

## **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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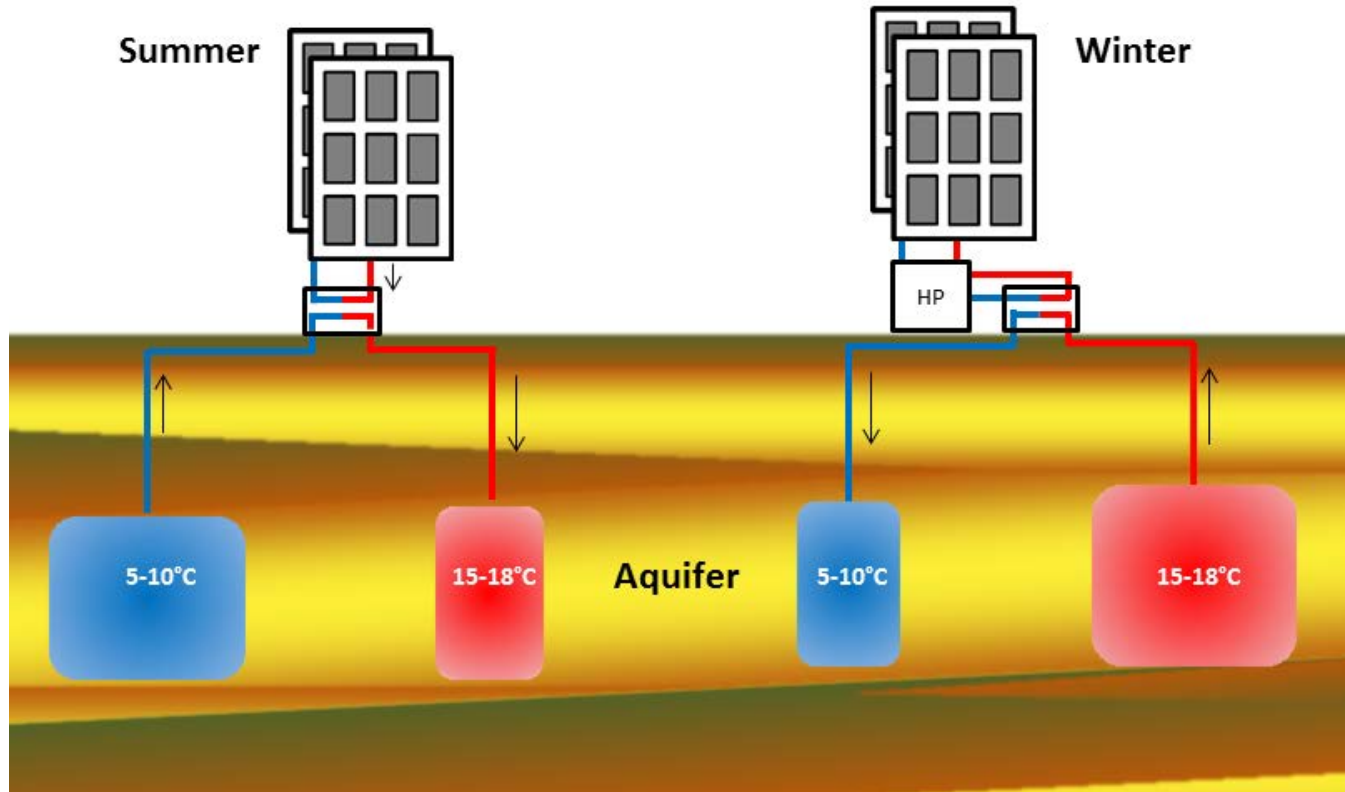
Ir. Vahab Rostampour



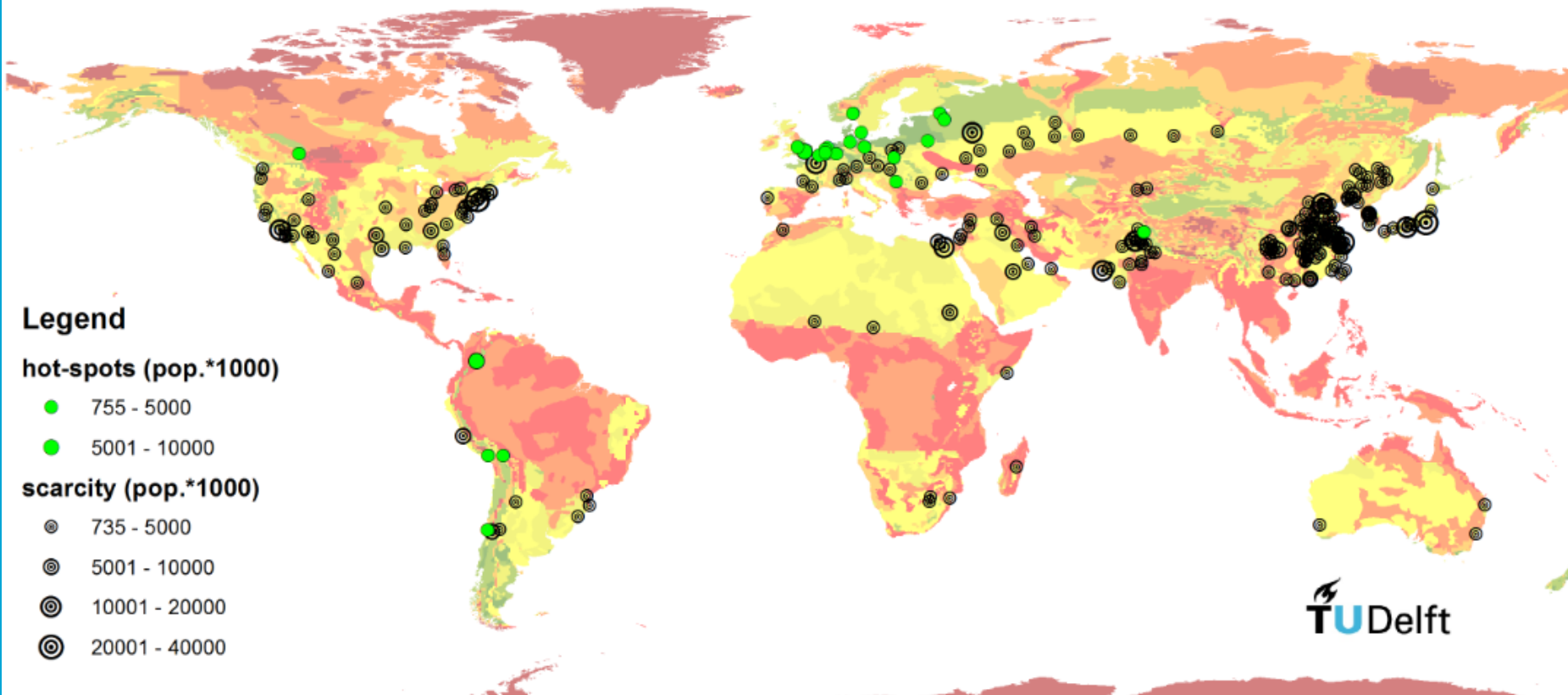
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# Aquifer Thermal Energy Storage



