Upscaling Geothermal Heat: Synthetic Models Advising Field Development (PPT)

Daniilidis, Alexandros; Nick, H.M.; Bruhn, David

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Upscaling Geothermal Heat: Synthetic Models Advising Field Development

Alexandros Daniilidis, Hamid Nick, David Bruhn

DAP symposium 2019, March 12th

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Kennisagenda ECW

Steering committee

Platform Geothermie

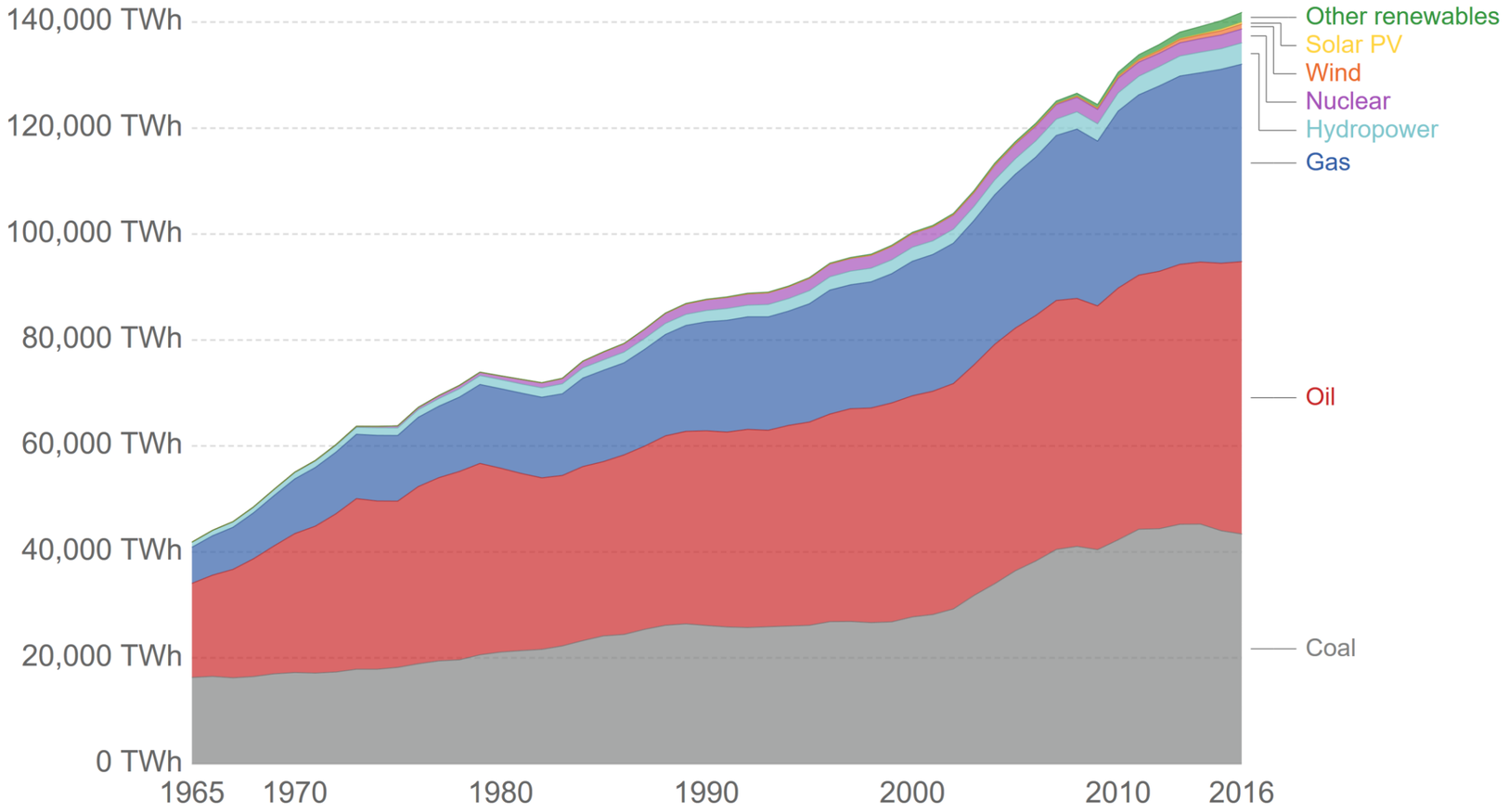
TNO

ebn

Motivation

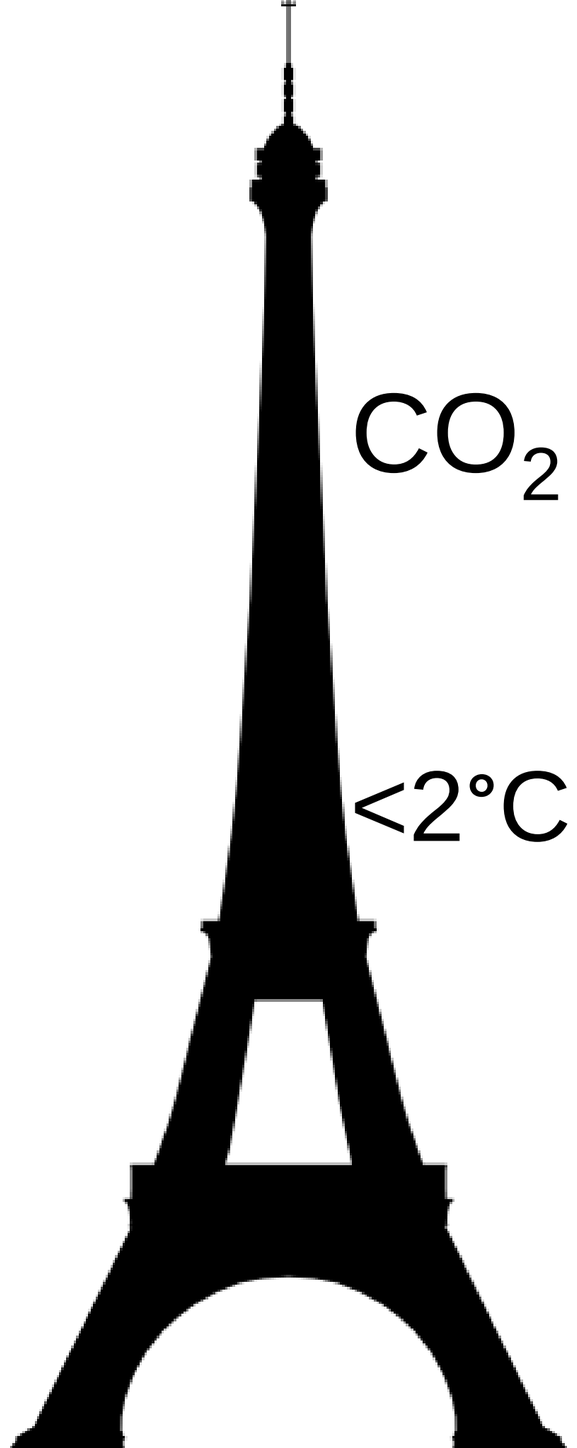
Primary energy consumption by source, World

Primary energy consumption by source across the world's regions, measured in terawatt-hours (TWh). Note that this data does not include energy sourced from traditional biomass, which may form a significant component of primary energy consumption in low to middle-income countries. 'Other renewables' includes renewable sources including wind, geothermal, solar, biomass and waste.



