Calgary Geothermal Workshop

Friday, May 12, 2023
Calgary, AB

Workshop Program and Abstract Book

energi SIMULATION

GeoS
ENERGI SIMULATION CENTRE FOR GEOTHERMAL SYSTEMS RESEARCH

UNIVERSITY OF CALGARY

This is the digital publication of the conference program with abstracts
for the 2023 Calgary Geothermal Workshop.

Presentations may be found at:
`https://ucalgary.ca/labs/geothermal-energy/industry-partnerships/2023-workshop`

Contents

Welcome

Evolving from the **Geothermal Energy Laboratory** launched in 2021 at the University of Calgary, the **Energi Simulation Centre for Geothermal Systems Research** was established in 2022 under a transformative investment in research funding from **Energi Simulation**.

The morning's agenda will include technical updates on work being conducted by researchers at the University of Calgary and across Canada, followed by update and technical presentations from members of industry and a discussion of new research directions and opportunities in the afternoon.

The workshop will be chaired by Dr. **Roman J. Shor** and Dr. **Apostolos Kantzas**, co-leads of the **Energi Simulation Centre for Geothermal Systems Research (GeoS)** and members of the Department of Chemical and Petroleum Engineering at the University of Calgary.

Academic Leadership Team

Dr. **Apostolos Kantzas** is a professor in the Department of Chemical and Petroleum Engineering at the University of Calgary and held a Canada Research Chair (CRC) in Energy and Imaging and is currently an Industrial Research Chair (IRC) in Fundamentals of Unconventional Resources. Dr. Kantzas has extensive experience with transport phenomena in porous media and is a co-director of the GeoS center.

Dr. **Roman J. Shor** is an associate professor, the Energi Simulation Industrial Research Chair in Geothermal Systems and the director of GeoS at the Department of Chemical and Petroleum Engineering and works primarily on modelling and control strategies for drilling systems, on integration of exploration, drilling and production workflows and applications of machine learning and artificial intelligence for energy systems.

Timetable

Overview

8:00–8:30		**Breakfast & Coffee**
8:30–8:50		**Opening Remarks**
8:50–9:30	KL	**Keynote talks** Geothermal in Northern Canada and CO_2-Plume Geothermal
9:30–10:30	CT	**Technical Talks**
10:30–10:45		**Coffee**
10:45–12:30	CT	**Technical Talks**
12:30–13:30		**Lunch**
13:30–15:30	IS	**Industry Updates**
15:30–15:50	CT	**New Projects and Field Trials**
15:50–16:00		**Closing Remarks**
16:00–17:00		**Energy Beers**

CT: Contributed Talk, IS: Invited Speaker, KL: Keynote Lecture

Technical Program

Presentations of selected recent work from researchers at the Energi Simulation Centre for Geothermal Systems Research at the University of Calgary, University of Alberta, Institut national de la recherche scientifique (INRS) and ETH Zurich.

