

Proceedings

Workshop on Low-medium Temperature Geothermal Heating & Cooling Solutions

Dublin, Ireland on 10 October 2023



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Title:

Proceedings for Workshop on Low-medium Temperature Geothermal Heating & Cooling Solutions in Dublin, Ireland on 10 October 2023.

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We would like to express our gratitude to the co-organizers of the workshop Low-Temperature Geothermal Heating and Cooling Solutions in Dublin on 10 October 2023: the GEOTHERMICA Initiative, CETPartnership TRI4 Heating & Cooling, Geological Survey Ireland (GSI), and Sustainable Energy Authority of Ireland (SEAI). A special thanks goes to our hosts in Ireland, GSI and SEAI.

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Figure 1: Participants at the Workshop on Low-medium Temperature Geothermal Heating & Cooling Solutions in Dublin.

Introduction

The GEOTHERMICA Initiative, CETPartnership TRI4 Heating & Cooling, and Geological Survey Ireland organised a workshop at the EPIC Museum in Dublin on 10 October 2023. The workshop focused on low-medium temperature geothermal heating and cooling solutions for campuses and cities. Around 50 people from 11 countries attended the workshop (from Ireland, the United Kingdom, Canada, Sweden, Iceland, Scotland, Germany, Belgium, The Netherlands, Switzerland, and the United States).

Representatives from the European Geothermal Energy Council, Geological Survey Ireland, GEOTHERMICA Initiative, and CETPartnership TRI4 Heating & Cooling gave an overview of the geothermal sector in Europe and insights into the latest developments.

Speakers from academia, research, and industry presented projects from the Netherlands, Ireland, Canada, the United States, Scotland, Switzerland, and Iceland on geothermal heating and cooling solutions for campuses and cities. Below, you can find their presentations.

The workshop highlighted promising concepts for utilizing low- and medium temperature geothermal energy for the heating and cooling transition of cities and campuses. Discussions during the workshop underlined the potential, as well as the need to take a broad perspective on low- and medium temperature geothermal in future activities, for example in the Calls of CETPartnership TRI4 Heating and Cooling.

Keynote Addresses

The workshop provided a global overview on the solutions geothermal technologies can provide on a city and sub-city scale. In his opening remarks Koen Verbruggen (Director Geological Survey Ireland), Gerdi Breembroek (Leading Expert CETP TRI4) and Stephan Schreiber (Co-Chair GEOTHERMICA Initiative) pointed out the importance of joining forces for the heating transition on a transnational scale. Major players in the Geothermal community can support newcomers and foster the broader rollout of geothermal energy utilization even in medium-low temperature settings.

Networks as the GEOTHERMICA initiative, the Clean Energy Transition Partnership and the SET Plan Implementation Working Group Geothermal provide the platform for transnational collaboration and knowledge exchange.

In three introductory presentations Emil Martini (EGEC), Sarah Blake (GSI) and Gerdi Breembroek & Stephan Schreiber gave an overview of the current policy situation in Europe, the status quo and the future of geothermal energy utilization in Ireland, and the diversity of geothermal applications which are available but also necessary for the heating transition in Europe.

Sessions

The workshop was divided into two sessions. Session 1 focused on low-medium temperature geothermal for campuses. Session 2 focused on low-medium temperature geothermal for cities. Summaries from the presentations are available below.

Session 1: Low-medium Temperature Geothermal for Campuses

Martin Bloemendal, PhD, Assistant Professor at Delft University of Technology introduced the TU Delft Subsurface urban energy lab for development of geothermal technologies. Dr Bloemendal explained the benefits of underground heat storage, including that there are no space requirements above ground, and that there are large capacities. Potential downsides are that subsurface infrastructure is needed and it is dependent on local geological conditions. The main takeaways are that large scale seasonal heat storage is needed; underground accommodates capacity for seasonal storage; and via fundamental research at demo's towards cheap and robust seasonal heat storage underground.

