



RESULT

Enhancing REServoirs in Urban developmenT: smart wells and reservoir development, Geothermica Project Number 200317

WGC – geothermica presentation, 2021.10.27, Reykjavik
jan.hopman@tno.nl, jan_diederik.vanwees@tno.nl

Objectives

- The main objective is to demonstrate the potential for increased performance by 30-100% of major (marginal) reservoirs for heating in urban areas in the northern EU.

RESULT achieves this by deploying

- best in class well technology options,
- optimization methods and drill and learn strategies,
- reservoirs models and uncertainty assessments,
- reservoir development optimization in different settings in Europe.
- innovative procedure and techniques will be used and demonstrated in asset development and drilling a geothermal doublet

Well scenarios

- Well scenarios - vertical, horizontal, triplet, RJD, multilaterals: 30-100% gain in flow performance

Concept select

- Well Concept select: techno-economic trade-offs for single reservoir model

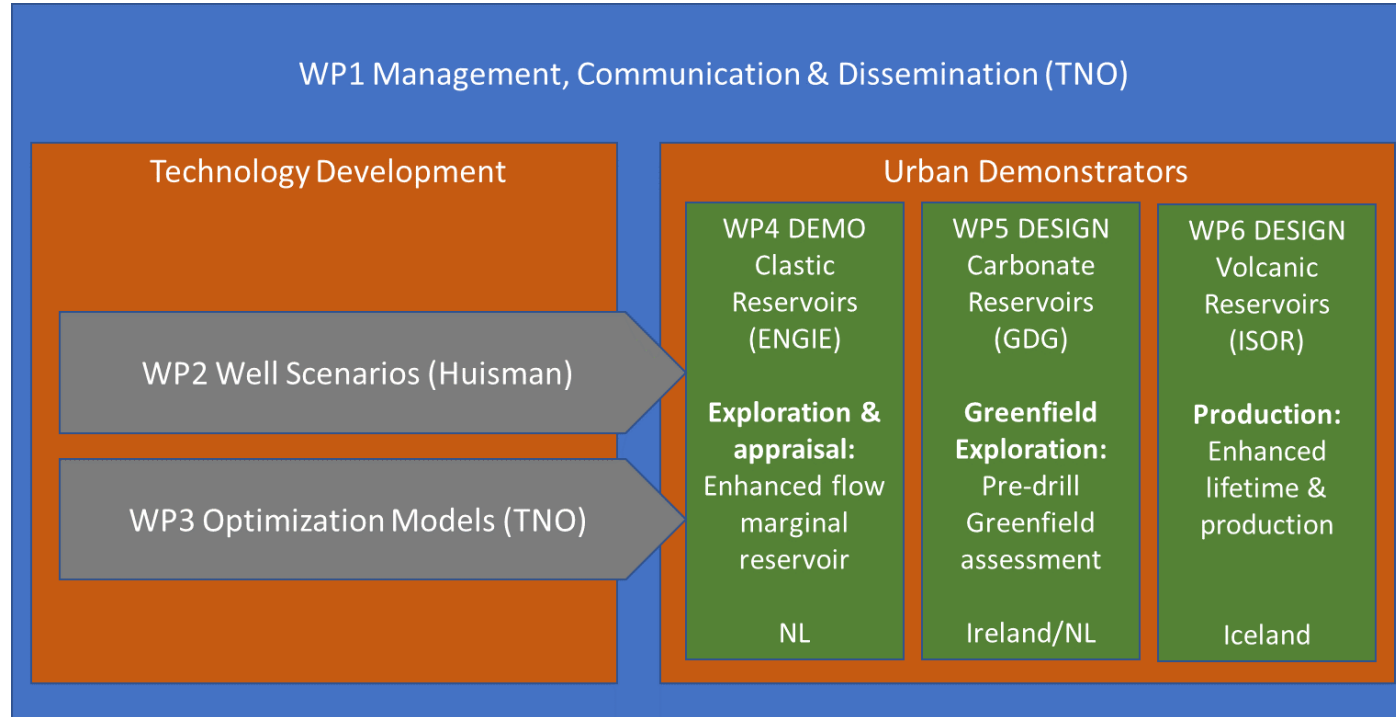
optimization

- Optimization under full reservoir uncertainty – EVEREST – 10-20% extra gain in performance