8:50–9:10	KL	**Jasmin Raymond** INRS	Geothermal Potential of Remote Northern Communities: Overview of Research Undertaken
9:10–9:30	KL	**Martin Saar** ETH Zurich	CO_2-Plume Geothermal (CPG): evaluating the potential
9:30–9:45	CT	**An Mai & Gordon Meeham** University of Calgary	Closed Loop Geothermal System Modelling Using CMG and COMSOL
9:45–10:00	CT	**Cedar Hanneson** University of Alberta	Magnetotelluric Imaging of the Magma Body Beneath Mount Meager, Southwestern Canada
10:00–10:15	CT	**Zhenqian Xue & John Chen** University of Calgary	The Feasibility of CO_2 Utilization in an Enhanced Geothermal System
10:15–10:30	CT	**Kai Zhang & John Chen** University of Calgary	Geothermal Development Associated with Enhanced Hydrocarbon Recovery and Geological CO_2 Storage in Oil and Gas Fields
10:30–10:45	**Coffee Break**		
10:45–11:00	CT	**Fatemeh Keramat & Lexuan Zhong** University of Alberta	Computational Fluid Dynamics Analysis of Geothermal Borehole Performance in Nine Cities in Canada During Winter Season
11:00–11:15	CT	**Philip Adebayo** University of Calgary	The Potential of Ground Source Heat Pump and Photovoltaic Thermal Hybrid Solar Collector for Building Decarbonization in Alberta
11:15–11:30	CT	**Seyed Ali Madani** University of Calgary	Experimental Study of Granite's Thermal Properties Temperature Dependency Using a Steady State Approach
11:30–11:45	CT	**Shahab Ghasemi** University of Calgary	Experimental and Numerical Study of Heat Transfer in Pore-Scale
11:45–12:00	CT	**Scott Hess** University of Calgary	Geo Predict: A User-Friendly Web Application for Drilling Data Analysis
12:00–12:15	CT	**Prathik Prasad** University of Calgary	A Novel Data Science Approach to Borehole Dysfunction Analysis
12:15–12:30	CT	**Nader Nourdanesh** University of Calgary	Using Thermoelectric Generators (TEGs) for Electric Power Generation from Waste Heat in Geothermal Plants
12:30–13:30	**Lunch Break**		

KL: Keynote Lecture, CT: Contributed Talk;

Industry Updates

Keynote presentations highlighting recent technical achievements and ideas.

13:30–14:00	IS	**Lisa Mueller** FutEra Power	Innovation Behind First Geothermal Power Plant in Alberta
14:00–14:30	IS	**Peter Graham & Blair Shunk** Algar Geothermal	Algar Geothermal: What a Single Well Can Do
14:30–15:00	IS	**Cole Narfason** Eavor Technologies	Eavor H1 2023 Update
15:00–15:30	IS	**Mazda Irani** Ashaw Energy Solutions Inc.	Challenges in the Modeling of the Fracture in EGS developments

New Projects and Field Trials

Overview of new projects and field trials under development. Partnership opportunities will be presented for relevant projects.

15:30-15:40	CT	**Roman J. Shor** University of Calgary	**Demonstration Project**: A Middle-Deep (2.4 km) Geothermal Heating System for the University of Calgary Main Campus
15:40-15:50	IS	**Brian Senio[1] & Roman J. Shor[2]** [1]Eavor Technologies & [2]University of Calgary	A Proposal for a **Geothermal Centre of Excellence**
15:50–16:00	**Closing Remarks**		
16:00–17:00	**Energy Beers**		

CT: Contributed Talk; IS: Invited Speaker

Abstracts

Geothermal Potential of Remote Northern Communities: Overview of Research Undertaken

Jasmin Raymond, Mafalda Miranda, Félix-Antoine Comeau

KL

Institut national de la recherche scientifique (INRS), Québec City, Québec, Canada

The sustainable development of Canada's North is a growing priority with approximately 134,000 people, mostly Indigenous, living in a diesel-dependent dynamic. Research is ongoing to help develop renewable energy alternatives such as geothermal despite the data gap challenge that needs to be addressed. This presentation will review resource potential studies conducted in the Yukon, Northwest Territories and Nunavut as well as techno-economic studies made in Nunavik (Quebec) to evaluate the feasibility of geothermal technologies. While shallow geothermal systems can be deployed in a short-term period, deep geothermal systems are a long-term objective that may provide sufficient energy to meet communities' heavy heating needs.