## ATES Possible scarcity of space and hot spots



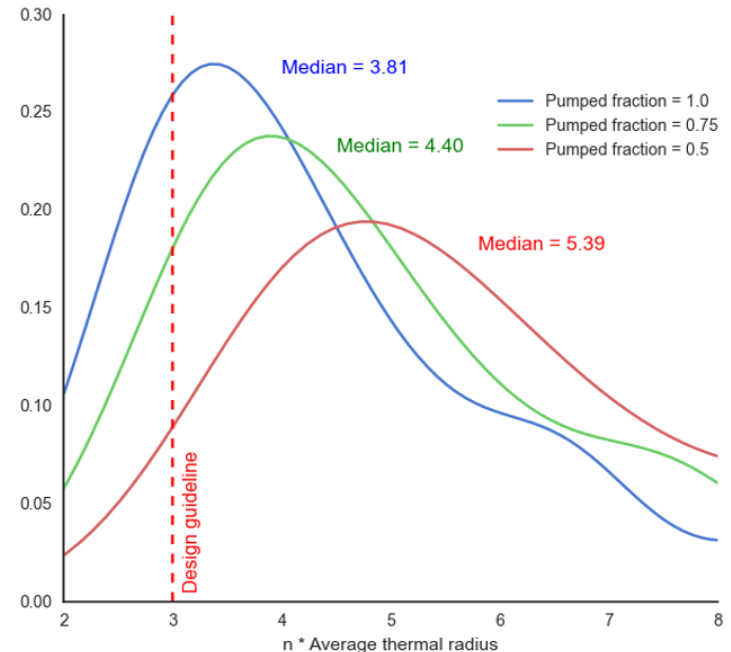
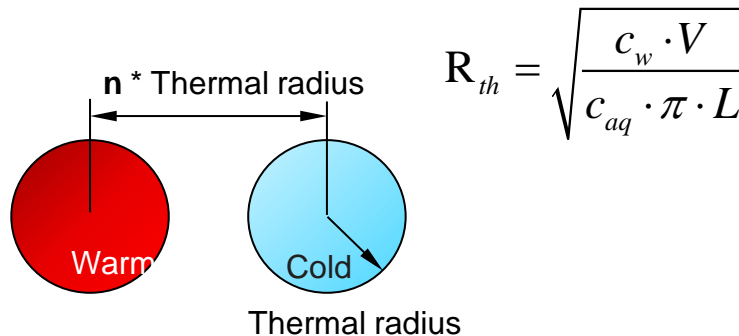