Vol

- Drill and Learn, >5% extra gain in performance

Work Packages & dependencies



WP-leads

- WP1: Jan Hopman (TNO)
- WP2: Korneel v/d Meer (Huisman)
- WP3: Jan Diederik van Wees (TNO)
- WP4: Edwin Slop (Huisman)
- WP5: James McAteer (GDG)
- WP6: Helga Tulinius (ISOR)

Project Duration:

- 2020.09.01-2023.08.31

Consortium

Partner	Country/Region
TNO	The Netherlands
EBN	The Netherlands
ENGIE	The Netherlands
Huisman	The Netherlands
Aardwarmtebron Zwolle	The Netherlands
GDG	Ireland
ISOR	Iceland
Reykjavik Energy	Iceland



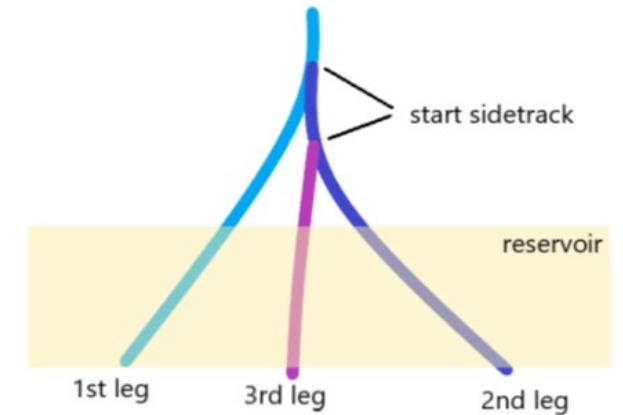
WP2: Well Scenarios

Multilateral Well

Preliminary results. Concepts might change and values will change over the course of the project.

Output (P50)	Single Well	Multilateral Well (3 laterals)		
Pump Power ¹	142	281		kW
Geothermal Power ¹	2.47	5.25		MW
COP ¹	17.2	18.4		kW/kW
CAPEX	100	210	150	%

Conventional drilling ECI+RSS drilling



Conclusions

- Multilateral completions are a proven technology within the Oil & Gas industry
- Geothermal power output increases significantly when applying multilaterals
- The Coefficient of Performance (COP) is similar to a single well application
- Due to the increased construction complexity of a multilateral well, the Capital Expenditure (CAPEX) is higher.
- CAPEX can be addressed by using innovative drilling tools.

DRILLING TOOLS

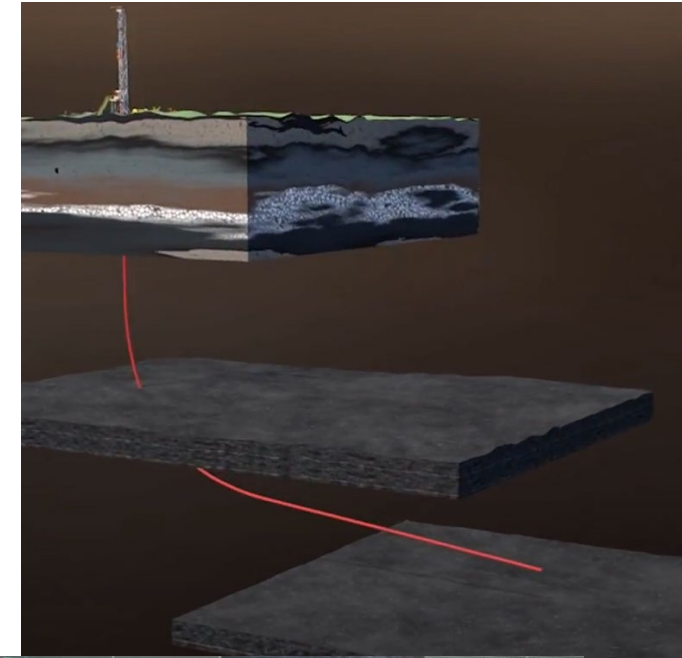
Directional Drilling (SYNCRODRILL RSS)