CO_2-Plume Geothermal (CPG): evaluating the potential

Martin Saar[1], *Jasper de Reus*[1], *Roman Shor*[2]

KL

[1] ETH Zurich, Switzerland
[2] Department of Chemical and Petroleum Engineering, University of Calgary, 2500 University Drive NW, Calgary, AB T2N 1N4

CO_2-Plume Geothermal (CPG) is a technology co-invented by Martin Saar that uses the benefit of CO_2 as a geothermal working fluid to produce two to three times the geothermal power compared to H_2O (Saar et al. 2011). CPG makes use of naturally permeable reservoirs at 2-5 km depth which are typically targeted for carbon capture and sequestration (CCS), and is applicable to both saline aquifers, as well as depleted oil and gas reservoirs. As eventually all injected CO_2 is geologically stored, CPG transforms CCS into CCUS: both CO_2 utilization, as well as geological storage. An enabler for large-scale CPG implementation is the quantification of the overall potential of this technology at a country scale, in terms of power produced, levelized cost of energy (LCOE) and the total CO_2 stored in the process. The results from a CPG potential study performed in deep saline aquifers in the United States are presented. This forms the starting point of a similar evaluation of the CPG potential in Canada, as part of a larger industry-academic initiative.

Closed Loop Geothermal System Modelling Using CMG and COMSOL

An Mai, Gordon Meehan

CT

Department of Chemical and Petroleum Engineering, University of Calgary, 2500 University Drive NW, Calgary, AB T2N 1N4

Geothermal can potentially be used for district heating, where the extracted heat from subsurface serves as the heat source for the heat pump. In this study, various borehole configurations were modelled using CMG STARS and COMSOL Multiphysics. CMG STARS is a commercial reservoir simulator that can model heat flow, with recently added geothermal modelling capability. COMSOL is a finite element simulation software for a variety of physical and engineering applications including fluid flow and heat transfer. The borehole is designed as a co-axial tube heat exchanger with an internal tubing and outside casing. Water is injected in the annulus and heated water is returned through with tubing with a layer of insulation added to the outside of the internal tubing to retain heat. The flow rate required to meet the heating demand is investigated through a series of simulation analysis.

In CMG, both vertical and horizontal co-axial tubing configure was investigated. The vertical well is 2 km deep, with a bottomhole temperature of 60°C. For the analysis on the horizontal wells, a 2 km lateral section was added at the same depth of 2000 m. Simulation was used to optimize between the water injection rate and the temperature of the returned water at the surface. The energy load requirement will dictate the number of wells to be drilled. As expected, the addition of the lateral section drastically increased heat extraction, thus, for the same load a significantly reduce number of boreholes to be drilled.

In COMSOL, the same co-axial configuration was modeled using a two-dimensional axisymmetric geometry to reduce computational requirements. Rather than setting a bottomhole temperature, a generalised geothermal gradient of 25 K/km was used to estimate the temperature of the reservoir along the length of the well. COMSOL coupled the turbulent fluid flow, convective and conductive heat transfer physics together into a non-isothermal flow simulation. The results were then compared to those generated by CMG.

Magnetotelluric Imaging of the Magma Body Beneath Mount Meager, Southwestern Canada

***Cedar Hanneson*[1], *Martyn J. Unsworth*[2]**

CT

[1] Department of Physics, University of Alberta, 116 St 85 Ave, Edmonton, AB T6G 2R3
[2] Department of Earth and Atmospheric Sciences, University of Alberta, 116 St 85 Ave, Edmonton, AB T6G 2R3

Magnetotelluric data were collected on and around the Mount Meager Volcanic Complex, an active volcanic complex with eruptions 2,400 and 24,300 years ago, then 3-D inversion was used to create an electrical resistivity model to a depth > 20 km. The model is characterized by high resistivity (> 100 Ωm) in the upper 6-7 km, implying relatively dry, unaltered rock. Within this resistive layer, localized conductors are observed in the upper 2 km beneath Pylon Peak and Fish Creek, corresponding to low-permeability clay-rich layers, acting as caprocks to geothermal fluids below. Beneath the resistive upper crust, there is a large conductor at 5-15 km below sea level with an average resistivity of 3 m, interpreted to be a magma body comprised of 18-32% dacitic-to-trachydacitic melt with 6-8 wt% H_2O at a temperature of 800-900°C. There are fluid pathways from the northern part of the magma body, up toward Mount Meager and the nearby fumaroles. Along with other geophysical and geological models of the Garibaldi Geothermal Energy Project, it will reduce the exploration risk associated with geothermal energy development.