Source: BP Statistical Review 2016

OurWorldInData.org/energy-production-and-changing-energy-sources/ • CC BY-SA



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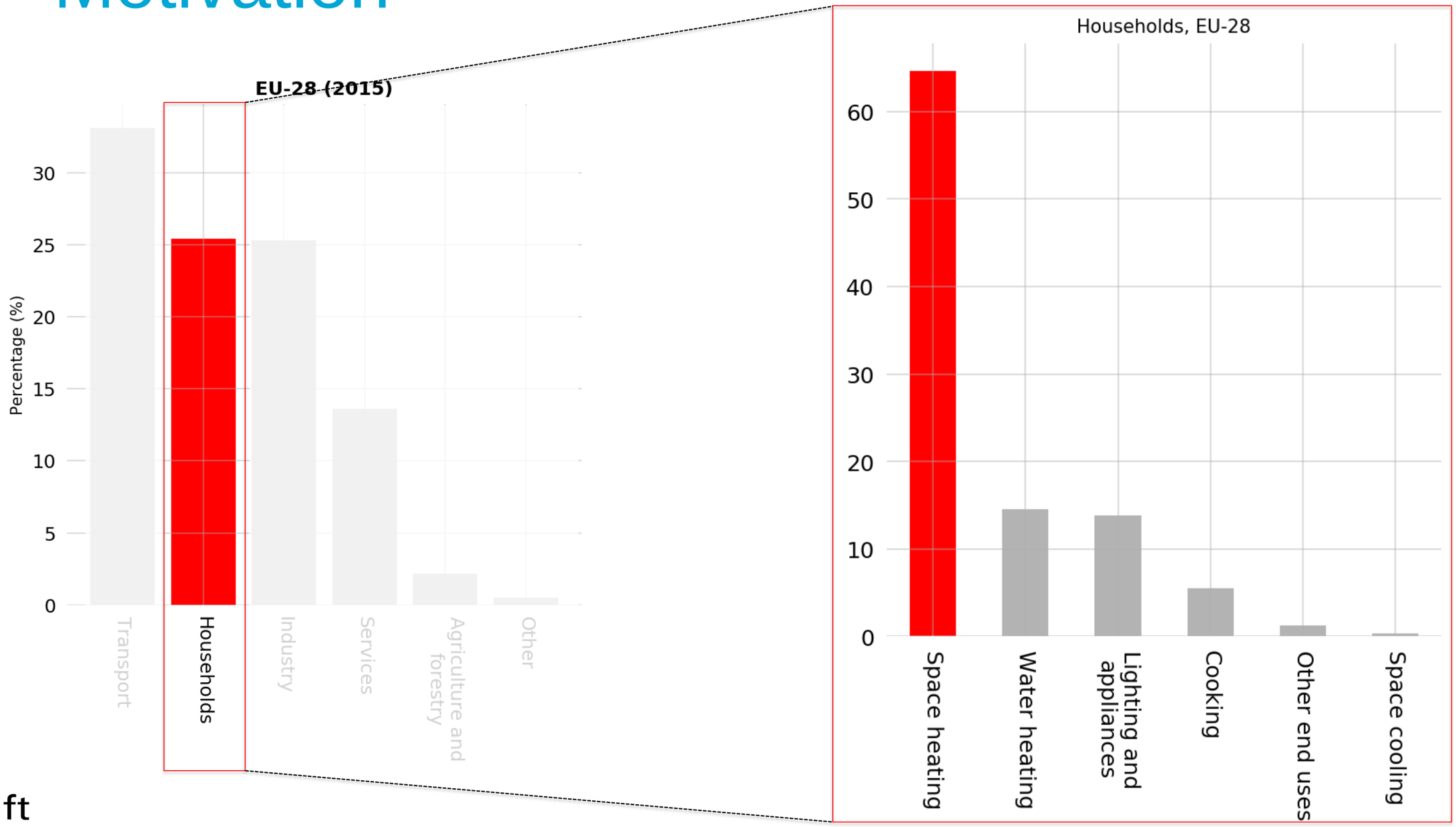
Motivation



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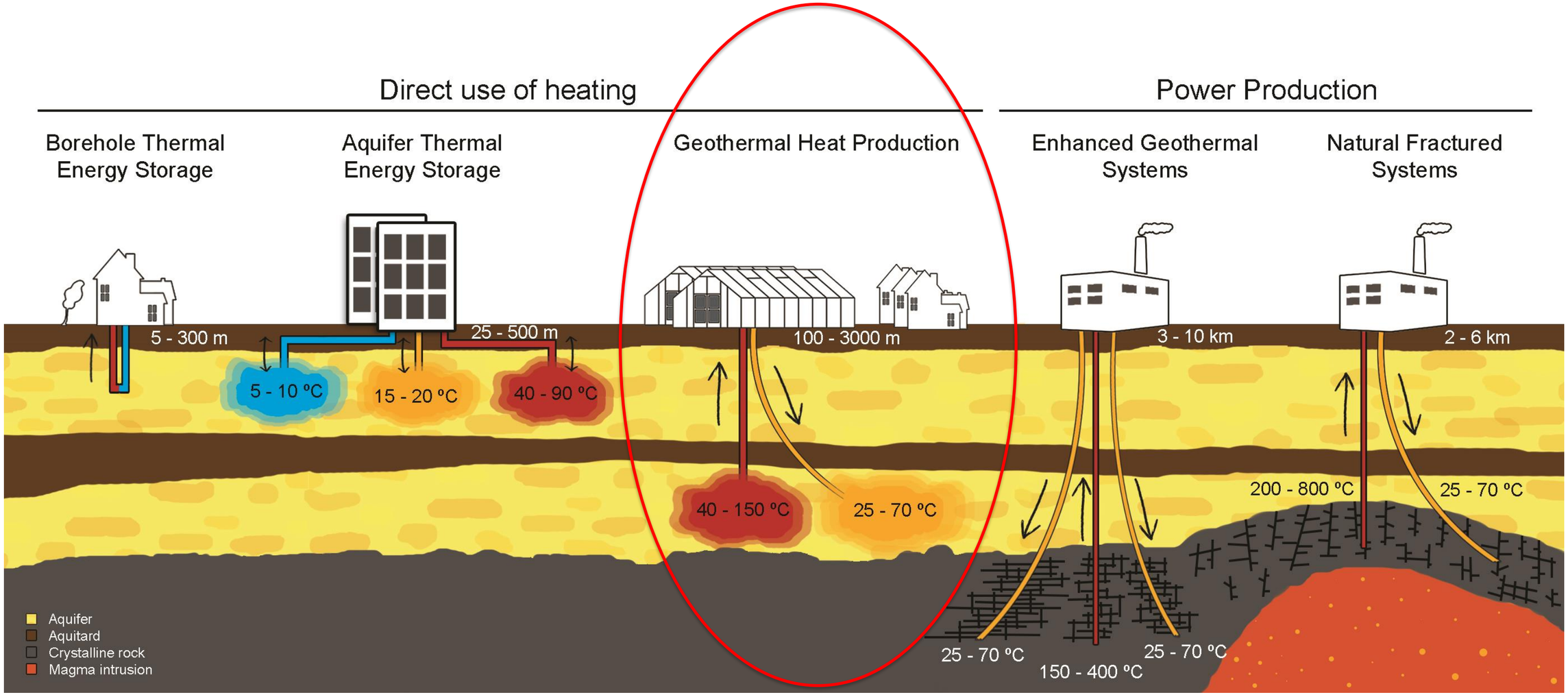
Geothermal systems



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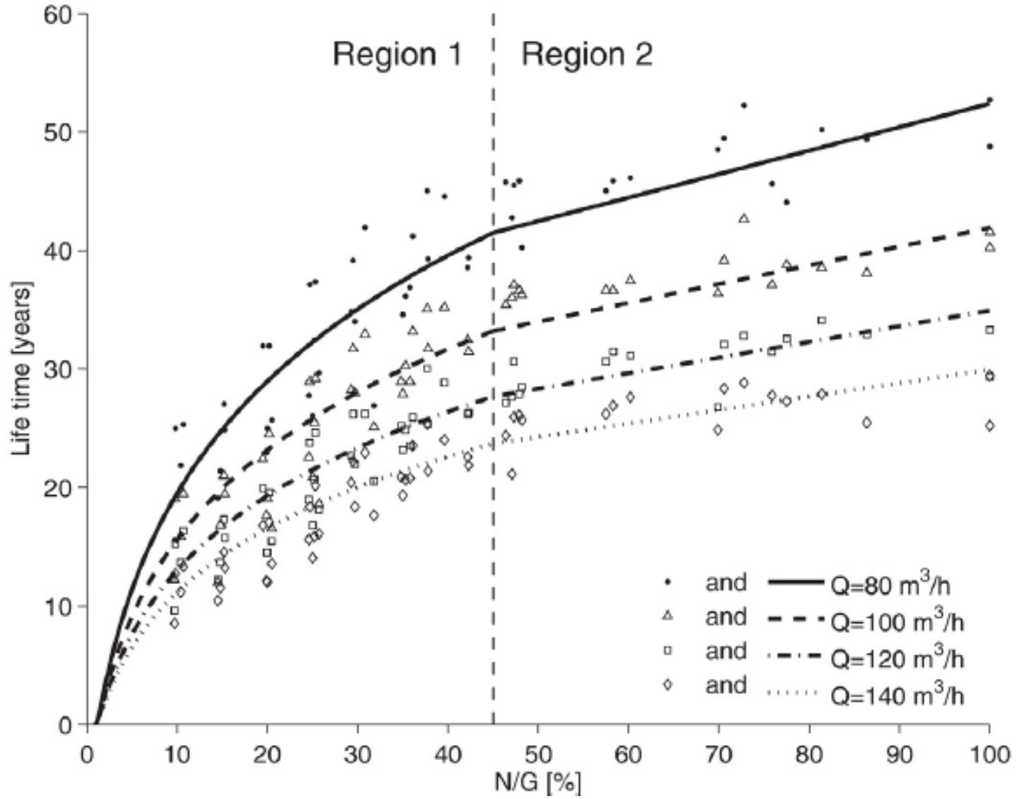
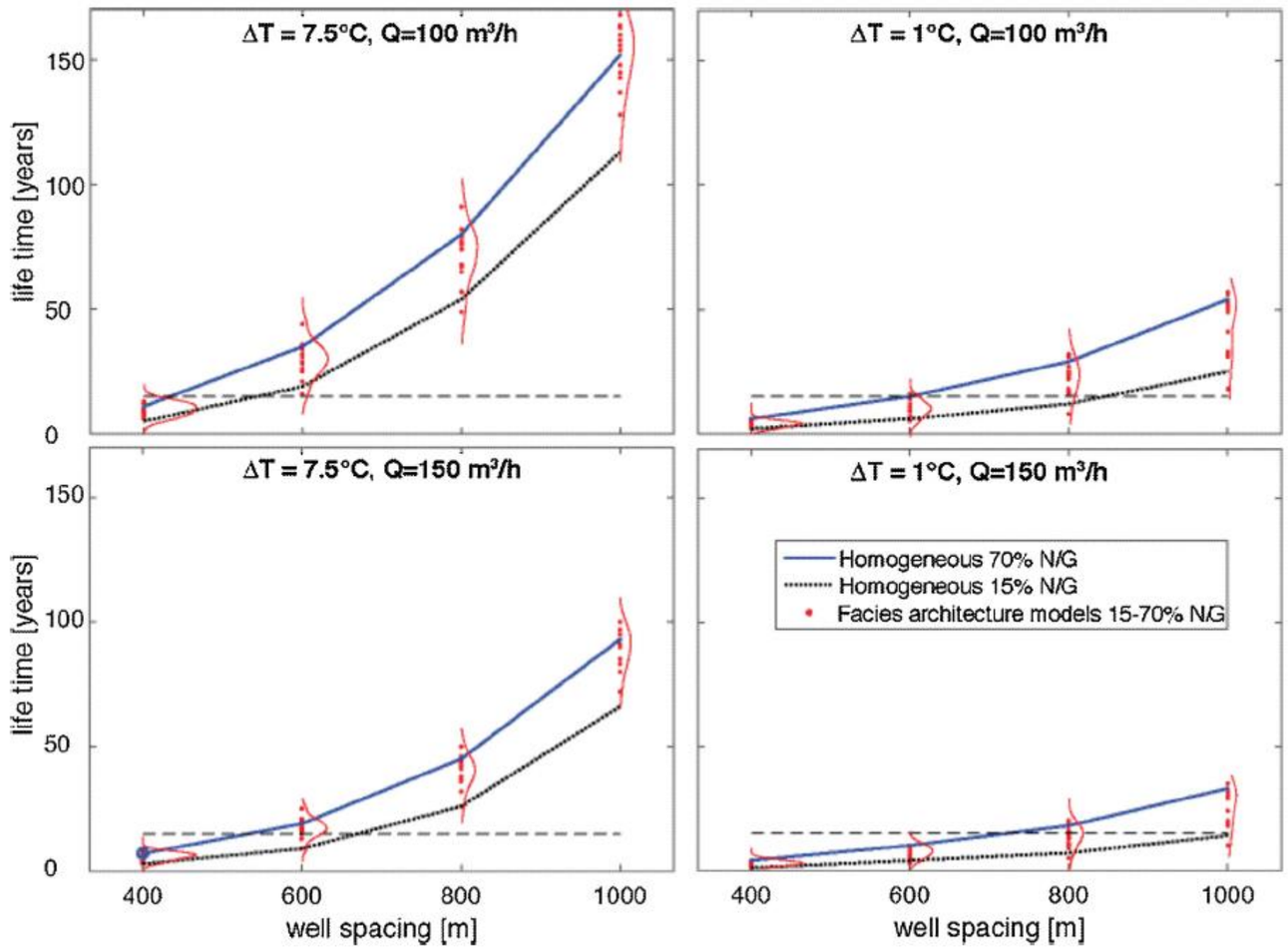
Background
Three types of reservoir models



