October 2022

Introduction

The RESULT project has now been ongoing for over two years and in this time significant progress has been made towards the project objectives. This Newsletter outlines the work carried out to date.

Project Objectives

For clean cities (mission Horizon Europe) geothermal reservoirs are prospected to be developed in many urban areas with the intent of replacing fossil fuel fired heating. In many urban areas the development of geothermal reservoirs can be challenging due to suboptimal (marginal) reservoir conditions. The main objective of RESULT is to demonstrate the potential for increased performance by 30-100% of such (marginal) reservoirs for heating in urban areas, with a focus towards the northern EU.

RESULT, which stands for **Enhancing REServoirs in Urban deveLopmenT: smart wells and reservoir development,** achieves this by deploying:

1) Advanced reservoirs models and uncertainty assessments,
2) Best in class well technology options, including innovative multilateral wells,
3) Optimization methods, incorporating drill and learn strategies,
4) Optimization case studies in clastic, carbonate and volcanic settings in Europe,
5) The innovative procedure and techniques will be used and demonstrated in a field development and drilling of a geothermal doublet.

RESULT runs from September 2020 - September 2023.

WP1: Management, Communication & Dissemination

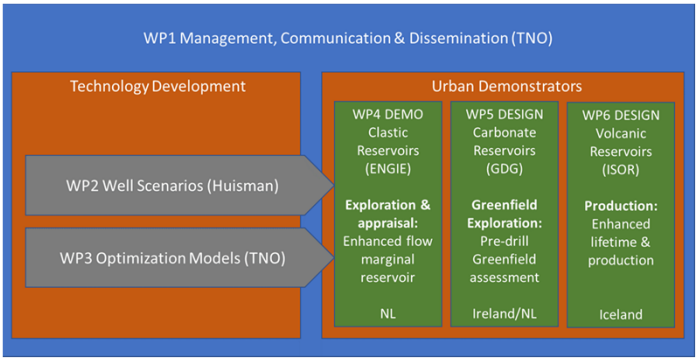
WP1 has been progressed on schedule. The project website (https://www.result-geothermica.eu/) outputs include the Newsletters and public deliverables from the project can be found here to download.

The research part of the project is progressing according to plan, with the first results being publicly available. In the following year more public deliverables are planned.

The field development demonstration, including drilling of a geothermal doublet is planned in Zwolle (the Netherlands) and has been delayed.

On 6 September 2022 the project had a Mid-Term Review with Geothermica and the national funding agencies of Netherlands, Iceland & Ireland. The project received constructive feedback, including dissemination of project results and how to deal with the delay of the project demonstration.

The following figure shows the project structure:

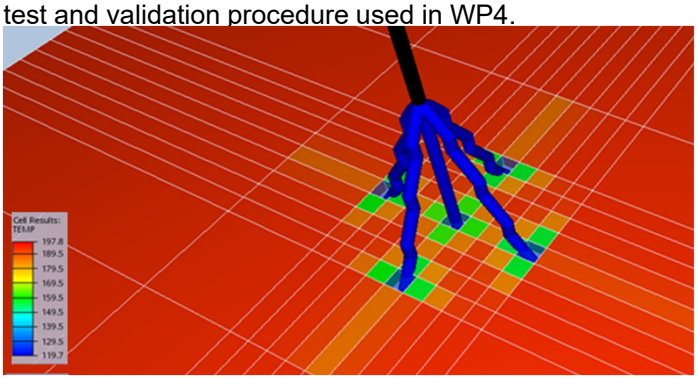


WP2: Well Scenarios

Work package 2 has been completed with the delivery of the fourth and latest report in a series complementing works on well scenarios for the exploitation of marginal geothermal reservoirs.

The first report, dealing with lessons learned on advanced well concepts has been made publicly available from the RESULT website. It provides an overview of the various design and completion techniques and their impact on the Injectivity Improvement Factor (IIF) and Productivity Improvement Factor (PIF). The most promising completion techniques were further analyzed and compared in terms of their techno-economic feasibility, providing a template for studying capital expenditure, operational expenses and yield on the basis of technical parameters and financial data.

Other (confidential) reports deal with, technical design models and techno-economic models for cost-benefit analysis models feeding into the optimization workflows of WP3, as well as the definition of different well concepts considered as well as Drill & Learn approaches, and the test and validation procedure used in WP4.



WP3: Optimization Models

An optimization workflow has been completed and tested in synthetic cases for the initial design as well as for the progressive near real-time design improvements while drilling (Drill &Learn), The optimization approach has been based on existing optimization tools developed for the hydrocarbon industry, adapted to the geothermal sector. It includes:

- representative 3D Reservoir structural, stratigraphic (facies) complexity, focused towards representative parametrization for reservoir flow simulation (i.e. permeability).
- Support ensembles of 3D model realizations, capturing relevant uncertainties for flow simulation and which serve as input for optimization.
- Incorporation of advanced well design features.
- KPI prediction, objective function, and multi-criteria optimization deploying the O&G optimization approach EVEReST.
- Drill & Learn effects (adaptive designs based on (partial) revelation of 3D model realization).

Showcasing of the models and optimization of benchmark cases for sedimentary settings has been completed.

