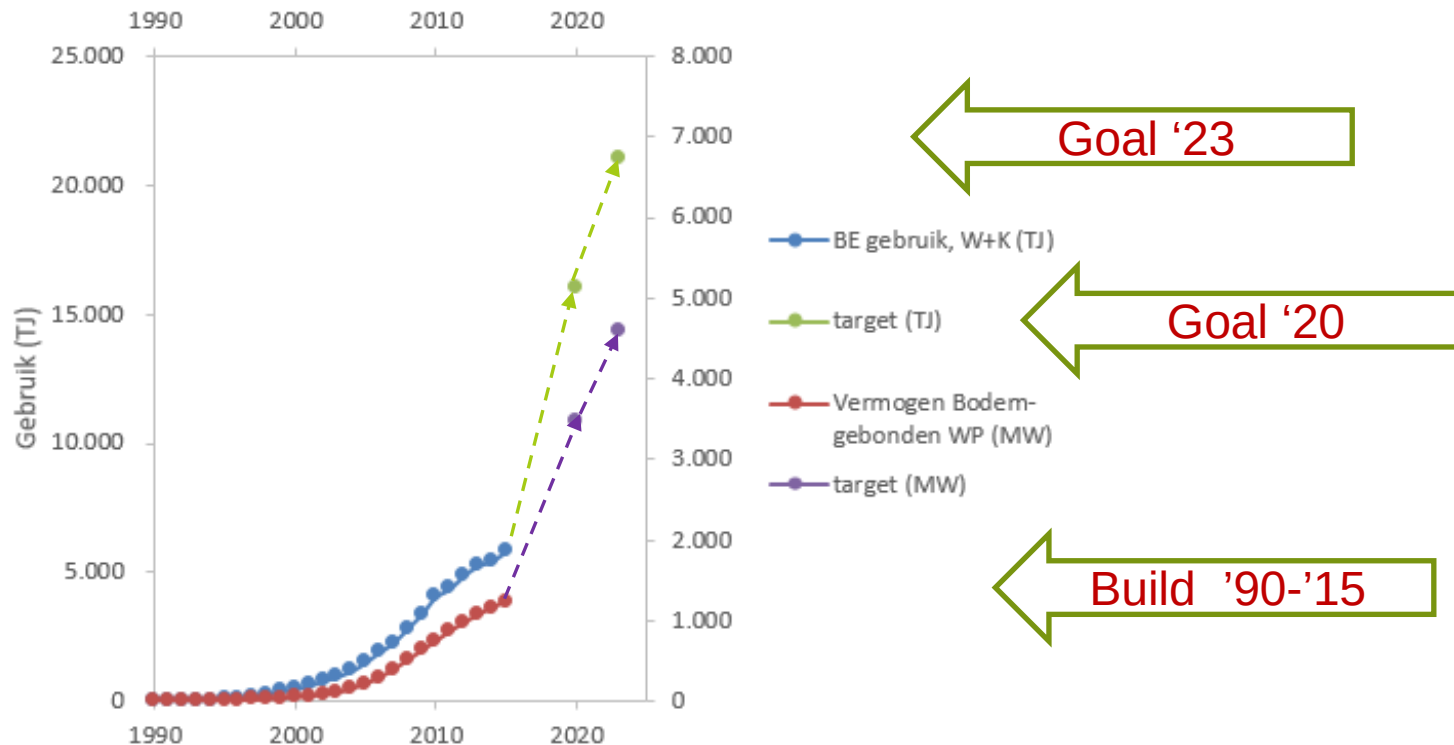
Sensitivity		
Rank	Variable	Estimated importance
1	ΔT	0.3910
2	Q_{mult}	0.3336
3	Policy	0.1604
4	COP_{hp}	0.0478
5	COP_c	0.0451





SER / Paris Agreement

BE gebruik en vermogen



Phase change materials

Thermo Chemical materials

Bovengrondse buffertank

Ondergrondse buffertank

bodemenergie WKO

bodemenergie HTO

KWR

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