The Feasibility of CO_2 Utilization in an Enhanced Geothermal System

Zhenqian Xue, Zhangxing (John) Chen

CT

Department of Chemical and Petroleum Engineering, University of Calgary, 2500 University Drive NW, Calgary, AB T2N 1N4

The development of a geothermal system can supply low-carbon electricity to support the rising energy demand under the energy transition from fossil fuel to renewables. CO_2 can substitute for water for energy recovery from geothermal reservoirs owing to its better mobility. Additionally, trapping injected CO_2 underground can achieve environmental benefits by targeting greenhouse gas (GHG) mitigation. In this presentation, different flow schemes are established to assess heat mining and CO_2 storage capacity by injecting CO_2 into an enhanced geothermal system (EGS). The Qiabuqia geothermal field in China is selected as a study case to formulate geothermal reservoir simulations. The results show that a pure CO_2 injection after a pre-water slug can provide better performance in heat mining. Besides, this operational strategy can provide extra benefits for obtaining appreciable CO_2 retention, which can supply some profits by the policy of a carbon credit. The generated geothermal electricity under a pure CO_2 injection is the lowest, as well as with a few amounts of CO_2 storage capacity. Considering the assessment on heat mining and CO_2 sequestration, the pure CO_2 injection after a pre-water slug is recommended for the operation of an EGS. Under this flow strategy, a larger well spacing, a lower injection temperature and a lower fracture conductivity are suggested, while an optimal production pressure difference should be further determined to balance its effect on geothermal production and CO_2 storage since it presents an opposite effect on these two parts. This work demonstrates the feasibility of heat mining associated with CO_2 geological permanent storage in an EGS by injecting CO_2. The proposed study shows that not only sufficient and sustainable energy can be supplied but also a significant amount of CO_2 emissions can be eliminated simultaneously. In addition, the investigation of geothermal energy production and CO_2 geological sequestration under different operational parameters can provide profound guidance for operators.

Geothermal Development Associated with Enhanced Hydrocarbon Recovery and Geological CO_2 Storage in Oil and Gas Fields

Kai Zhang, Zhangxing (John) Chen CT

Department of Chemical and Petroleum Engineering, University of Calgary, 2500 University Drive NW, Calgary, AB T2N 1N4

Field scale reservoir simulation and production history matching are performed to investigate CO_2 storage and CO_2 heat mining potential in the high-temperature Arun gas condensate reservoir in Indonesia. Our study shows that CO_2 injection into the depleted Arun reservoir can produce 51 MMbbl of condensate over a period of 16 years. Afterwards, continuous CO_2 injection without any production can allow 1.2 Gt of CO_2 to be stored over a 20-year period by raising the reservoir pressure to the initial value. In addition, subsequent recycling of CO_2 can produce substantial amount of geothermal energy for electricity production. Followed by that, we then conduct a first-of-its-kind evaluation of 16,990 oil fields and 71,907 gas fields in Canada for geothermal development with enhanced hydrocarbon recovery and geological CO_2 storage. Results show that 213 oil fields and 2,639 gas fields with a reservoir temperature above 100 °C and buried depth below 800 m are suitable for the CO_2 storage and heat mining projects. The 213 oil fields have potential CO_2 enhanced oil recovery of 643 million barrels, geothermal resources of 4.5 billion GJ and CO_2 storage capacity of 552 Mt. The 2,639 gas fields have potential CO_2 enhanced gas recovery of 6.3 Tcf, geothermal resources of 16 billion GJ and CO_2 storage capacity of 8 Gt.