Mark Geraghty, Environmental and Sustainability Manager at Technological University Dublin, Grangegorman Campus discussed the university's efforts to decarbonize their thermal energy and phasing out fossil fuel by using deep geothermal for district heating. Gas and electric supply costs have risen exponentially over the past two years, thus creating the need for alternative source of heating. Geothermal energy has the smallest surface footprint of any land-based energy source and generates minimal waste products. A trial hole has been drilled on site measuring 1 km, and will be aligned to a new district heating system. It has the potential to deliver a working geothermal heat source in a short timeframe.

Aggrey Mwesigye, Ph.D., P.Eng at University of Calgary introduced the University of Calgary District Heating System, and the proposed geothermal system. The overall system integrates three subsystems; subsurface geothermal system (15-20°C), heat pump, and building heat loop (90-77°C). It is a co-axial closed loop geothermal system. Sub-surface simulation results (without the seasonal thermal energy storage) show an evident decline of working fluid's return temperature, indicating depletion of thermal reservoir with time. Potential to offset 90%+ of heating load with 30 horizontal wells pairs in a closed-loop design. Reservoir thermal storage as part of a middle-deep closed-loop geothermal system.

Steve Beyers, P.E. Cornell University discussed low temperature geothermal for district heat in the eastern United States. Cornell seeks to demonstrate how low-temperature geothermal can provide baseline heat for the eastern United States at lower overall cost and risk than conventional resources. The goal is to reduce greenhouse gas (GHG) emissions. There are vast amounts of geothermal energy available, the challenge is to find ways to use geothermal energy safely, effectively, and efficiently. Most U.S. heating and cooling needs are at temperatures lower than 120°C with most of it supplied by natural gas, oil, and propane. To meet carbon reduction goals, transportation and heat must be electrified. Highly efficient

thermal systems (like direct geothermal heating/cooling) reduce the need for large amounts of electricity in winter. Direct use of heat is much more efficient than conversion to electricity (about 16x as much heat as electricity). Beyers stated that their proposed system produces heat using a fraction of the electricity of air source heat pumps (ASHPs), and the total cost for renewable geothermal heat is much lower than using ASHPs when factoring the cost of the required grid resources. The Cornell University Borehole Observatory (CUBO) concludes that temperatures are sufficient (more than 80°C at 3 km), that subsurface conditions are relatively impervious, and fluids are continually produced by the shut-in well.

David Townsend, Founder & CEO at TownRock Energy presented the CETPartnership Galleries2Calories GeoBattery Research Project in Edinburgh. The project, which was co-funded by Scottish Enterprise, Geological Survey Ireland, U.S. Department of Energy, and the European Union, aims to use abandoned flooded coal mines to store and transport waste heat. While 600,000 households in Scotland face fuel poverty, there is 1,677 GWh of waste heat across 1,000 locations. There is potential for thermal storage and transfer in mines. A 3D model of the G2C area has been built in FEFLOW with the mesh structure created in the Leapfrog Geological Model. Initial Thermo-Hydraulic simulations have been conducted to evaluate the potential heat plume extension in the subsurface. The results of pumping tests carried out in Glasgow UKGEOS were used to define the hydraulic conductivity ranges assigned to the model voids. Aims of the G2C Heat GeoBattery project are conducting a feasibility study for ACF cooling using mine water; development of the experimental field site; and modelling and monitoring. Outcomes of the project are the following: outline techno-economic modelling tool for the Heat GeoBattery concept; UK and Scottish Governments policy and regulatory recommendations for the use of mine workings as thermal stores; guidance on potential application of Heat GeoBattery concept to European & United States flooded mineral mines; and best practice guidelines from the Galleries2Calories project for future projects.

Session 2: Low-medium Temperature Geothermal for Cities

Loïc Quiquerez, PhD, Energy Systems Expert at Services Industriels de Geneve presented “Scenarios for Integration of Medium-depth Geothermal in an Evolving District Heating System - Case study Geneva.” Services Industriels de Geneve (SIG) is a public company with capital of CHF 100 million. SIG handles the management of energy, water, optical fibres, and water-treatment networks. All electricity is from renewable sources. Almost half of the energy consumed is for heating. The key takeaways from Dr Quiquerez’s presentation were the following: shallow geothermal energy offers the option to deliver via decentralized projects or connect to low temperature networks, and increasing development of projects for heating, cooling, and heat storages; medium-depth geothermal energy offers validated geothermal potential (first geothermal plant project underway to confirm exploratory results), and integration requires extension of the district heating network and optimization of

temperature levels; and that geothermal energy is expected to represent 30% of thermal needs by 2050.