# Uncertainties & Planning

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**

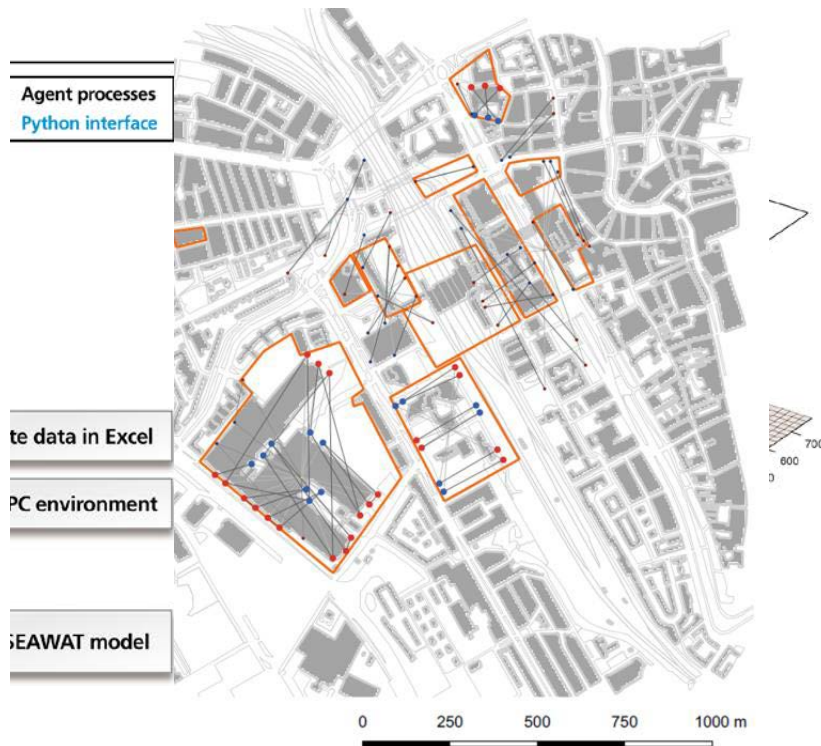
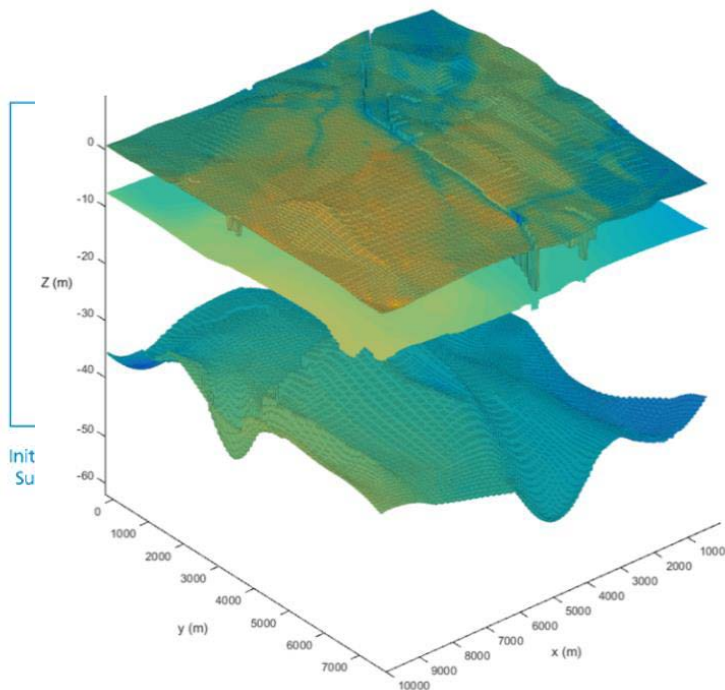
4 scenarios

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

Assess

- Cost
- CO<sub>2</sub> savings

# Simulation architecture



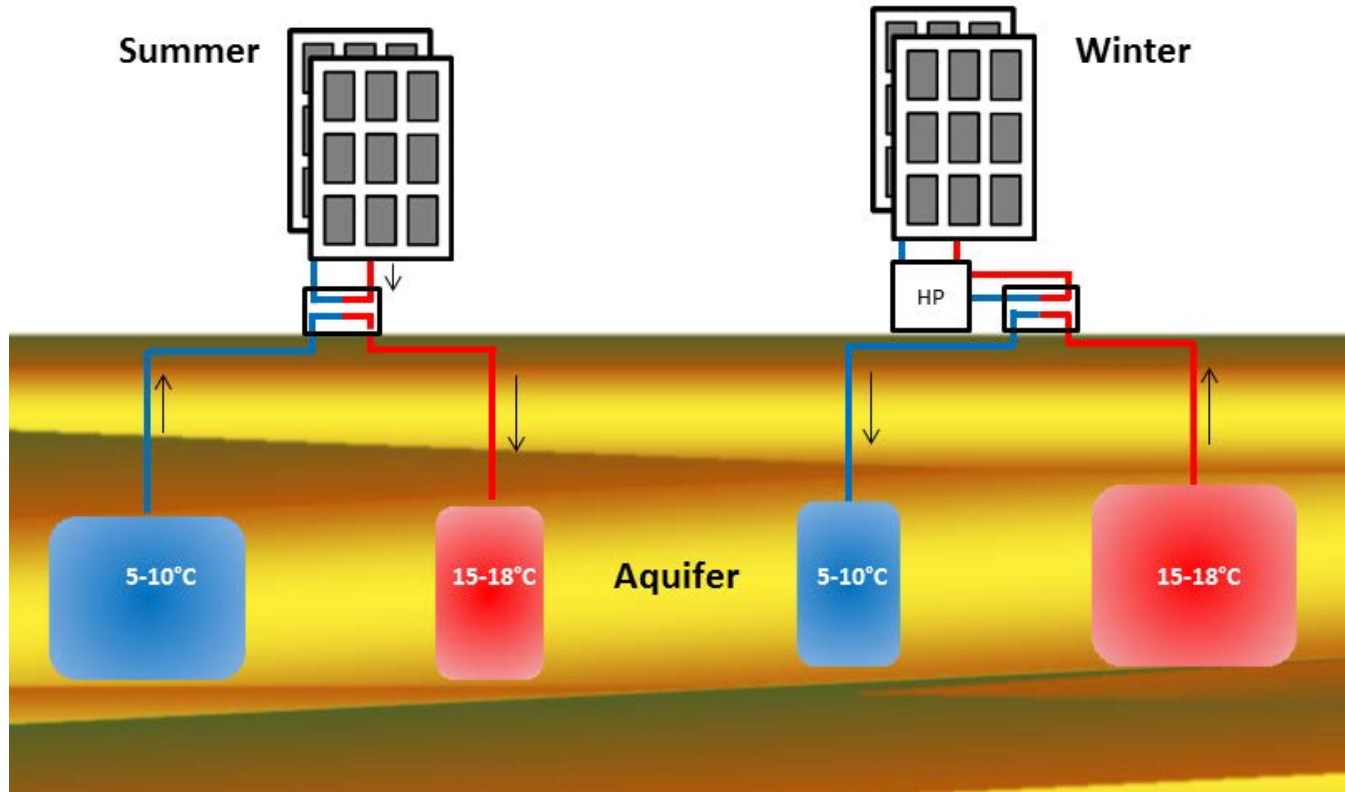
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Jaxa-Rozen, M., J.H. Kwakkel, and M. Bloemendaal, *The Adoption and Diffusion of Common-Pool Resource-Dependent Technologies: The Case of Aquifer Thermal Energy Storage Systems*, in PICMET. 2015: Portland.