Computational Fluid Dynamics Analysis of Geothermal Borehole Performance in Nine Cities in Canada During Winter Season

Fatemeh Keramat, Lexuan Zhong CT

Department of Mechanical Engineering, University of Alberta, 116 St 85 Ave, Edmonton, AB T6G 2R3

In this work, the thermal performance of a two-dimensional borehole system containing a U-shaped pipe surrounded by porous soil in nine provinces in Canada is analyzed using computational fluid dynamics. The effect of soil porosity and thermal conductivity on ice formation and heat transfer performance are investigated. The $\kappa - \epsilon$ turbulent model and Darcy-Forchheimer model are employed in the pipe and porous medium, respectively. In addition, the solidification model is activated to track the possibility of ice formation within the soil medium. The temperature profile based on the depth of the soil is customized for each city and the surface temperature of the soil is determined based on the environmental weather in 2021 and is loaded to the simulations as a user-defined function code. Also, the properties of soils, including density, thermal conductivity, and porosity are considered separately for each location in the simulations. According to the results, the ice formation profile around the U-shaped tube and borehole is confirmed. The ice formation possibility indicates that increasing the porosity and thermal conductivity of the soil enhances heat transfer and reduces the ice formation around the borehole.

The Potential of Ground Source Heat Pump and Photovoltaic Thermal Hybrid Solar Collector for Building Decarbonization in Alberta

Philip Adebayo, Aggrey Mwesigye

CT

Department of Mechanical and Manufacturing Engineering, University of Calgary, 2500 University Drive NW, Calgary, AB T2N 1N4

To minimize dependence on fossil fuels and shift towards lower-carbon energy choices for building heating and cooling, stakeholders from all over the world are initiating new sustainable energy system pilot projects. Ground source heat pumps (GSHP) are becoming more popular as a dependable and sustainable way to lessen the carbon footprint of buildings. In comparison to traditional air source heat pumps, GSHPs operate with consistent ground temperatures to deliver heating and cooling with much greater efficiency. Borehole arrays of a GSHP system serving numerous structures will eventually become unbalanced in cold climates like Alberta where planning does not mitigate seasonal energy demand imbalance. Yearly building load imbalances can result in long-term fluctuations in ground temperature due to heat buildup or loss in the ground, which reduce system efficiency and cause premature system failure.

It might be economically feasible to develop bivalent energy systems to correct this imbalance and enhance GSHP sustainability. Systems using bivalent energy are hybrids where a source/sink combination like GSHP can handle a large portion of the thermal load, while another source/sink combination like solar thermal (PVT) can handle the remaining thermal load. Additionally, excess energy from one system may be dumped into the other for seasonal storage. This work examines the possibility of adopting a low enthalpy solar thermal PVT system to enhance the long-term performance of a vertical borehole GSHP system while collaborating with a local property developer. Starting with the test platform and ending with distributed Thermal Energy Networks feeding structures from various borehole arrays, the results of the field-scale experimental test will be expanded in stages of development. The outcomes will be used to map system viability across Alberta and develop energy system design strategies for specific subsurface conditions.

Experimental Study of Granite's Thermal Properties Temperature Dependency Using a Steady State Approach

Seyed Ali Madani[1], ***Amir Fayazi***[1,2], ***Roman Shor***[1], ***Apostolos Kantzas***[1,2],

CT

[1] Department of Chemical and Petroleum Engineering, University of Calgary, 2500 University Drive NW, Calgary, AB T2N 1N4
[2] PERM Inc., Calgary, AB

Granite rock is one of the main constituent formations of most geothermal reservoirs. In any heat transfer operation including geothermal processes, obtaining accurate knowledge about the thermal behavior of engaged materials is crucial. One of the main parameters among thermal features is thermal conductivity which defines the capability of a material to transfer heat. In this experiment, thermal conductivity values of different granite rock samples have been assessed by an in-house steady-state setup to obtain more accurate results in comparison with traditional transient methods. In this setup, a reference material with a known thermal conductivity is used to determine the thermal conductivity of samples based on the one-dimensional conduction heat equation. To minimize heat losses, an adjustable heat jacket is used around the setup's chamber. Thermal conductivity values have been obtained for different temperatures in a wide range from 40 to 150 Celsius. To analyze the effect of the structure and mineralogy of samples, samples' petrophysical properties were assessed along with the mineral composition by the X-ray Powder Diffraction (XRD) test. Based on the results of this study, thermal conductivity values decrease with increasing temperatures. The slope of its declining behavior varies with different temperature ranges due to the transformations of solid minerals.

