November 2020

INTRODUCTION

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.

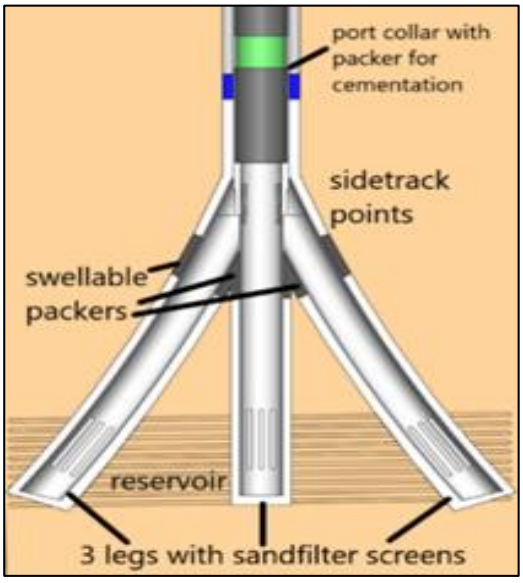
RESULT, which stands for **Enhancing REServoirs in Urban deveLopmenT: smart wells and reservoir development,** achieves this by deploying:

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.

The RESULT project runs from September 2020 till September 2023 .The virtual Kick-Off meeting was held on 16 September 2020.

WP2: WELL SCENARIOS

Well technology scenarios deal with identifying most promising engineering options for wells and the thermal loop of the geothermal heat production, in view of environmental and other constraints for urban settings. This includes an inventory and selection of design of the well trajectory, drilling and completion technologies (e.g. jetting, enhanced casing installation, etc.), engineering options for the thermal loop, including artificial lift..



TIMELINE:
September 2020 – September 2023

WP3: Optimization Models

An optimization workflow will be developed for the initial design as well as for the progressive near real-time design improvements while drilling. The optimization workflow can be utilized in the exploration phase as well as in the reservoir development phase after first wells have been drilled. The optimization approach adapts existing optimization tools developed for the hydrocarbon industry to the geothermal sector, and takes into account:

- Capabilities to include 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 and constraints
- KPI prediction, objective function, and multi-criteria optimization deploying the O&G optimization approach EVEReST
- Include drill and learn effects (adaptive designs based on (partial) revelation of 3D model realization)

The models and optimization will be showcased in benchmark cases for clastic, carbonate and volcanic reservoir settings.

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. Sub-objectives are:

- Demonstrate the business case of proposed multi-lateral well design and drill and learn for marginal reservoir conditions in urban area Zwolle (back-up Haarlem). This includes:
  - Detailed reservoir characterization and uncertainty assessment
  - Site specific techno-economic model, definition (of KPI for) optimization objective function
  - Optimization of the a-priori well design, including drill and learn.
  - Value of information assessment adding to the business case
- Successful construction of low cost multi-lateral wells for geothermal energy production in clastic reservoirs
- Practical demonstration of the drill and learn approach on site, based on staged appraisal (logging, coring and flow test analysis) of yet drilled legs and fast-track adaptations for the drilling design based on optimization for the remaining legs.
- Demonstration of the production doublet based on the low cost multi-lateral design.
- Provide recommendations for development in clastic reservoirs in the Netherlands

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:

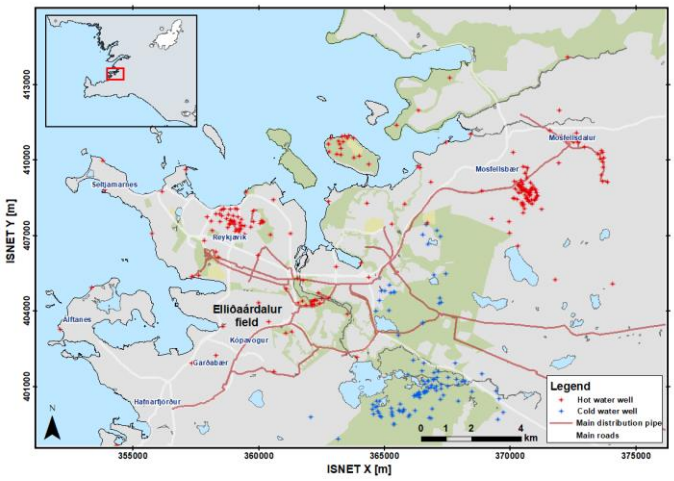
- We will focus on deep Paleozoic carbonate lithologies in Northern Europe at two urban sites, in Ireland (Dublin area) and in the Netherlands (Nijmegen area), both of similar geological age and marked by similar basin evolution history.
- For Ireland, the GEO-URBAN project is currently investigating the feasibility of geothermal reservoir exploitation in Dublin cities urban center. The Irish case study for the RESULT project will comprise of the desktop application of the optimization models developed in WP3 to the most up to date models of fractured reservoirs within the Dublin Basin. This data will be used in the development of an optimized well scenario.
- The Netherlands case study will be focused on the Nijmegen area. Sparsely available well data will be used in the development of an optimized well scenario.

The case studies will highlight the impact of alternative well scenarios and reservoir management methodologies on reservoir exploration and exploitation. The learnings from more mature reservoir operations in Iceland and exploration and appraisal in WP4 and WP6 will help maximize the efficiency of the exploration phase and the operational phase of potential future geothermal resources developments within both the Dublin and Nijmegen areas.

WP6: Design for Volcanic Reservoirs

The objective from this work package 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 stimulate geothermal hot water production from wells already drilled, with the goal of utilizing these wells to the fullest extent. Past stimulation efforts will be studied and the resulting increase estimated. This will serve as a reference case for future stimulations, both in Reykjavik and in other urban geothermal fields. A major focus will be placed on enhancing individual well performance and the lifetime of the geothermal fields to ensure sustainable utilization. A desk study on the utilized geothermal systems in the Reykjavík urban area will be performed with a principal focus on the Elliðaárdalur system. This will include reservoir analysis, drilling analysis and historical field management analysis. The study will for example include an analysis of whether the following aspects can be applied to enhance the performance of lower performing wells:

- Sidetrack laterals - Learning from the experience of RESULT partners.
- Laterals 10 meters long smaller diameters – fishbone technology.
- Radial jetting with up to 100 m laterals.
- Effect and possibility of reinjection.
- Casing depth and its effect on system behavior and utilization.
- The potential of chemical injection into production wells to prevent downhole scaling and corrosion.



Map of the capital area in Iceland showing the location of hot and cold water wells, the main distribution pipes and the location of the Elliðaárdalur field (Data source: National Land Survey of Iceland and Reykjavík Energy).

Contact:

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