# Assessment framework



# Assessment framework

Cost and CO<sub>2</sub> savings

$E_h$

$E_c$

# Results

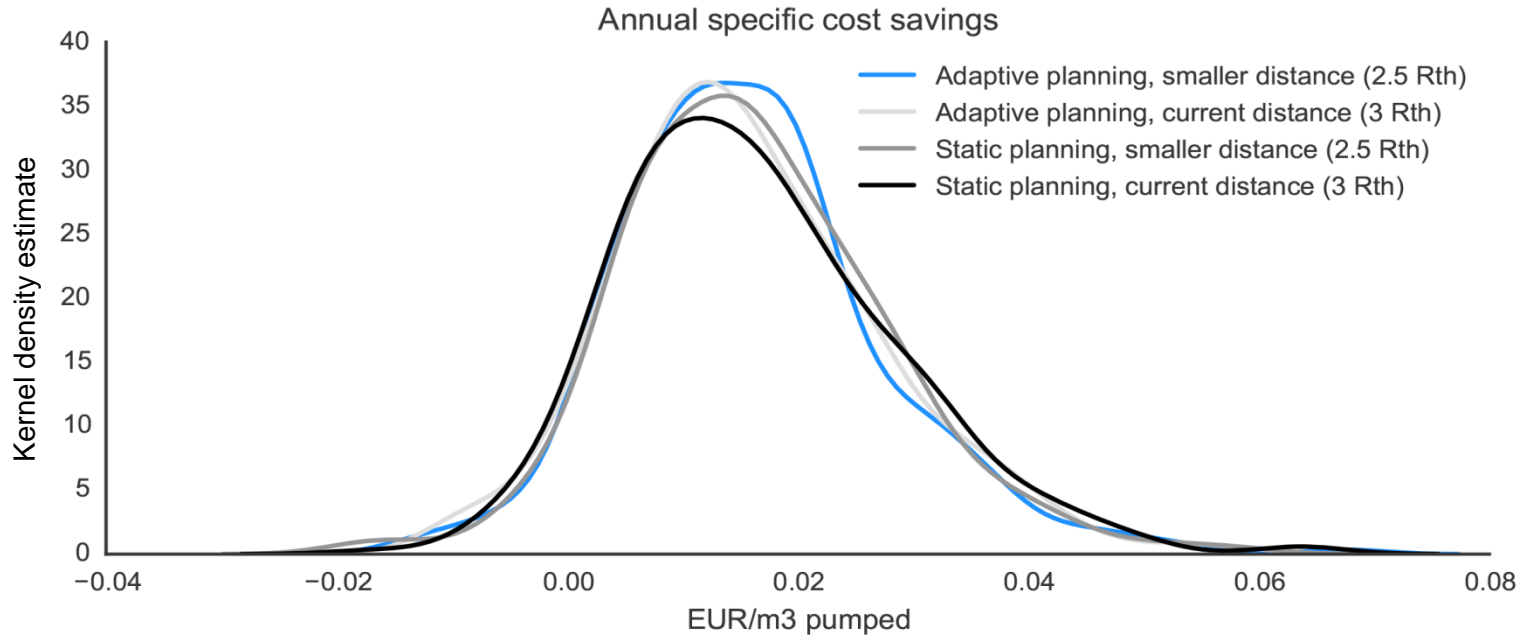
Number of ATEs systems → + 20%

Total cost savings → + 10%

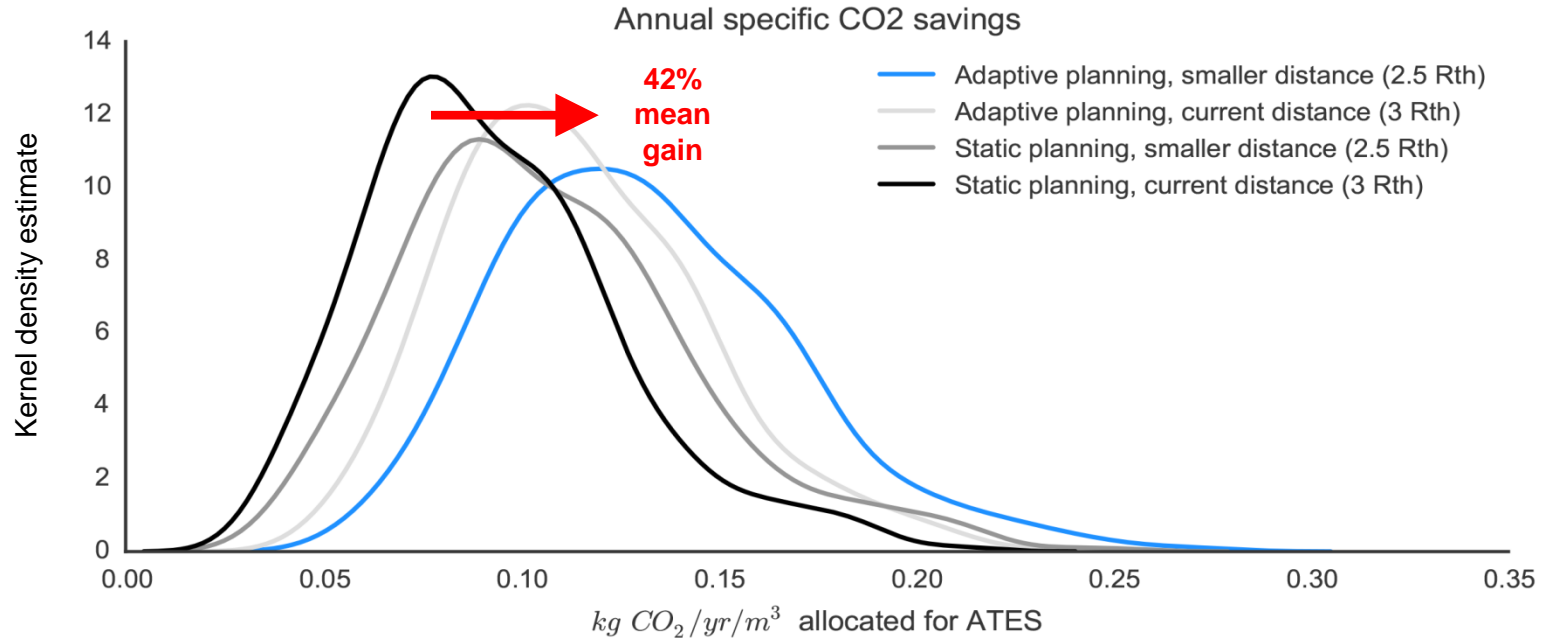
Total GHG emission → -10%

# Results: Costs

Specific cost savings	Mean (EUR/m <sup>3</sup> )
Adaptive 2.5 R <sub>th</sub>	0.01583 (96.6%)
Adaptive 3.0 R <sub>th</sub>	0.01579 (96.4%)
Baseline 2.5 R <sub>th</sub>	0.01613 (98.5%)
Baseline 3.0 R <sub>th</sub>	0.01638 (100%)