Crooijmans et.al. 2016

Background
Well spacing



Willems et.al. 2017

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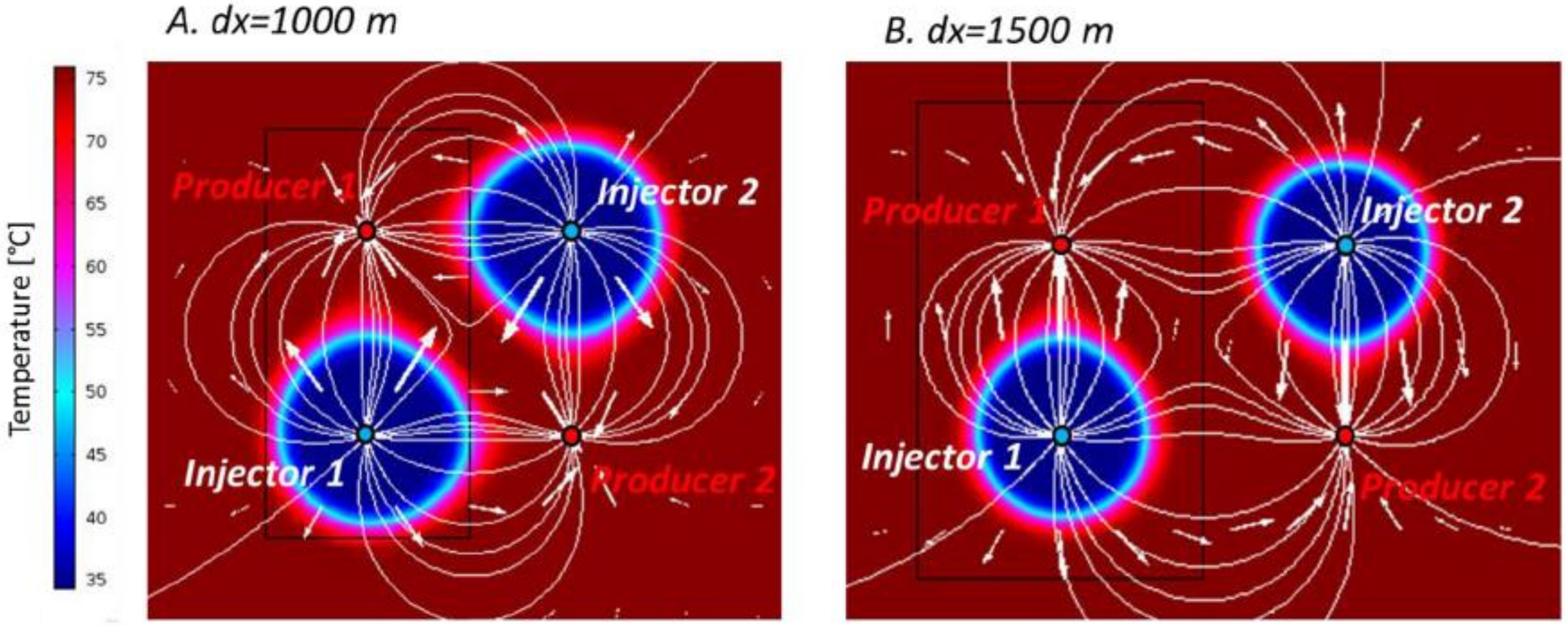
Background
Interference – two doublets