WP4: Demonstration in a Clastic Reservoir

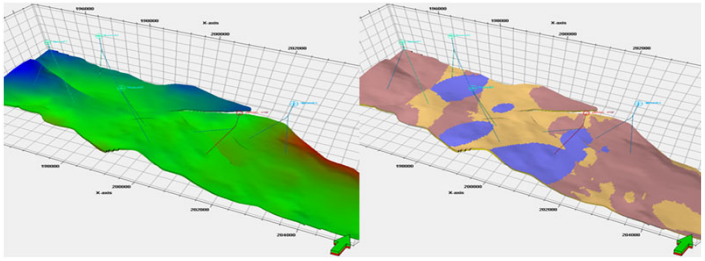
WP4 aims to demonstrate enhanced techno-economic performance with multi-lateral well designs and the Drill & Learn strategy for unlocking marginal reservoirs for district heating in white spot areas in the Netherlands.

A 3D geological model of the reservoir has been constructed, which served as input for modelling the dynamic reservoir behavior based on several well geometry scenario's. The observed combination of primary sedimentological features and secondary cementation leads to a relatively high degree of uncertainty in the performance of the reservoir, irrespective of the type of well. Therefore a probabilistic modelling approach (i.e. very large number of possible geological scenario's) was selected. The result was that for most geological scenario's, a sub-horizontal well type is preferred in terms of productivity/injectivity and associated geothermal power.

Parallel to this study, the same well concepts have been analyzed with a fast model approach. This allows the analysis of different well designs in terms of geothermal power and expenditures (CAPEX and OPEX). The conclusion was drawn that the techno-economic performance of a conventional (deviated) well was rather unattractive, while horizontal and multilateral wells often showed positive Net Present Values.

The actual demonstration in Zwolle will be delayed due to external preparations which are required to deliver the heat after the demonstration.

The following figures give an impression of reservoir temperature and sedimentary facies in Zwolle.



WP5: Design for Carbonate Reservoirs

The objective of this work package is to evaluate the impact of multi-lateral well designs and the drill and lean approach for deep carbonate green field reservoirs marked with limited data available:

The focus of WP5 is on deep Paleozoic carbonate lithologies in Northern Europe at two urban sites, in Ireland (Dublin area) and in the Netherlands (Nijmegen area), both of similar geological age and marked by similar basin evolution history. To date the activities for WP5 have revolved around the completion of Desktop studies: Dublin completed and Nijmegen ongoing.

The case study results highlight the importance of subvertical permeability pathways formed by fractures and fault zones, which result in permeability anisotropy having a significant impact on the well concept selection and optimization of well designs.

WP6: Design for Volcanic Reservoirs

The objective for work package 6 is learning from past operations and studies of mature urban geothermal fields in the capital area of Reykjavik (10s of wells are used for district heating). Learnings will point out and recommend actions to improve performance of existing wells, with the goal of utilizing these wells to their fullest extent.

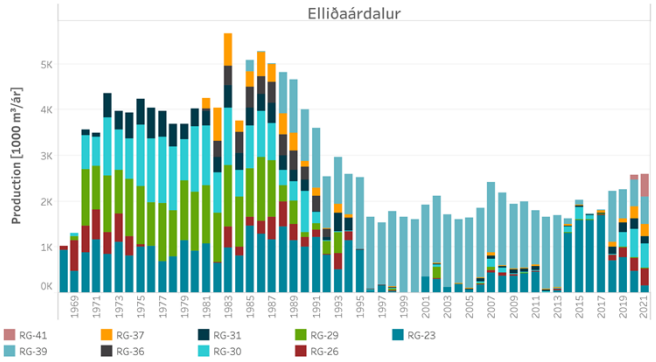
A principal focus is on the Elliðaárdalur geothermal field which has been in operation since 1968. The utilization of the system has been challenging as the field has suffered from cooling and undesired chemical changes leading to decreased utilization in recent decades (see figure). Ongoing within WP6 is detailed analysis of the geothermal field and the production history. Drilling and past stimulation efforts within the field have also been studied. These studies will serve as a reference case for future stimulations, both in Reykjavik and in other urban geothermal fields. The reservoir analysis has included the construction of a 3D geological and temperature model in the Leapfrog software which allows data comparison and visual representation of reservoir data. All production data (flow, temperature, chemistry, water level etc.) has been analysed to shed light on changes in the reservoir. A special emphasis is put on geochemical changes and how they relate to cooling in the field.

To date WP6 is on schedule with three reports completed in year two:

- D6.1 Review of stimulation efforts and guidelines for drilling and completion of low temperature wells in Elliðaárdalur field – Delivered September 2021.
- D6.5 Report on geological model in Leapfrog and heat model – Delivered November 2021
- D3.3 Benchmark study for volcanic settings – Delivered March 2022

Deliverable 6.2 is due in the end of October 2022.

The product of WP6 will be a roadmap for future operations, both for Iceland and for the other fields included in the RESULT project, that highlights the potential issues in operating geothermal wells in urban areas and provides suggestions for identifying key problems, as well as a set of solutions to combat and prevent those problems.



Project Timeline:
September 2020 – September 2023

www.result-geothermica.eu

CONTACT:
For questions and/or comments, please contact the coordinator:

Jan Hopman
jan.hopman@tno.nl

This project has been subsidized through the ERANET Cofund GEOTHERMICA (EC Project no. 731117), by RVO (the Netherlands), Rannis (Iceland) and GSI (Ireland).