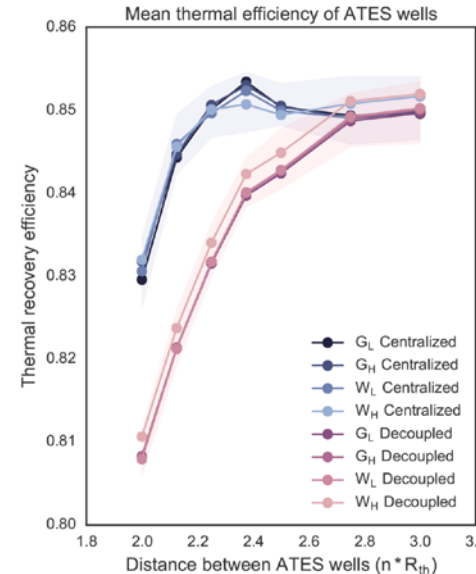
# Results: GHG emissions



# 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

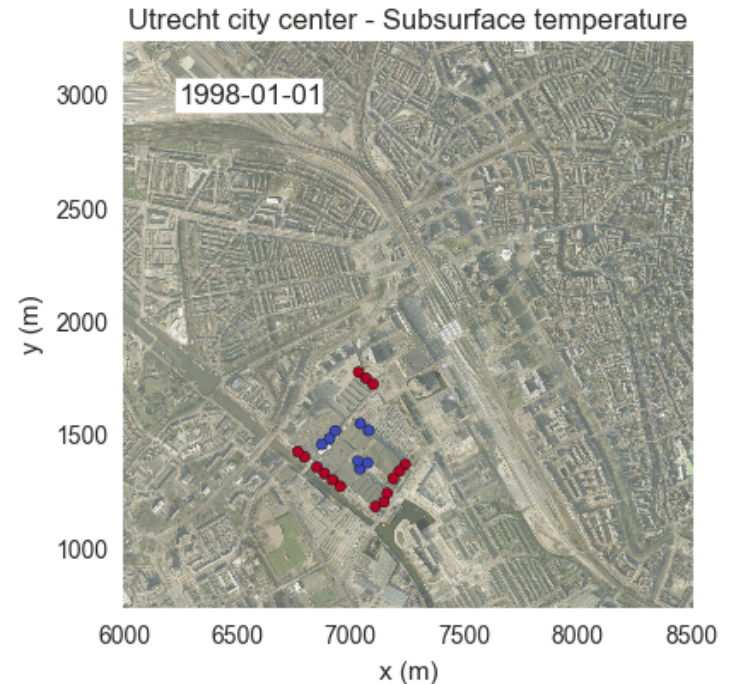


# Use it, or lose it

## Adaptive governance of aquifers with ATEs

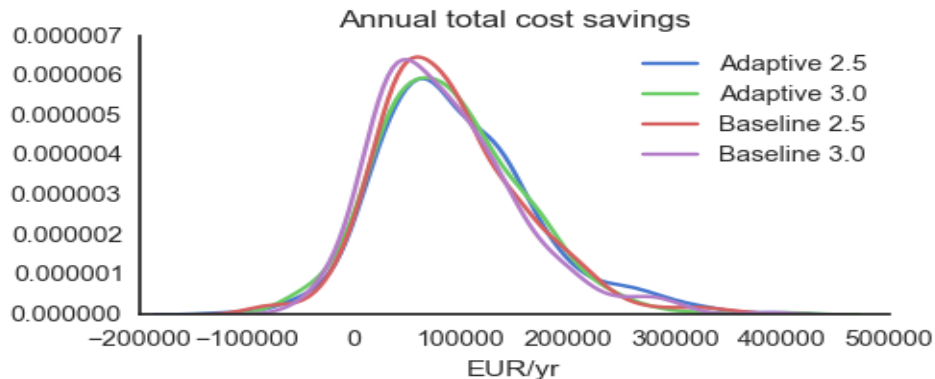
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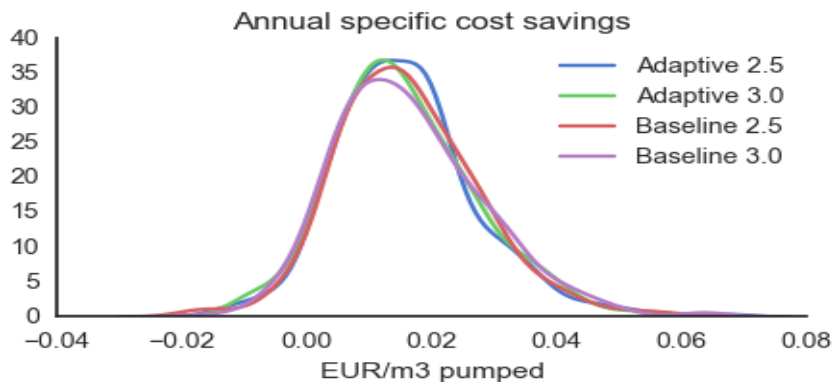
### 3. Utrecht case study

# 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	<i>Gas price</i>	0.5727
2	$Q_{mult}$	0.1302
3	$\Delta T$	0.0965
4	<i>Elec. price</i>	0.0474
5	$COP_{hp}$	0.0428



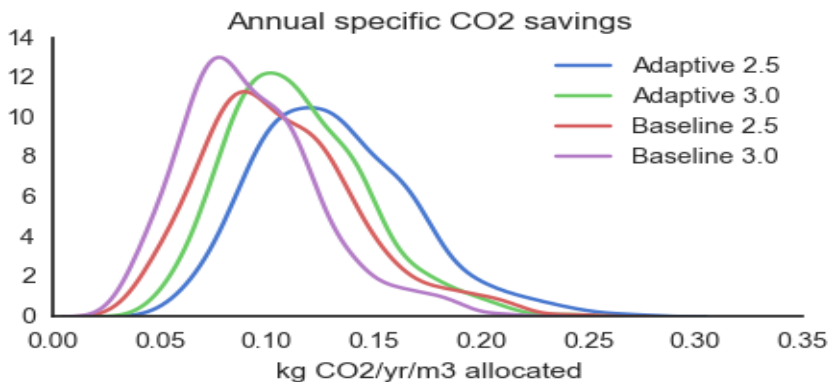
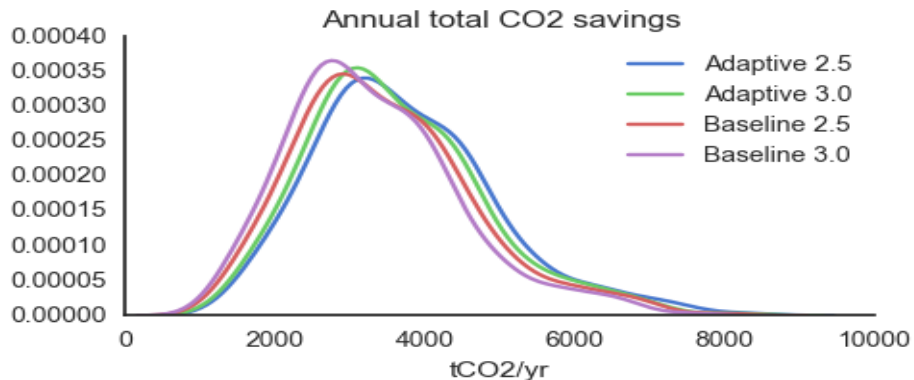
Specific cost savings	Mean (EUR/m <sup>3</sup> )
Adaptive 2.5 $R_{th}$	0.01583 (96.6%)
Adaptive 3.0 $R_{th}$	0.01579 (96.4%)
Baseline 2.5 $R_{th}$	0.01613 (98.5%)
Baseline 3.0 $R_{th}$	0.01638 (100%)

Sensitivity		
Rank	Variable	Estimated importance
1	<i>Gas price</i>	0.6674
2	$\Delta T$	0.1132
3	<i>Elec. price</i>	0.0517
4	$COP_{hp}$	0.0451
5	$COP_c$	0.0293