Heimir Tryggvason, PhD, Specialist District Heating and Direct Use of Geothermal Energy at the National Energy Authority of Iceland gave an overview of the use of lower temperature geothermal sources for space heating in Iceland. More than 90% of space heating in Iceland comes from geothermal district heating, and the remaining 10% is heated with electricity. Electricity for residential house heating is subsidized in Iceland. There are grants for alternative heating based on up to 12-year savings of subsidies. The support scheme for heat pump grants has been simplified. It is available to those eligible for subsidies and covers 50% of the equipment cost, up to 9,000 EUR. Seawater heat pump station has been in operation since 2018 in the Westman Islands, where cooled seawater is used for refrigeration, which resulted in 30% reduction in electricity use. Low-temperature geothermal exploration is underway in the Westfjords of Iceland. The geothermal system is 30-40°C at 300-600 meters depth. Further drilling proposed for use with heat pump.

Roman Shor, Associate Professor and Energi Simulation Industrial Research Chair in Geothermal Systems at University of Calgary discussed geothermal heating and cooling for cold continental and subarctic climates in Canada. Space heating accounts for 63% of typical Canadian residential energy use, with water heating accounting for 19%. Around 60% of home heat comes from natural gas and oil. Heat pumps and direct use of geothermal requires much less energy than space heating using green or blue hydrogen. Calgary has a higher heating load than a cooling load. Typical Geo-exchange system design allows for both heating and cooling. Ongoing projects include Retrofit Potential & Cost (economics (payback) and carbon offset for ground source and air source heat pumps, policy and incentives to encourage retrofits); Building Scale Systems (sizing and design of subsurface and surface systems); and Community Scale Systems (district heating network design, layout and buildout planning).

Matthias Franz, PhD, University of Gottingen, Germany, introduced “New opportunities in hydrothermal plays, with lessons learned from the Schwerin and Hamburg Projects.” Deep sedimentary basins of Germany include the North Germany Basin (NGB), the North Alpine Molasse Basin, and the Upper Rhine Graben. Development examples of the NGB includes Schwerin and Waren. Exploration of hydrothermal plays include well data and 2D/3D seismic data. The Schwerin pilot site is on fluvial channel belt with temperature between 50°C and 60°C. The Schwerin project has demonstrated that there are new opportunities in shallower depth. Currently, there are more than 10 localities in northern Germany under consideration for geothermal development.

Challenges & Recommendations

The workshop outlined a number of challenges that GEOTHERMICA and the CETPartnership can help address. Although countries and regions are at different stages of development,

these challenges are often common and transnational projects can help provide not only technical solutions but also share knowledge and information to help transform our energy sector. Three key challenges were identified:

Raising awareness of Geothermal energy as a solution. One of the main roadblocks to developing geothermal resources is the lack of awareness which leads to insufficient support both politically and from key stakeholders such as energy providers, local authorities, customers, building designers and regulators. Several of the speakers discussed this issue and how essential it is to engage with these stakeholders from an early stage of project development. It is also important that geothermal development projects, including demonstration projects, commit the necessary resources to actively engage with the broad range of stakeholders to showcase the value of geothermal energy as part of our clean energy solution.

Technological, technical and geological challenges. The projects presented at the workshop, and those supported by GEOTHERMICA and the CETPartnership, are addressing multiple technological, technical and geological issues. As this sector evolves, it will be important not only to keep improving efficiencies (e.g. to allow district heating networks to operate at lower temperatures and maximum efficiency) but also further development of, for example, methodologies for improving subsurface knowledge and resource estimation. This is particularly important in regions or countries that have not had a terrestrial oil and gas history and therefore are lacking key subsurface data at depth.