RSS - Technology

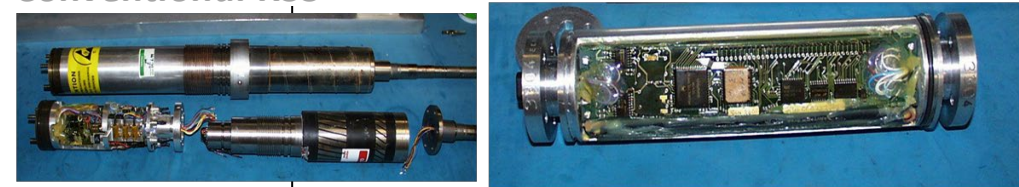
- Rotary Steerable System (ECI + RSS or Syncrodrill)
- Mechanical, automated, Closed Loop, Point the bit RSS

Value proposition

- Cost effective directional drilling
- Open hole side track capabilities
- Simple mechanical design - low cost
 - Target = RSS functionality against mud motor + bent sub cost



Conventional RSS



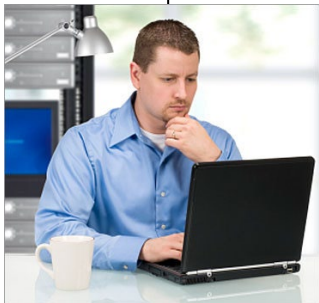
Syncrodrill



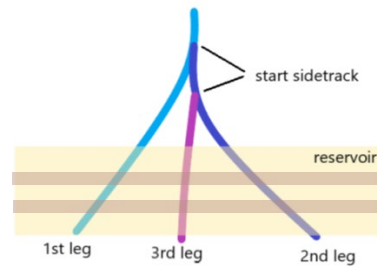


WP 3 Optimization and Drill & learn

Decision maker

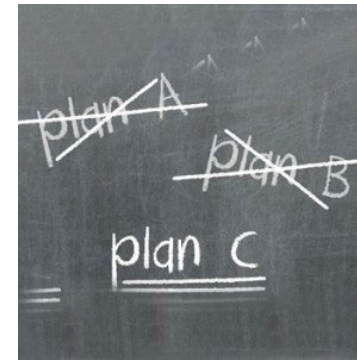


Simulation model