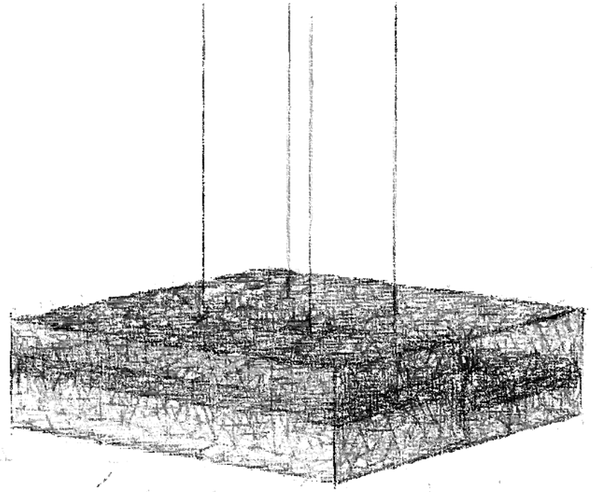


Willems et.al. 2017

Underlying idea

"Simple" synthetic model

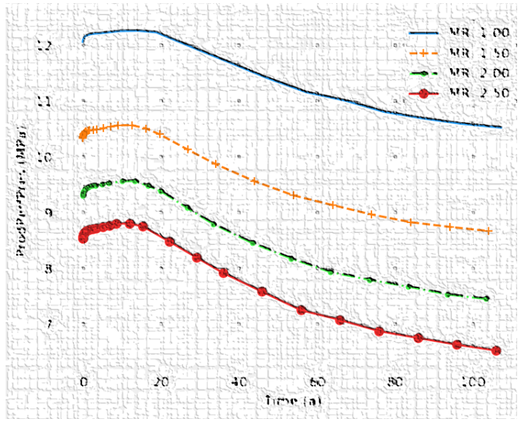
X1000s realization



Capture uncertainty

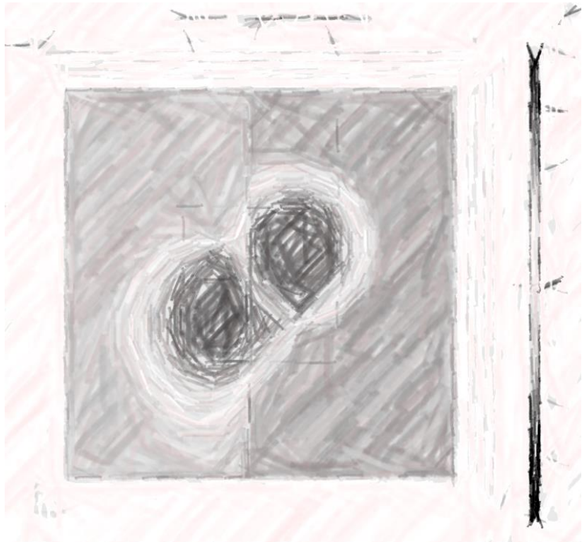
Consider scenarios

Analyze results



Obtain generalizable conclusions

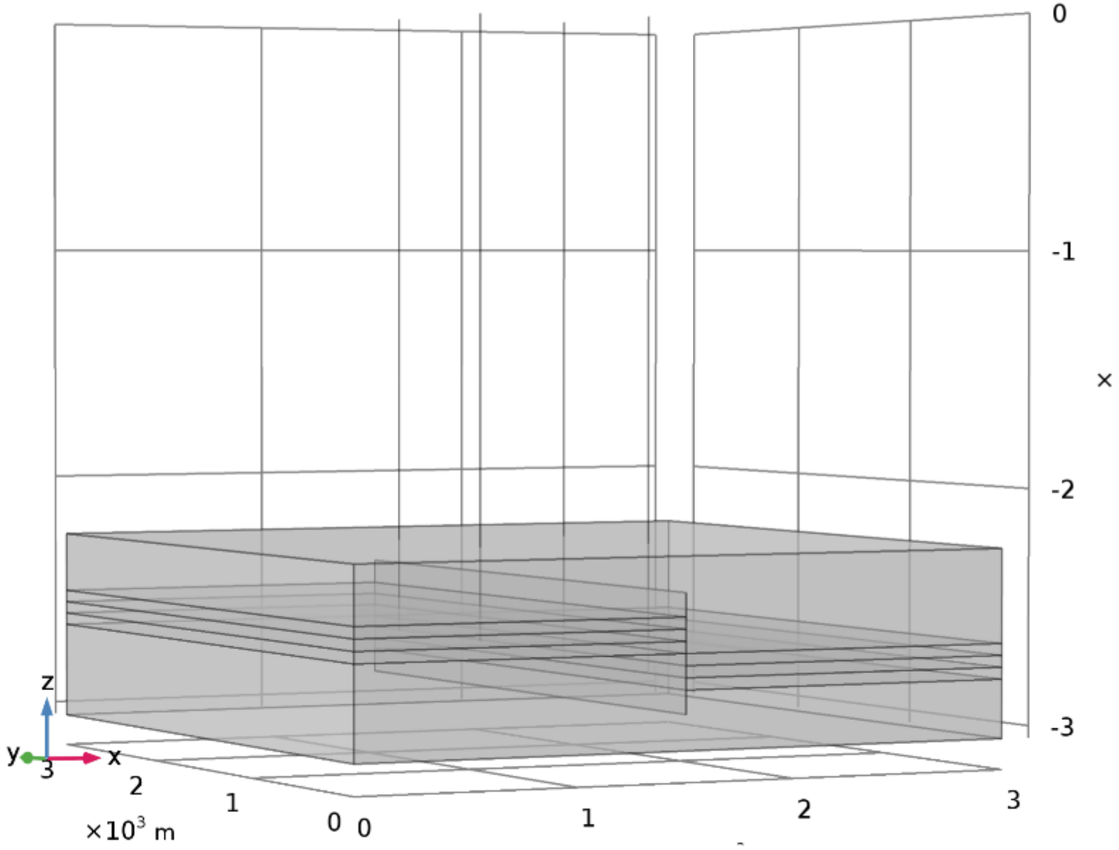
Devise strategy

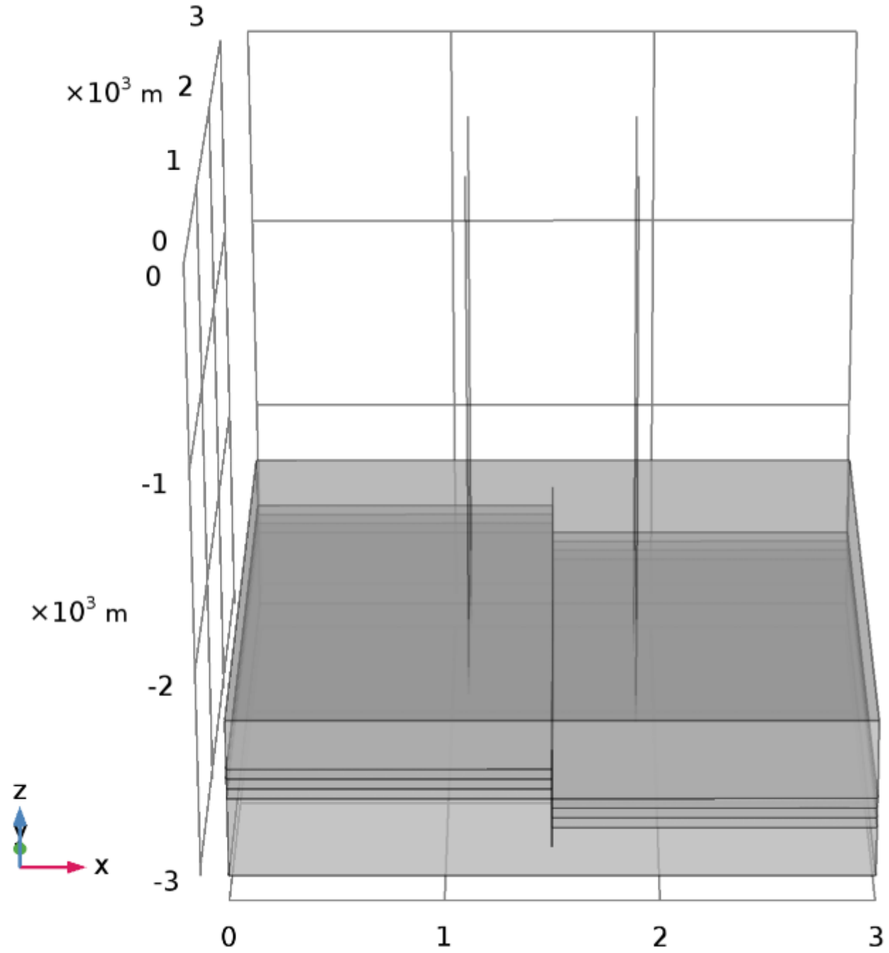