Experimental and Numerical Study of Heat Transfer in Pore-Scale

Shahab Ghasemi, Apostolos Kantzas

CT

Department of Chemical and Petroleum Engineering, University of Calgary, 2500 University Drive NW, Calgary, AB T2N 1N4

Due to its diverse industrial applications, heat transfer in porous media has received increasing interest. The purpose of geothermal projects is to provide heating of houses or generate electricity. Despite the various macroscopic or field studies, only a small number of studies were conducted at the pore scale. For this reason, a pore-scale study of heat transfer in porous media at high Peclet number conditions is presented. Experiments are conducted in a sand pack with various surrounding temperatures and injection rates. Granular porous media with different patterns were generated. The thermal dispersivity of each medium was calculated through thermal history matching. The temperature profile at the outlet is then fitted to the heat advection-dispersion equation. It is concluded that with increasing the Peclet number, the thermal dispersivity increases drastically, which means that the thermal dispersivity is highly dependent on the flow rate. The results of this study are of great importance for the design, implementation, and performance optimization of thermal processes in porous media.

Geo Predict: A User-Friendly Web Application for Drilling Data Analysis

Chace Nielson*, *Scott Hess*, *Roman Shor

CT

Department of Chemical and Petroleum Engineering, University of Calgary, 2500 University Drive NW, Calgary, AB T2N 1N4

For Geothermal drilling projects in Alberta, it is rare to find high thermal gradients. Without one, many challenges are encountered including drilling through hard rock, high temperatures and high pressures, and economic viability. The goal is to minimize these obstacles by better understanding and analyzing significant drilling parameters. This can be done through the Geo Predict. Geo Predict is a free, user-friendly web application built using python and javascript, which can assist energy companies with optimizing their drilling operations by providing them with real-time data analysis. Geo Predict was built in hopes to advance technology used in Geothermal Energy, but its versatile structure can be applied in any energy industry.

The application allows any Geothermal industry employee to upload drilling data and receive useful information, visuals, and analysis, including but not limited to, a bottom hole assembly visual, the well profile visual, and various drilling parameters (torque, weight on bit, ROP, RPM, etc.). Aside from visualizing the data, tools will be present to analyze the data to provide useful insights. This web app can be accessed from the field during a drilling project, at the office or even from home. Geo Predict is a vastly accessible tool and has been tested using Utah Forge Data. 100+ Forge data files have been processed through the Geo Predict web app, to analyze real drilling data and ensure the web application is functional.

The objective of this web application is to assist Geothermal projects. Improving the drilling process will be headway for more projects. Since drilling is the most capital-intensive part of a project, optimizing this process can reduce the cost significantly. Reducing costs could encourage companies to turn to this cleaner and more sustainable energy method. This will not only help the number of Geothermal wells being drilled in Alberta, but it would also benefit the already existing drilling workforce in the province and pave the way for a cleaner future in Alberta.

A Novel Data Science Approach to Borehole Dysfunction Analysis

Prathik Prasad, Scott Hess, Roman Shor CT

Department of Chemical and Petroleum Engineering, University of Calgary, 2500 University Drive NW, Calgary, AB T2N 1N4