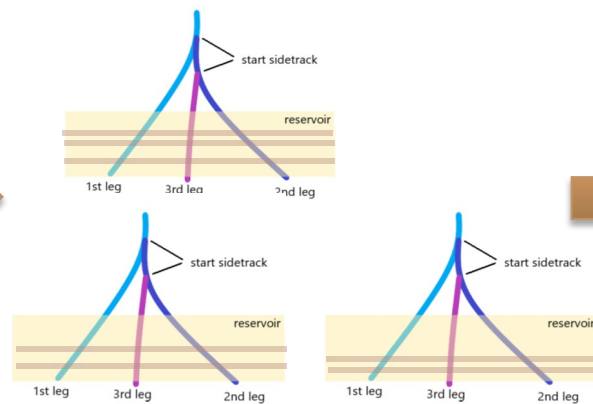
single truth

Decision



few options for change of design considered

(optimum) option, Driven by chance



Full uncertainty incorporated

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

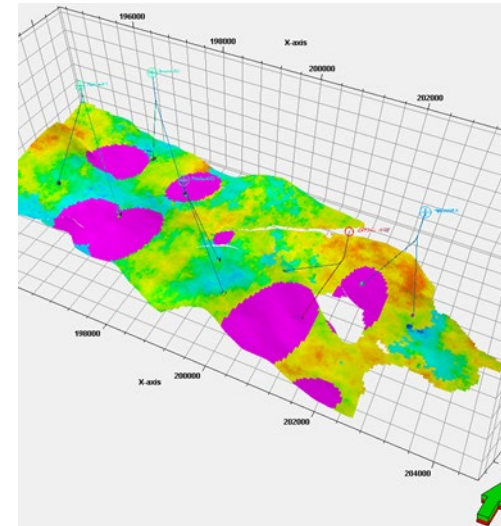
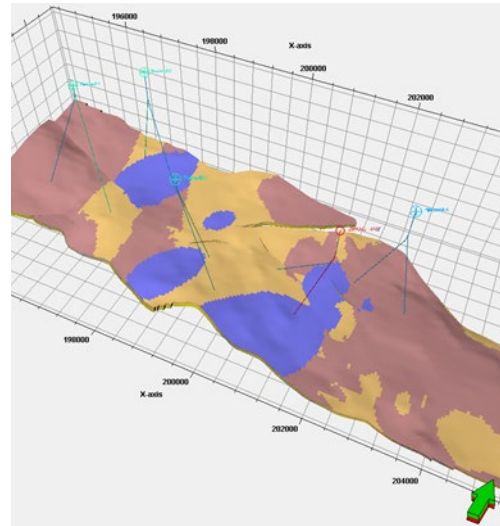
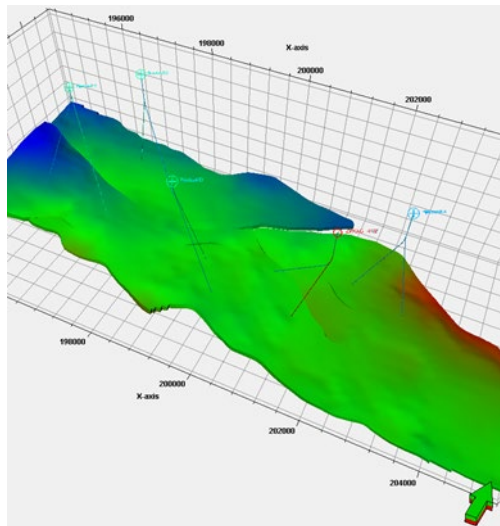
Explore wide range of options under uncertainty

Global optimum option, Robust under uncertainty



WP4 DEMONSTRATION CLASTIC RESERVOIRS

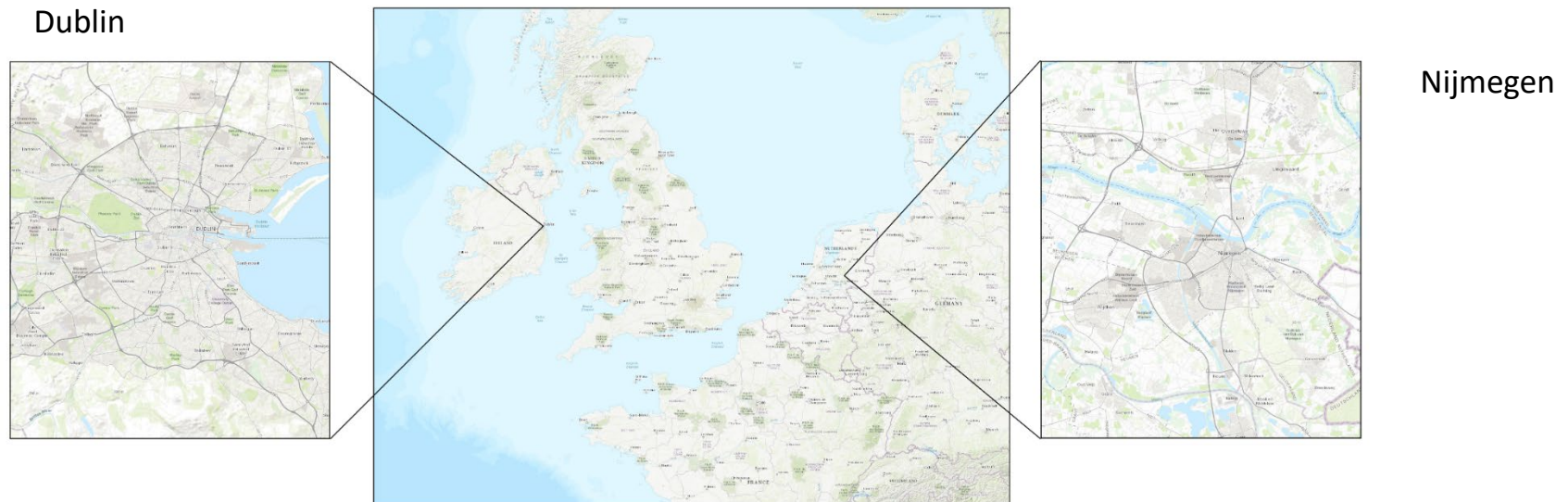
- Main sensitivities are por/permeability relationship and amount of cementation