"Upscale" findings to field scale

Synthetic model

2 doublets separated by one fault





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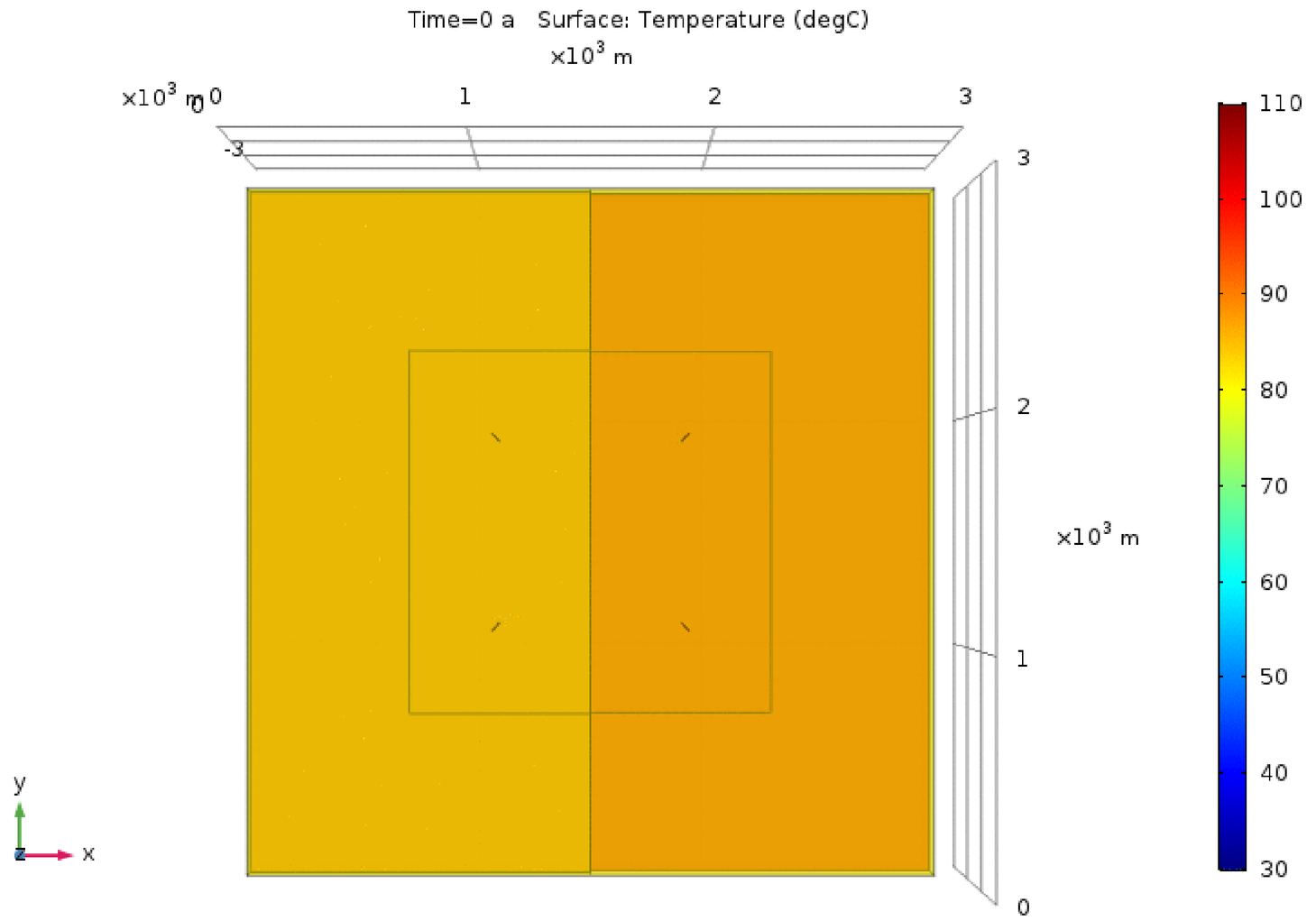
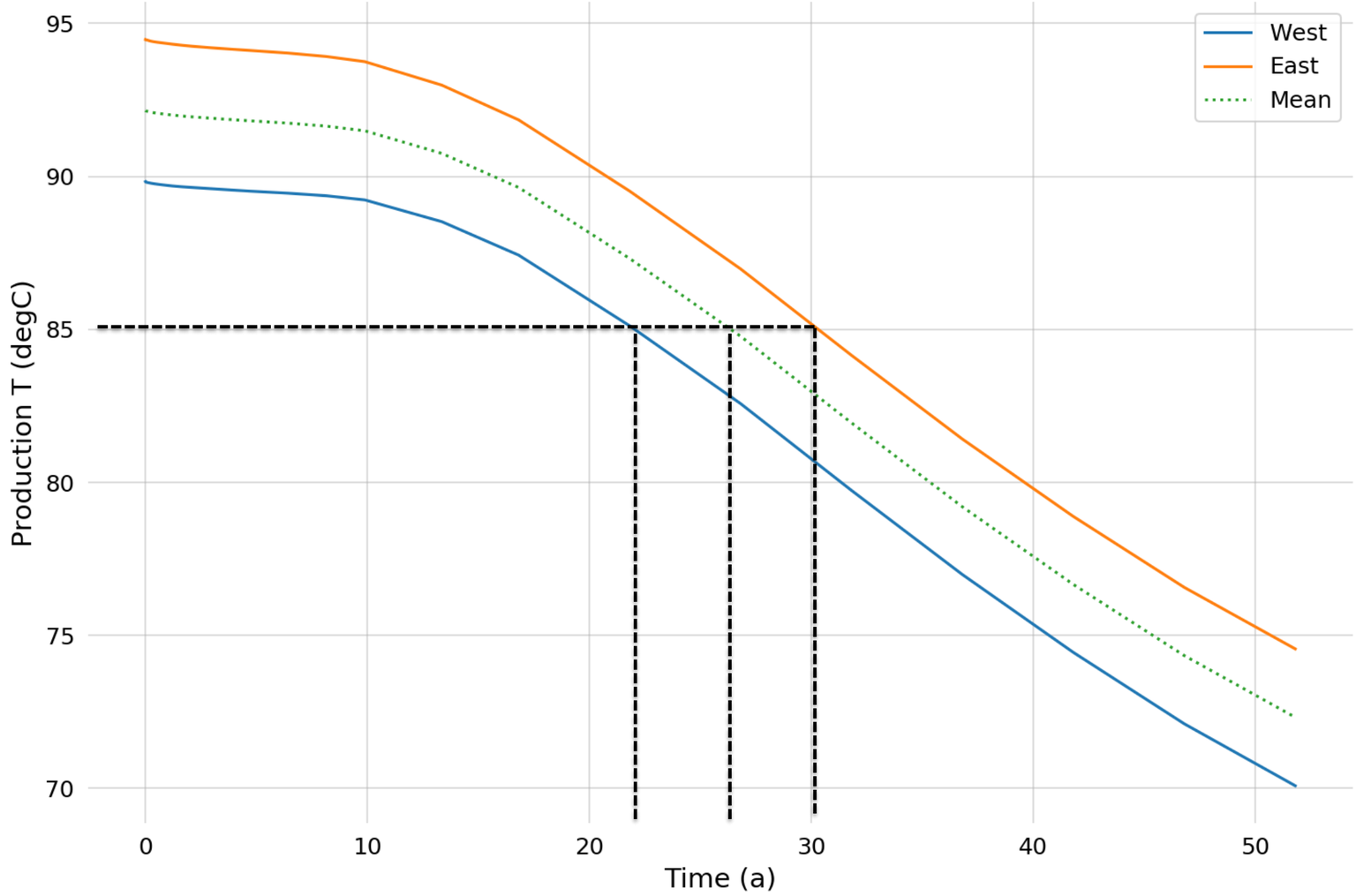
Example simulation

Top view



System lifetime
Temperature drop



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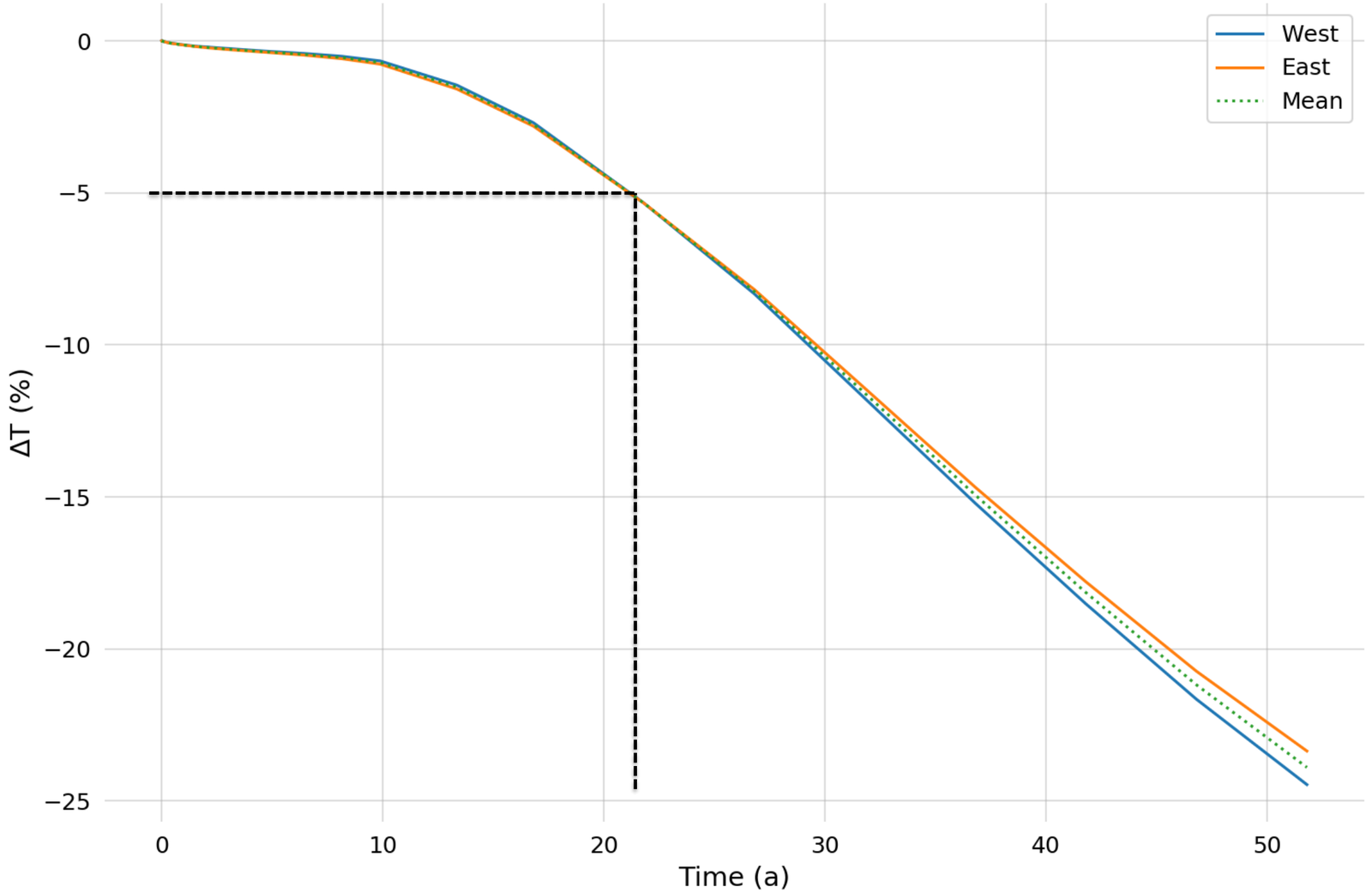
System lifetime