Interdisciplinarity and range of skills required. Several speakers highlighted the need for close collaboration between multiple disciplines and skills. For example, geology, engineering (from mechanical to civil to electrical), legal and finance experts, heat network experts, planners, architects, social scientists etc. To ensure geothermal heat projects are efficient, effective, and deliver the required energy to the right customer at the right time, all relevant expertise will be required. This can be problematic due to potentially competing priorities and variance in terminology, however close collaboration will be key to progressing geothermal heat projects of scale - particularly in complex setting such as urban areas.

Overall, the workshop underlined the positive progress made to date to identify and overcome challenges for the geothermal sector. Further investments of resources, funding and knowledge development should remain the key focus of the GEOTHERMICA Initiative and the CETPartnership.

Acknowledgements

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(GSI), and Sustainable Energy Authority of Ireland (SEAI). A special thanks goes to our hosts in Ireland, GSI and SEAI.



Thank you to all of the speakers that travelled from all over Europe, the United States, and Canada to participate in the workshop. Your contributions enriched the discussions and put the mark to begin further collaboration to exchange this dedication to promoting sustainable energy solutions among participants. We also thank all participants and contributors for sharing their expertise and experiences, highlighting the power of collective action in advancing low-medium temperatures geothermal solutions for campuses and cities.

Appendices

List of Speakers & Presentations

1. **Koen Verbruggen**, Director, Geological Survey Ireland, Department of the Environment, Climate and Communications (Opening Remarks)
2. **Stephan Schreiber**, Co-Chair, GEOTHERMICA Initiative (Opening Remarks)
3. **Gerdi Breembroek**, Leading Expert, CETPartnership TRI4 Heating & Cooling (Opening Remarks)
4. **Emil Martini**, Policy Associate, European Geothermal Energy Council:
[Overview of Low-medium Temperature Geothermal in Europe](#)
5. **Sarah Blake**, PhD, Senior Geologist, Geological Survey Ireland:
[Irish Geothermal Potential and Latest Developments](#)
6. **Gerdi Breembroek**, Leading Expert, CETPartnership TRI4 & **Stephan Schreiber**, Co-Chair GEOTHERMICA Initiative:
[Opportunities for Low-medium Temperature Geothermal for the Energy Transition in Europe](#)
7. **Martin Bloemendal**, PhD, Assistant Professor, TU Delft Campus:
[TU Delft Subsurface Urban Energy Lab for Development of Geothermal Technologies](#)
8. **Mark Geraghty**, Environmental and Sustainability Manager, TU Dublin:
[Decarbonising Heat in an Urban Setting](#)
9. **Aggrey Mwesigye**, Ph.D., P.Eng, University of Calgary:
[Low-to-medium Temperature Geothermal for Campuses](#)
10. **Steve Beyers**, P.E. Cornell University:
[Low Temperatures Geothermal for District Heat in the Eastern U.S.](#)
11. **David Townsend**, Founder & CEO, TownRock Energy:
[Galleries2Calories: Presenting Progress of the Edinburgh GeoBattery Research Project](#)
12. **Loïc Quiquerez**, PhD, Energy Systems Expert, Services Industriels de Geneve:
[Scenarios for Integration of Medium-depth Geothermal in an Evolving District Heating System - Case study Geneva](#)
13. **Heimir Tryggvason**, PhD, Specialist District Heating and Direct Use of Geothermal Energy, National Energy Authority of Iceland:
[Use of Lower Temperature Geothermal Sources for Space Heating in Iceland](#)
14. **Roman Shor**, Associate Professor and Energi Simulation Industrial Research Chair in Geothermal Systems, University of Calgary:
[Geothermal Heating and Cooling for Cold Continental and Subarctic Climates in Canada](#)
15. **Matthias Franz**, University of Göttingen:
New Opportunities in Hydrothermal Plays – Lessons Learned from the Schwerin and Hamburg Projects
16. **Hjalti Páll Ingólfsson**, Co-Lead, CETPartnership TRI4 (Closing Remarks)

17. Paul Ramsak, Co-Chair, GEOTHERMICA Initiative (Closing Remarks)

Agenda



Low-medium Temperature Geothermal Heating & Cooling Solutions

10 October 2023

08:30 **Registration and Welcome**

09:00 **Opening Remarks**

- **Koen Verbruggen**, Director, Geological Survey Ireland, Department of the Environment, Climate and Communications.
- **Stephan Schreiber**, Co-Chair, GEOTHERMICA Initiative.
- **Gerdi Breembroek**, Leading Expert, CETPartnership TRI4 Heating & Cooling.