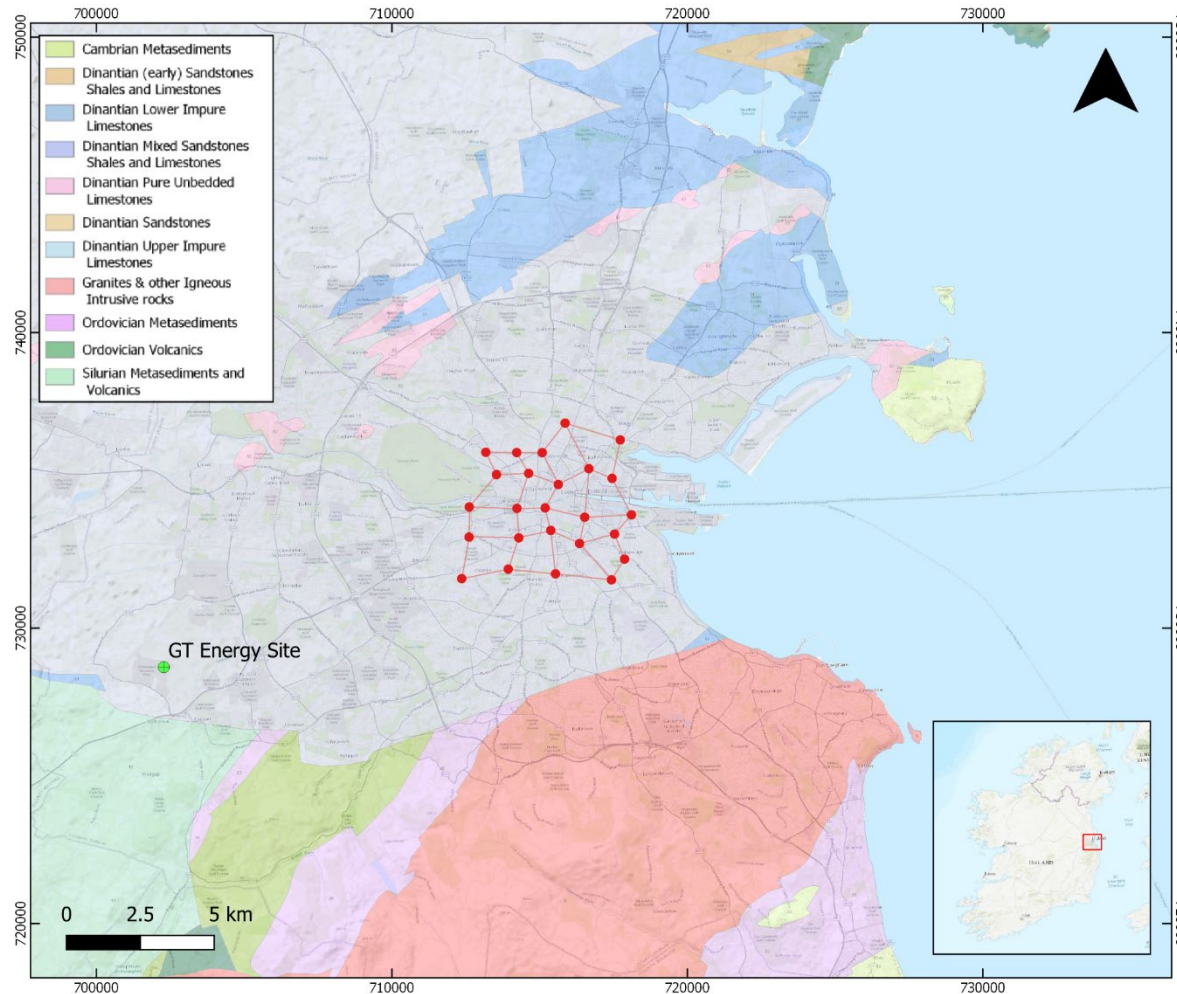
WP5: Design Study Carbonate Reservoirs

Objective:

- To evaluate the impact of multi-lateral well designs and the drill&learn approach for deep carbonate green field reservoirs marked with limited data available



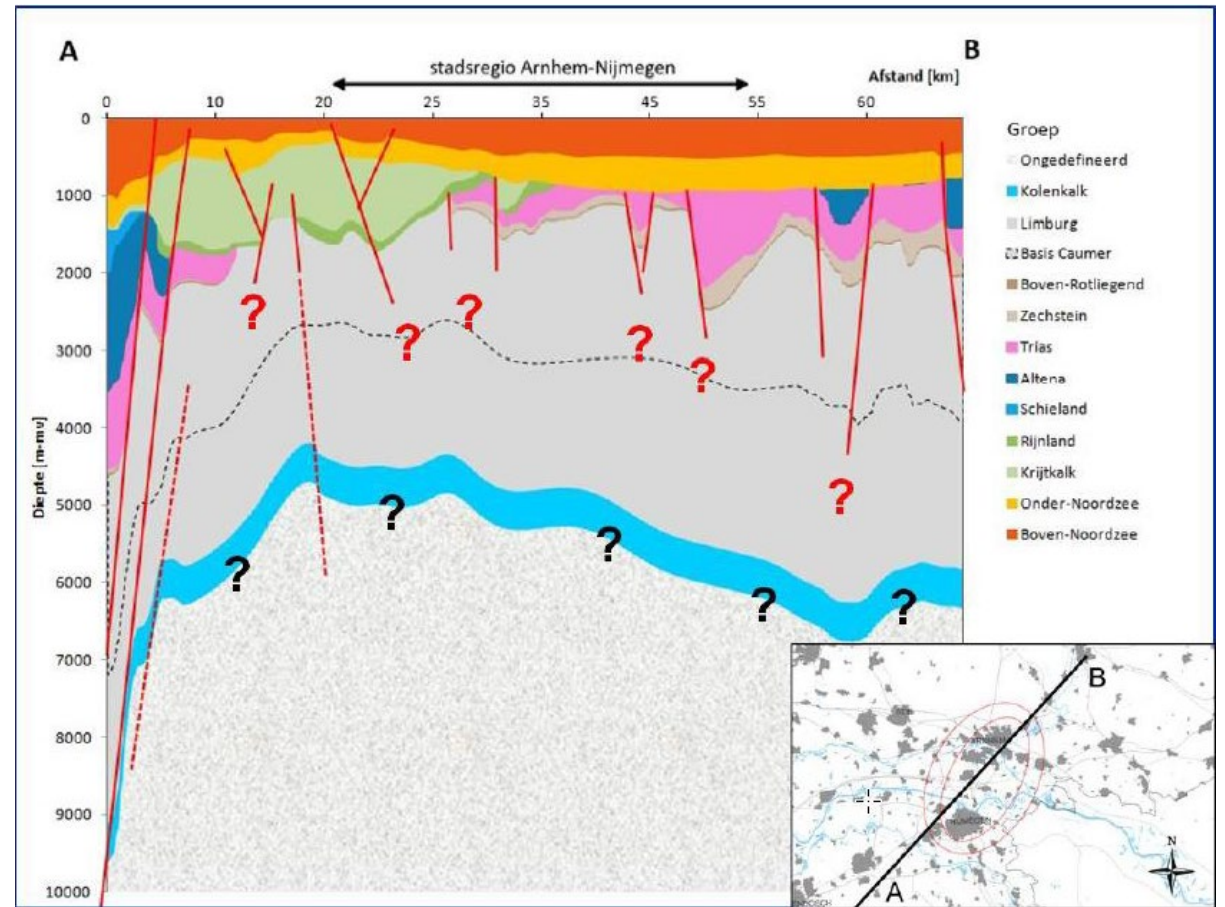
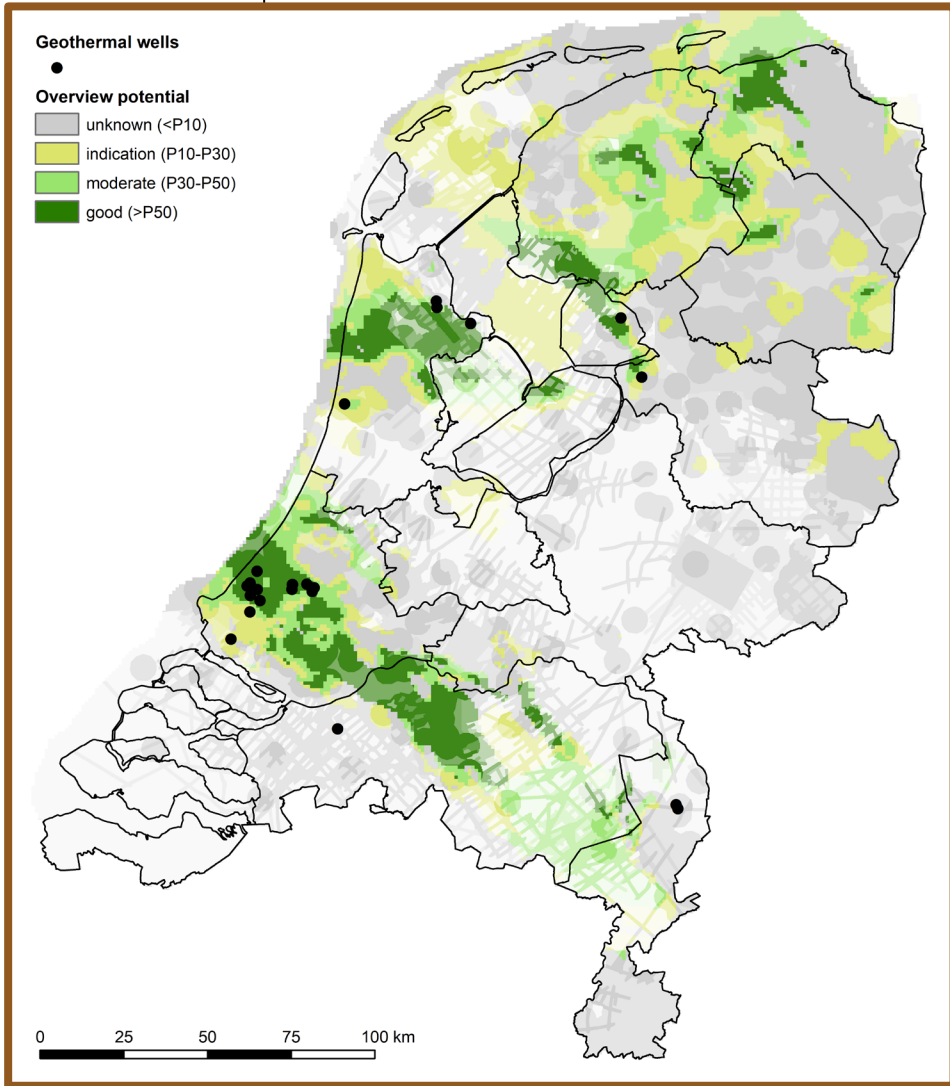
WP5 Building on Previous Studies