### 3. Utrecht case study

# GHG savings

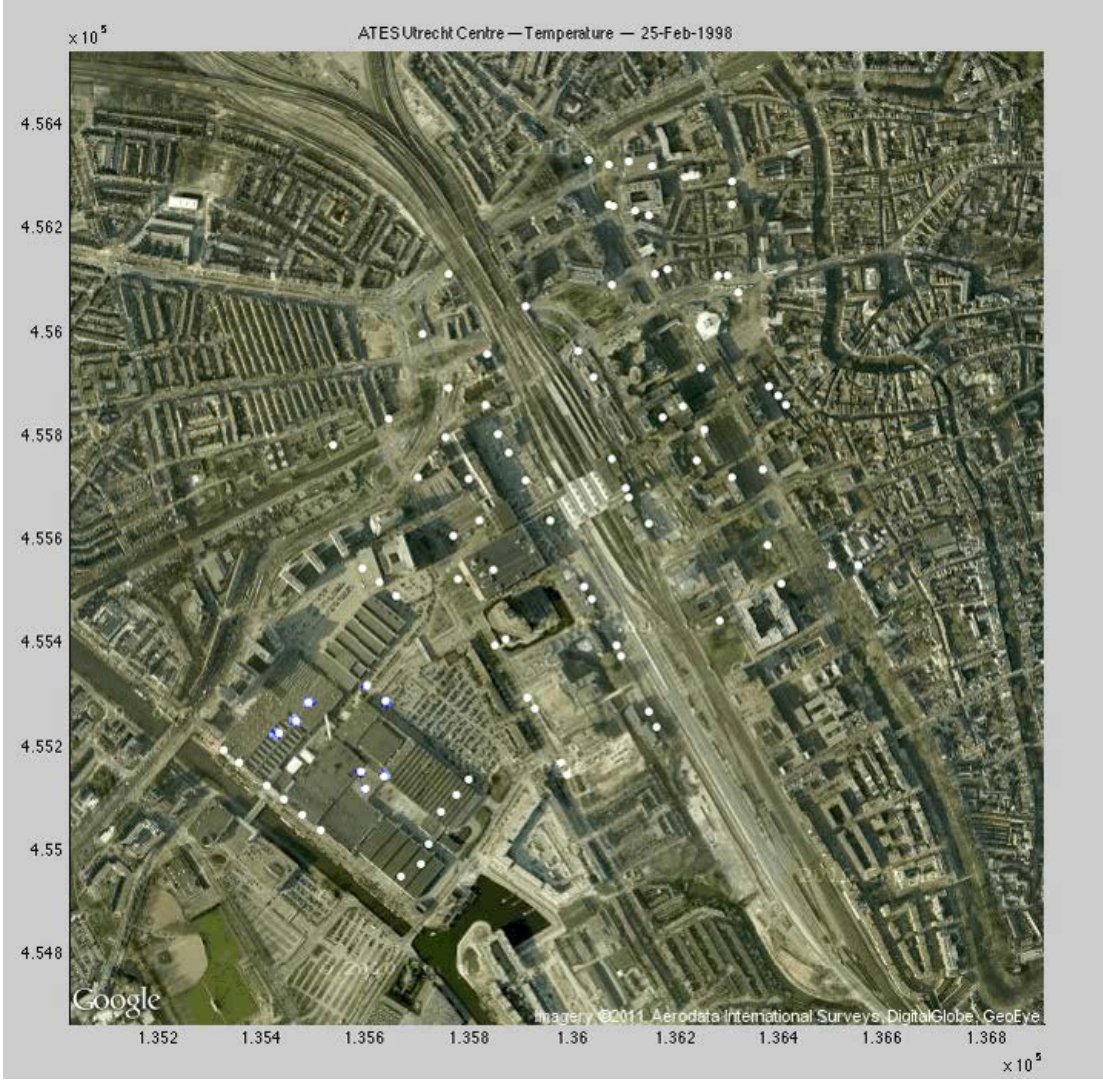


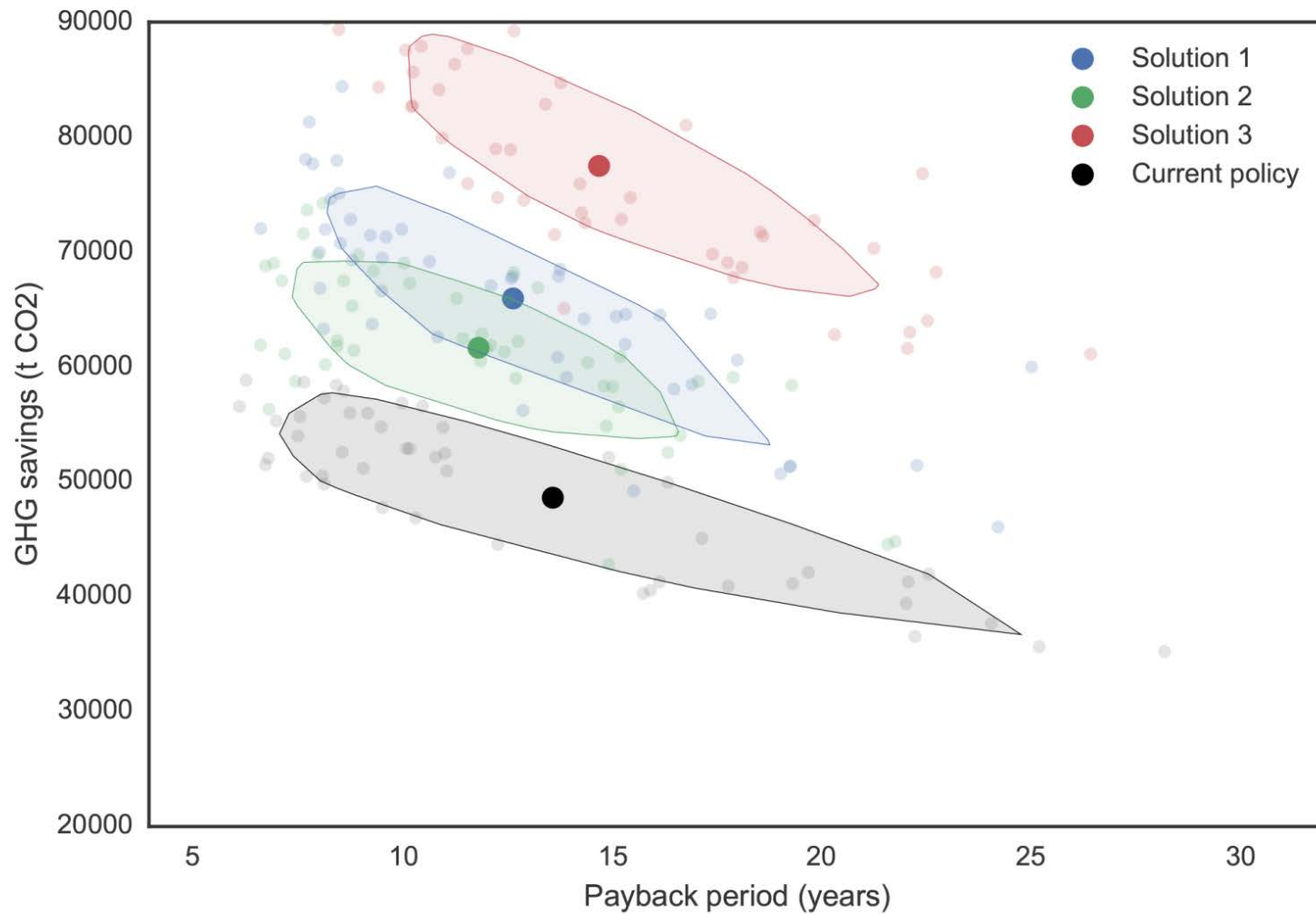
Total CO <sub>2</sub> savings	Mean (tCO <sub>2</sub> /yr)
Adaptive 2.5 R <sub>th</sub>	3739 (113%)
Adaptive 3.0 R <sub>th</sub>	3615 (109%)
Baseline 2.5 R <sub>th</sub>	3472 (104%)
Baseline 3.0 R <sub>th</sub>	3314 (100%)