Percentage drop $T \leq 95\% T_{t=0}$



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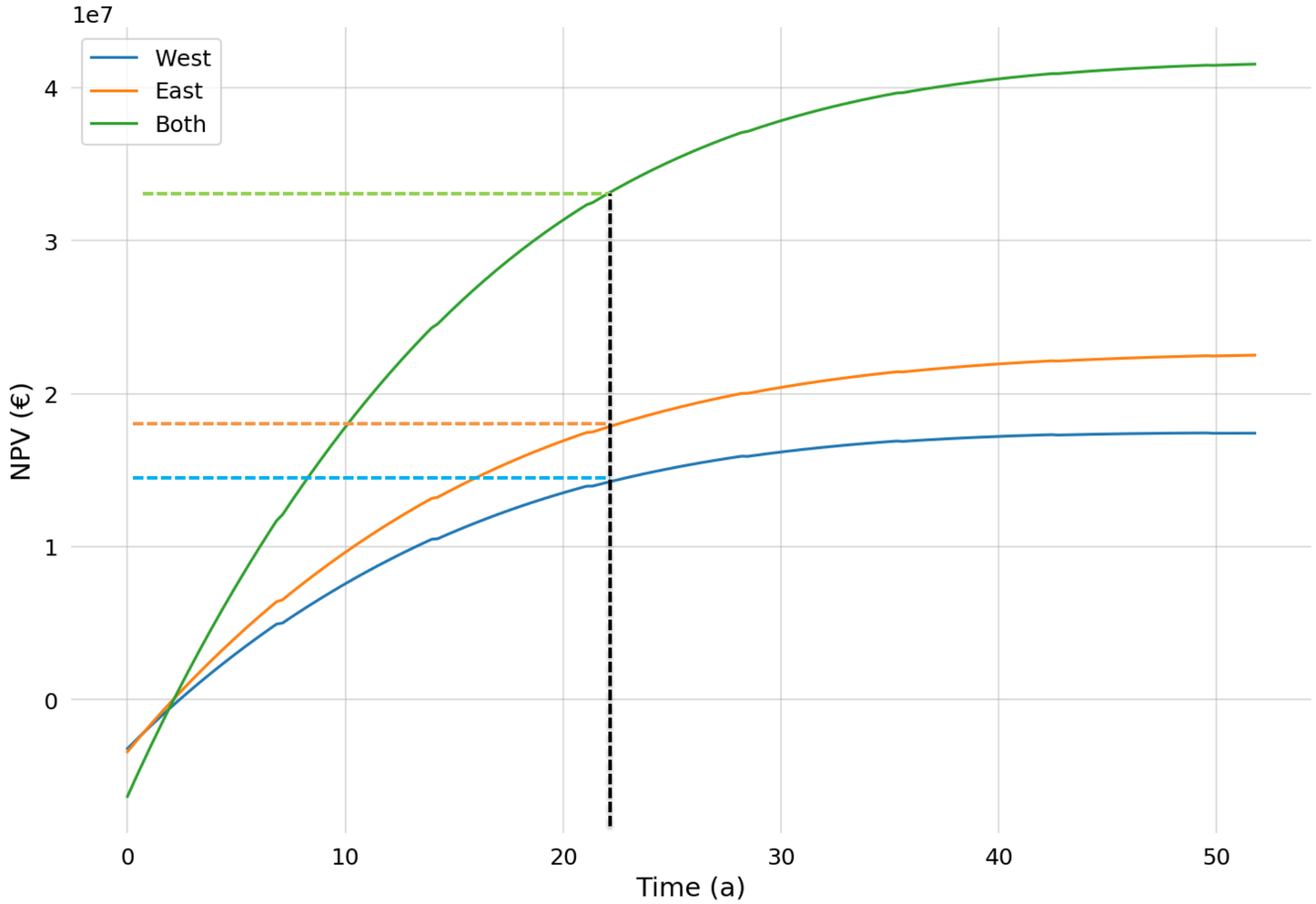
NPV
At system lifetime



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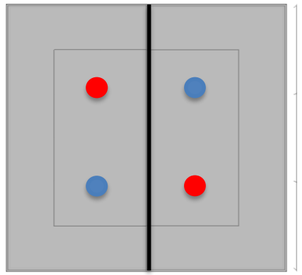
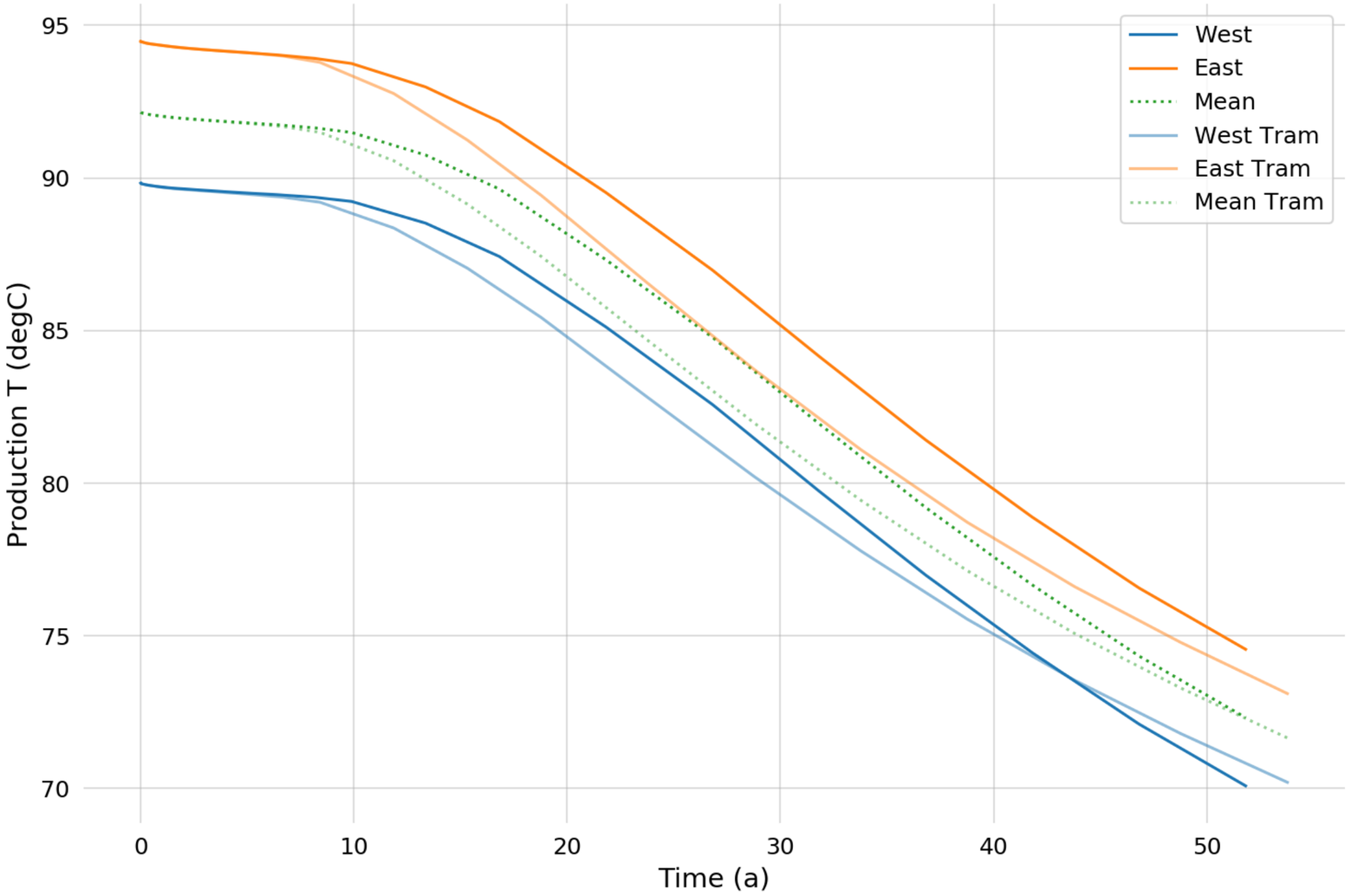
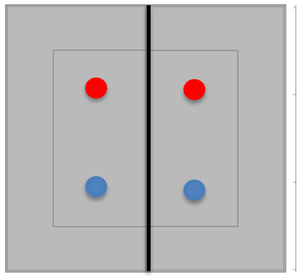
System lifetime
Well configuration