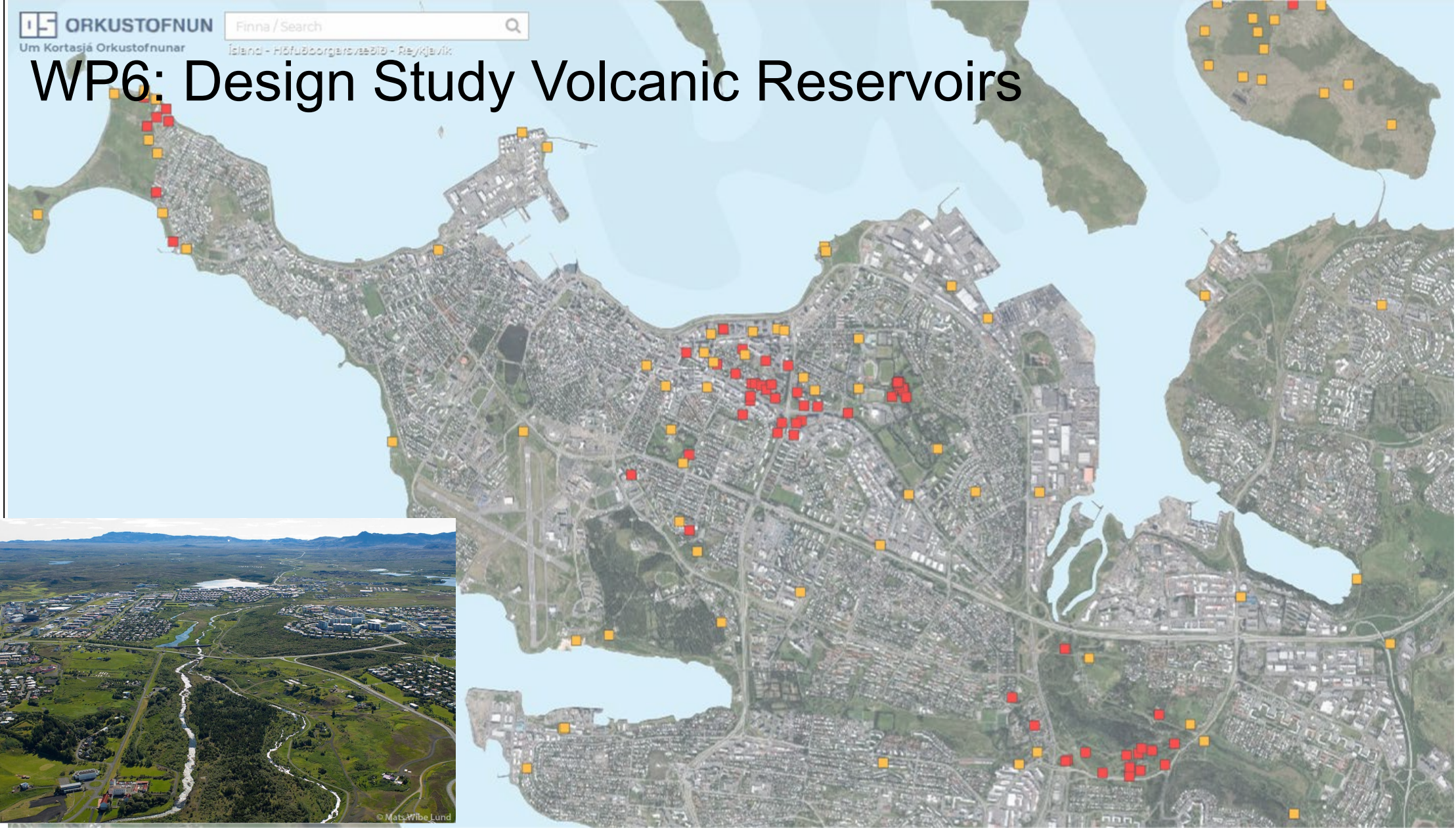


The Dublin Basin has been the focus of several Geothermal Research projects in recent years and the RESULT case study aims to build upon this work.

Most recently the Geothermica Funded GEO-URBAN project has undertaken a multi-disciplinary geophysical survey in Dublin's urban centre. This work is ongoing and a new set geological models is currently under development. These models will help inform the reservoir characterisation undertaken as part of the RESULT project.

WP5 Building on Previous Studies





WP6: Design Study Volcanic Reservoirs

WP6: Design Study Volcanic Reservoirs

Review of stimulation efforts and guidelines for drilling and completion of low temperature wells in Elliðaárdalur

Datasets:

- 34 wells drilled from 1932 to 1996 up to 2312 m deep
- Drilling histories – 10 drill rigs
- Well design
- Stimulation
- Well logs
- Production history

Questions:

- What drilling method gave the best result?
- Connection between well design and production?
- How much did stimulation enhance the production?

Conclusions

- Project Duration: 2020.09.01-2023.08.31
- Deliverables on schedule
- Demonstration in Zwolle (WP4) on critical path