09:15 **Overview of Low-medium Temperature Geothermal in Europe**

- **Emil Martini**, Policy Advisor, European Geothermal Energy Council: *Overview of Low-medium Temperature Geothermal in Europe.*
- **Sarah Blake**, Senior Geologist, Geological Survey Ireland: *Irish Geothermal Potential and Latest Developments.*
- **Gerdi Breembroek**, Leading Expert, CETPartnership TRI4 & **Stephan Schreiber**, Co-Chair GEOTHERMICA Initiative: *Opportunities for Low-medium Temperature Geothermal for the Energy Transition in Europe.*

10:00 **Session 1: Low-medium Temperature Geothermal for Campuses**

- **TU Delft Campus, The Netherlands. Martin Bloemendaal**: *TU Delft Subsurface Urban Energy Lab for Development of Geothermal Technologies.*
- **TU Dublin Geothermal Project, Ireland. Mark Geraghty**: *Decarbonising Heat in an Urban Setting.*

10:45 **Coffee Break**

11:00 **Session 1: Low-medium Temperature Geothermal for Campuses**

- **Calgary Campus, Canada. Aggrey Mwesigye**: *Low-to-medium Temperature Geothermal for Campuses.*
- **Cornell Campus, United States. Steve Beyers**: *Low Temperatures Geothermal for District Heat in the Eastern U.S.*



- **Galleries2Calories, Scotland. David Townsend:** *Galleries2Calories: Presenting Progress of the Edinburgh GeoBattery Research Project.*

12:00 **Panel Discussion on Campuses**
- **Aoife Braiden**, Research Manager, Geological Survey Ireland moderates.

12:45 **Lunch Break**

13:45 **Session 2: Low-medium Temperature Geothermal for Cities**
- **Geneva, Switzerland. Loïc Quiquerez:** *Scenarios for Integration of Medium-depth Geothermal in an Evolving District Heating System - Case study Geneva.*
- **Iceland. Heimir Tryggvason:** *Use of Lower Temperature Geothermal Sources for Space Heating in Iceland.*
- **Canada. Roman Shor:** *Geothermal Heating and Cooling for Cold Continental and Subarctic Climates in Canada.*
- **Germany. Matthias Franz:** *New Opportunities in Hydrothermal Plays – Lessons Learned from the Schwerin and Hamburg Projects.*

15:15 **Coffee Break**

15:30 **Panel Discussion on Cities**
- **Sarah Blake**, Senior Geologist, Geological Survey Ireland moderates.

16:15 **Closing Remarks**
- **Hjalti Páll Ingólfsson**, Co-Lead, CETPartnership TRI4.
- **Paul Ramsak**, Co-Chair, GEOTHERMICA Initiative.

16:30 **End of GEOTHERMICA Initiative and CETPartnership TRI4 Workshop**

18:00 **Networking Event**
The networking event will take place at the EPIC Museum. Refreshments will be provided.

11 October 2023

10:00 **Irish National Geothermal Energy Summit**

Invited speakers will explore the following themes:

- Ireland's new Geothermal Policy Statement.
- District Heating and Geothermal Energy.
- Decarbonising public sector spaces with Geothermal Heat.
- Geothermal Energy and the Just Transition.

15:30 **End of the Irish National Geothermal Energy Summit**

These proceedings capture the achievement of knowledge and insights shared at the workshop on Low-Medium Temperature Geothermal Heating and Cooling Solutions in Dublin in October 2023. We hope the valuable information and experiences shared within these pages will inspire innovation and collaboration to advance sustainable heating and cooling solutions through geothermal energy.