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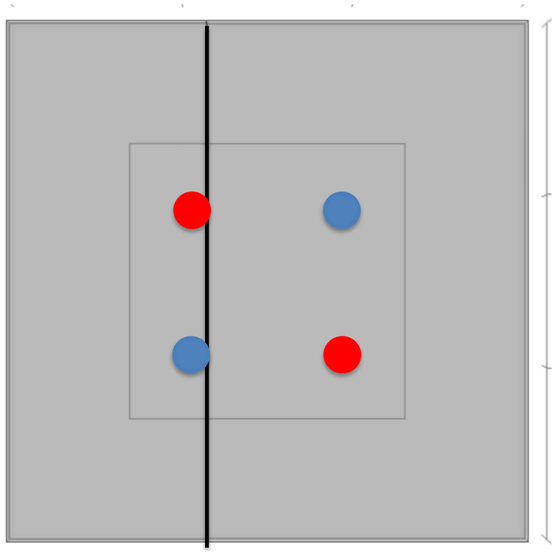
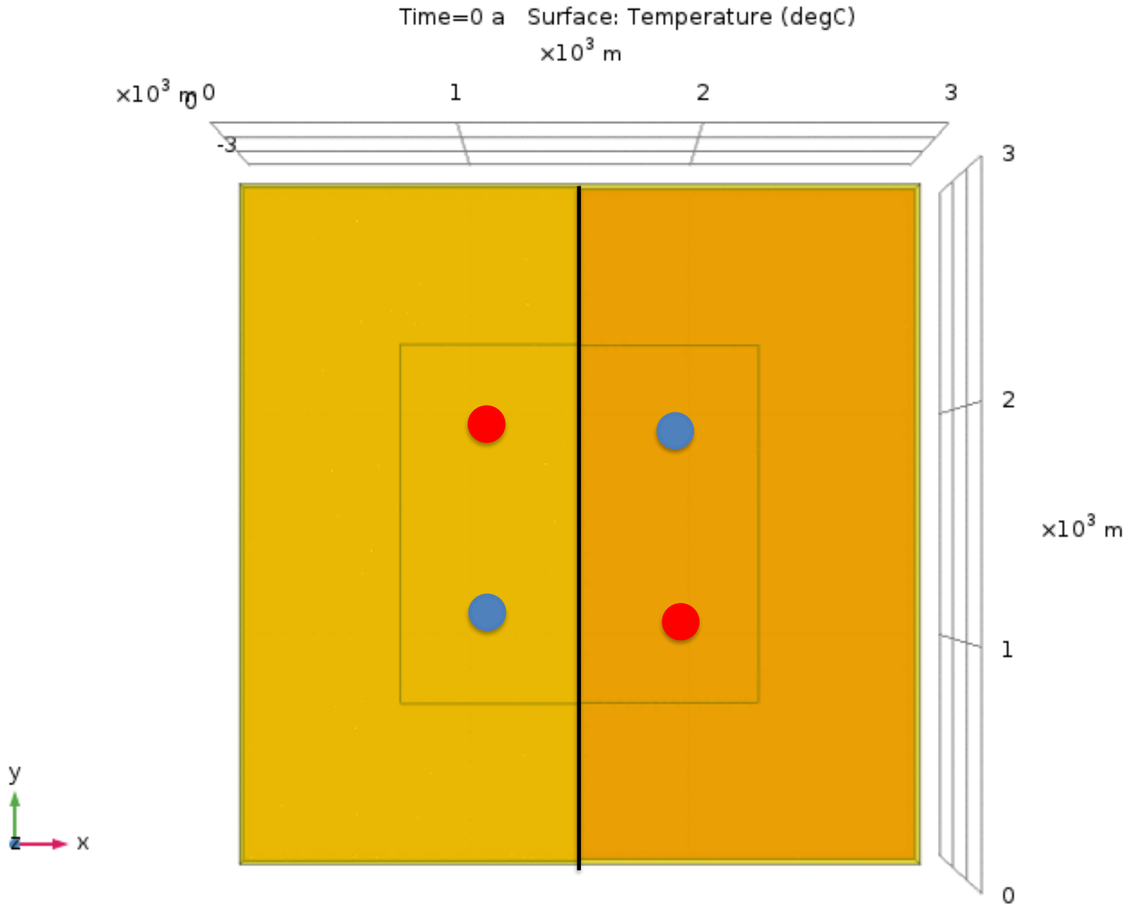
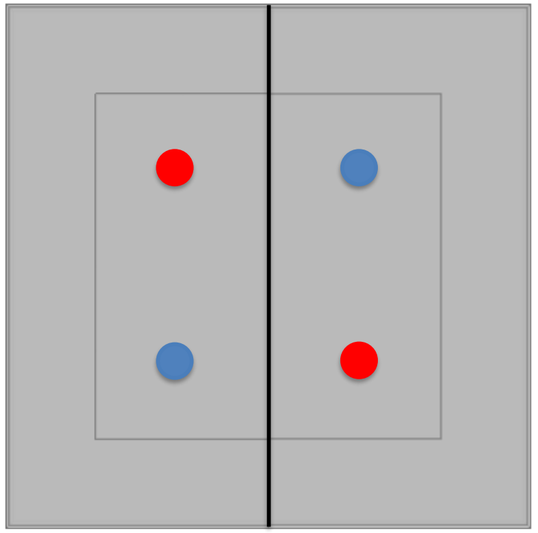
Example simulation
Top view

Uncertainty:
Reservoir layer properties
Fault distance
Fault properties
….



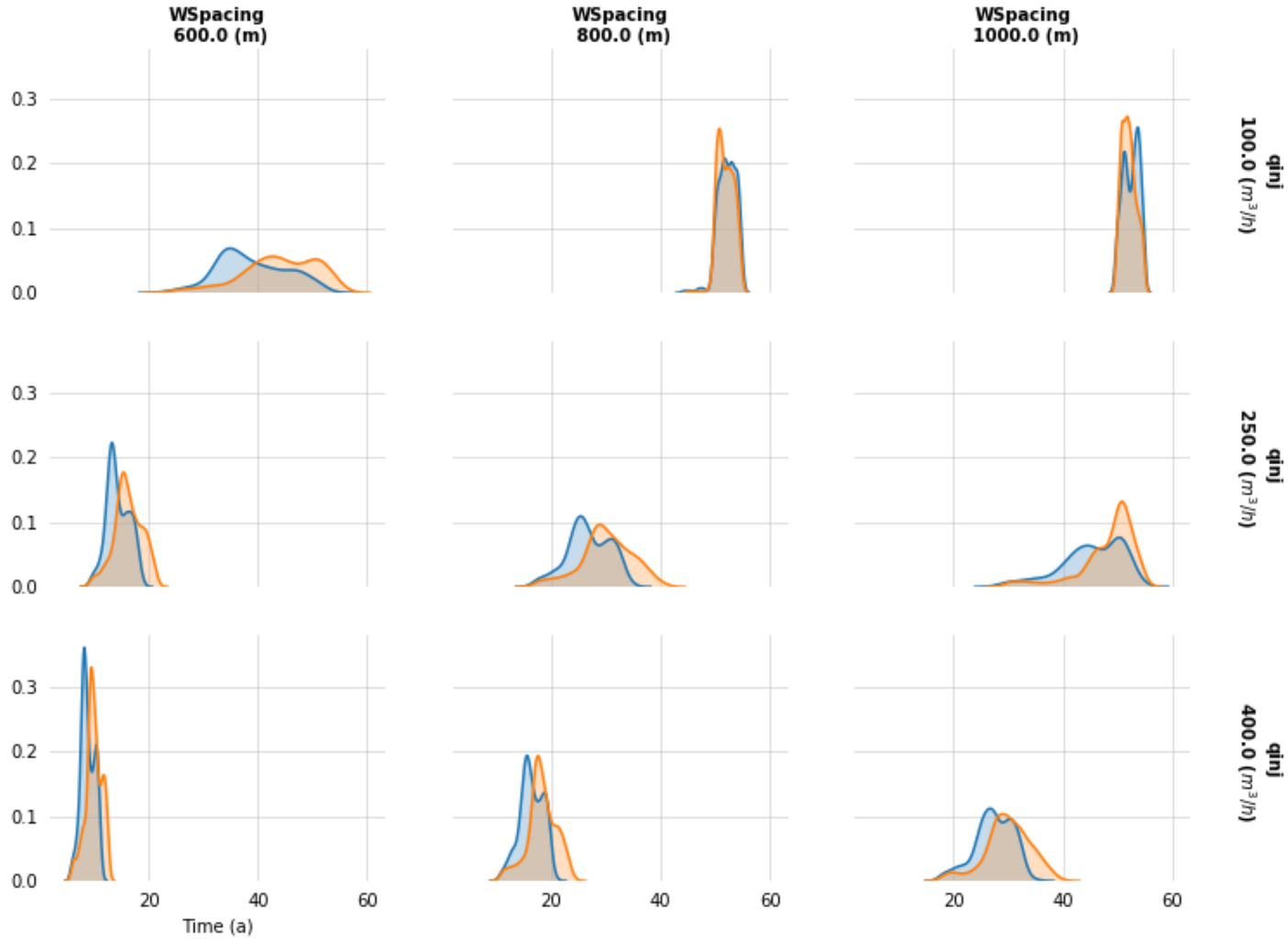


Scenario:
Well spacing
Well arrangement
Flow rate
….