Sensitivity		
Rank	Variable	Estimated importance
1	$Q_{mult}$	0.4598
2	$\Delta T$	0.3851
3	$COP_{hp}$	0.0525
4	$COP_c$	0.0492
5	Policy	0.0299

Specific CO <sub>2</sub> savings	Mean (kg CO <sub>2</sub> /yr/m <sup>3</sup> )
Adaptive 2.5 R <sub>th</sub>	0.1316 (142%)
Adaptive 3.0 R <sub>th</sub>	0.1144 (123%)
Baseline 2.5 R <sub>th</sub>	0.1067 (115%)
Baseline 3.0 R <sub>th</sub>	0.0927 (100%)

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



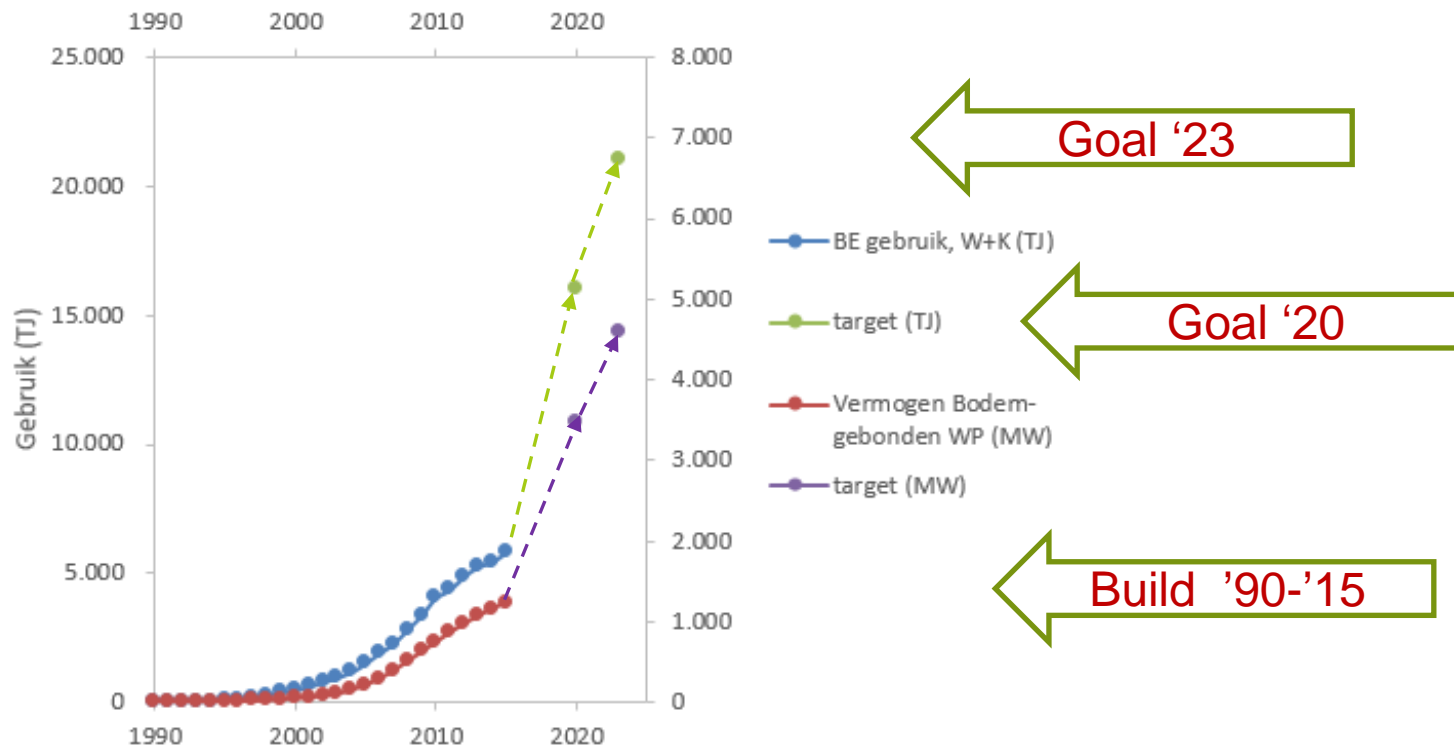


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# SER / Paris Agreement

BE gebruik en vermogen



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**Phase change materials**

**Thermo Chemical materials**

**Bovengrondse buffertank**

**Ondergrondse buffertank**

**bodemenergie WKO**

**bodemenergie HTO**

**KWR**

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