System lifetime

Well configurations T ≤ 95% T_{t0}



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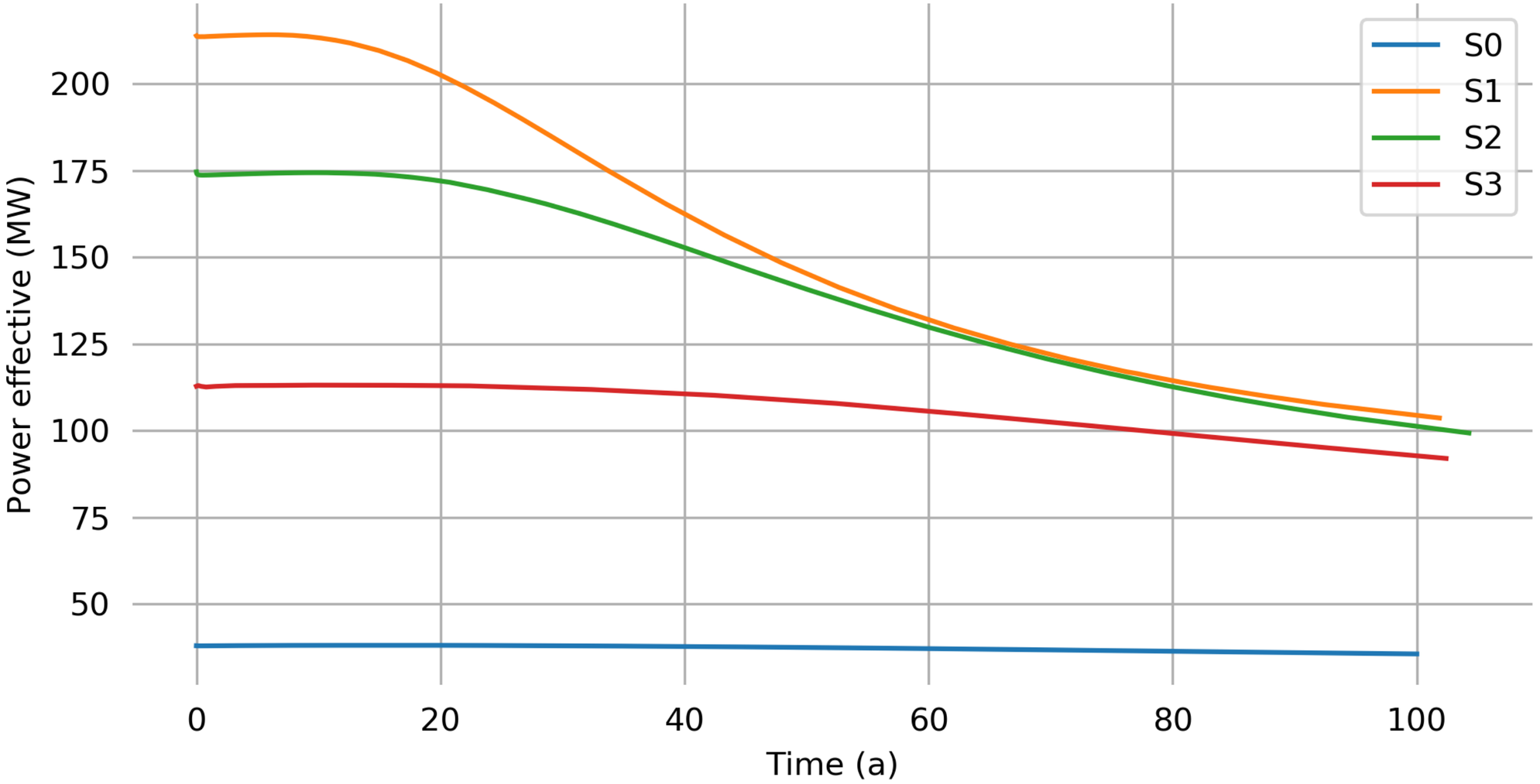
Systematic Overview

$T \leq 95\% \, T_{t0}$

Field scale



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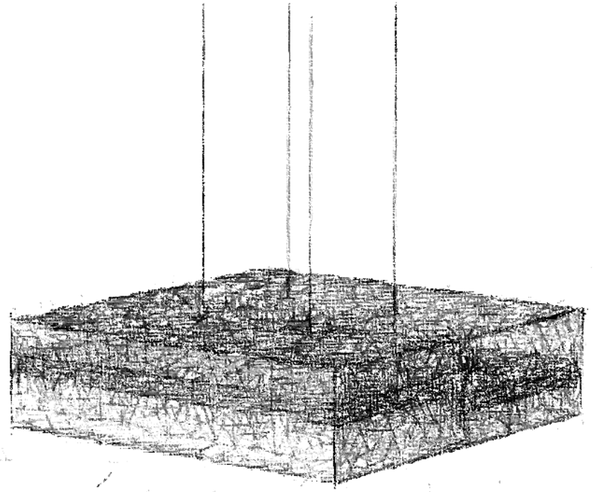
Overview

"Simple" synthetic model

X1000s realization



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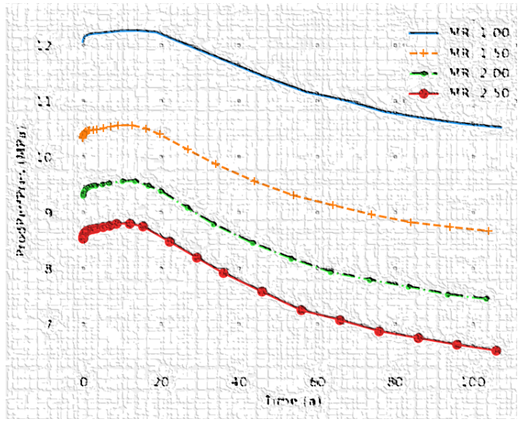

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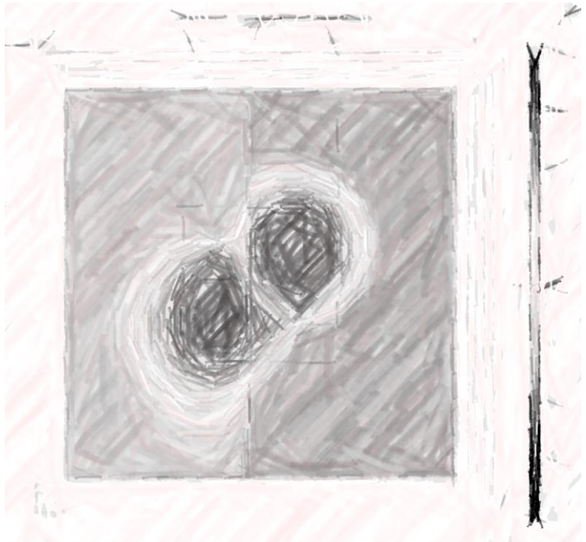
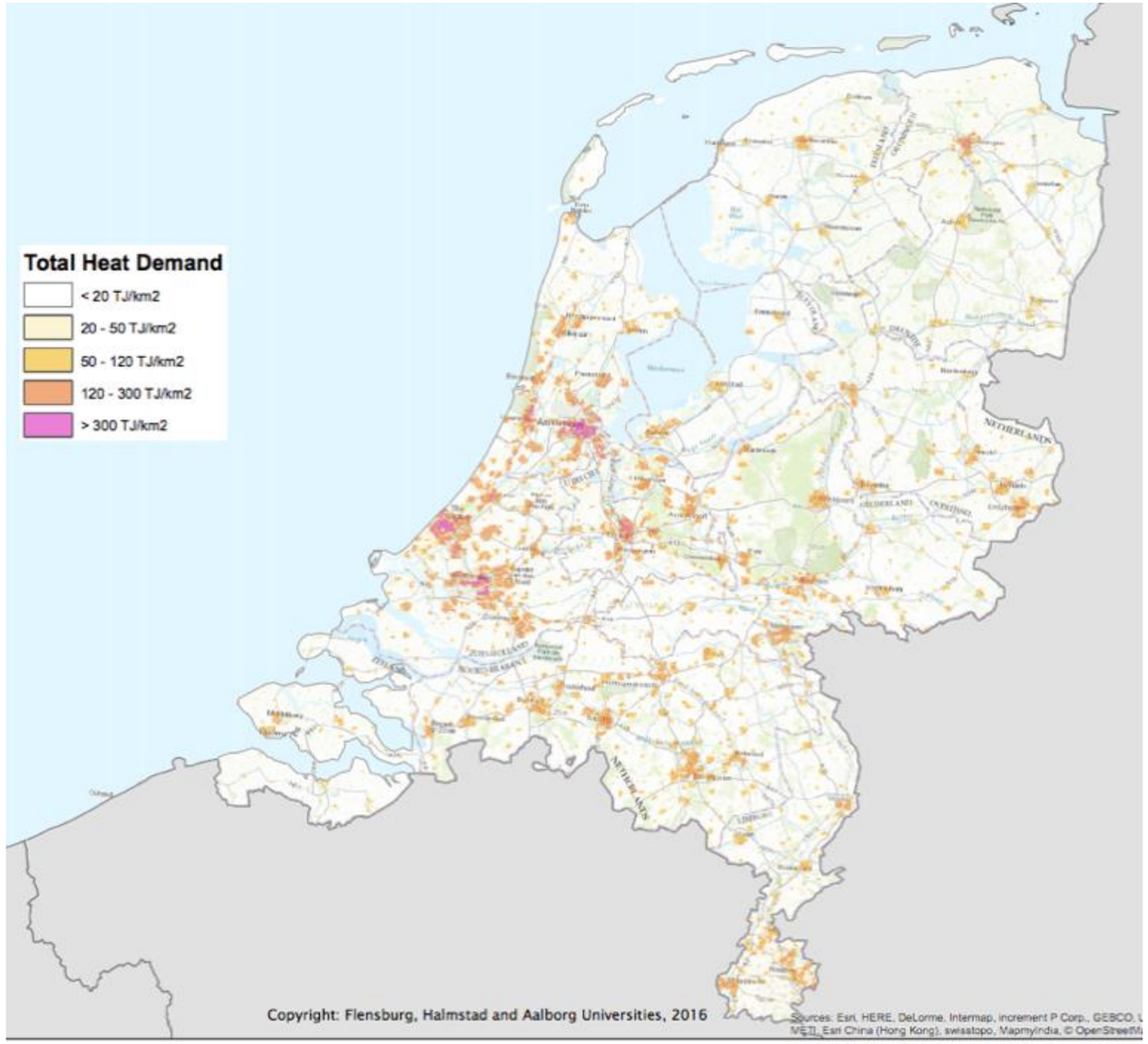


"Upscale" findings to field scale

Relevance



Source: Heat Roadmap Europe 2013

Contact:
A.Daniilidis@tudelft.nl