During drilling activities, monitoring the quality of the borehole is an essential task. Borehole dysfunctions such as constrictions, ledges, and differential sticking can cause significant amounts of non-productive time that decreases overall operational performance. The dysfunctions are most troublesome during tripping operations when the drill string is moved in and out of the borehole. Identification of dysfunctions before significant operational issues occur, such as stuck pipe, can allow proactive mitigating actions to reduce the impact on the tripping operation. Modelling methods for expected sliding friction for good borehole conditions provide a baseline for hook load operating parameters during tripping out of the borehole. Assuming the baseline hook load estimation is somewhat accurate, the anomalous high hook loads above baseline, referred to as overpull, provide measurements that should capture the resistance in the borehole due to dysfunctions. The focus of this study is to utilize overpull signatures and the drill string configuration to produce a resistance depth profile that can provide better depth resolution to place dysfunctions along the wellbore and also characterize the dysfunction mechanism. This work represents the initial steps of developing a forward modelling strategy using a source signal (i.e. the drill string) convolved with a resistance signal (i.e. the dysfunctions) to produce overpull signals. Initial tests show promising similarities compared to overpull real data.

Using Thermoelectric Generators (TEGs) for Electric Power Generation from Waste Heat in Geothermal Plants

Nader Nourdanesh, Apostolos Kantzas

CT

Department of Chemical and Petroleum Engineering, University of Calgary, 2500 University Drive NW, Calgary, AB T2N 1N4

The application of Thermoelectric Generators for converting geothermal energy to electricity is investigated in this paper, considering the effects of various parameters on their efficiency. Using renewable energy is one of the latest solutions to tackle climate change, global warming, air pollution, the ozone layer hole, etc. In this regard, a thermoelectric generator (TEG), which is a device for converting heat energy to power, could be used in different renewable energy systems like solar or geothermal. Although their initial cost is lower than the other methods of converting thermal energy to electricity, their efficiency is lower than the most common techniques. Therefore, finding the optimum situation to increase the efficiency of combined devices with TEGs can increase the likelihood of using them in different industries. The parameters investigated in this paper were the temperature of the operating fluid in channels, the optimum mass flow rate, and the channel slope. The results have shown that with increasing temperature differences of the fluid in the channel, the efficiency of the designed system increased significantly. In addition, by increasing the mass flow rate of the operating fluid in the channel, power generation and the whole system efficiency increase up to a certain plateau value. Furthermore, the experimental results have proven that increasing the slope of the channel increased the amount of power generation but has not caused a noticeable change in their efficiency.

List of Speakers

Roman J. Shor	University of Calgary, Calgary, Canada
Jasmin Raymond	INRS, Québec City, Canada
Martin Saar	ETH Zurich, Switzerland
An Mai	University of Calgary, Calgary, Canada
Gordon Meehan	University of Calgary, Calgary, Canada
Cedar Hanneson	University of Alberta, Edmonton, Canada
Daniel Zeinabady	University of Alberta, Edmonton, Canada
Zhenqian Xue	University of Calgary, Calgary, Canada
Kai Zhang	University of Calgary, Calgary, Canada
Fatemeh Keramat	University of Alberta, Edmonton, Canada
Philip Adebayo	University of Calgary, Calgary, Canada
Seyed Ali Madani	University of Calgary, Calgary, Canada
Shahab Ghasemi	University of Calgary, Calgary, Canada
Scott Hess	University of Calgary, Calgary, Canada
Prathik Prasad	University of Calgary, Calgary, Canada
Nader Nourdanesh	University of Calgary, Calgary, Canada
Peter Graham	Algar Geothermal, Calgary, Canada
Blair Shunk	Algar Geothermal, Calgary, Canada
Brian Senio	Eavor Technologies, Calgary, Canada
Cole Narfason	Eavor Technologies, Calgary, Canada
Mazda Irani	Ashaw Energy Solutions Inc., Calgary, Canada

Useful Information

Joining the Workshop remotely?

To join the Workshop virtually, please use the following **Zoom link**. The meeting passcode is: 646726

Upon entry, please keep your microphone muted.

Questions during the talks will be enabled through Slido, details of which will be provided before the talks start.

Joining the Workshop in person?

Talks will be held on the basement level of Engineering Block C building (ENC, floor B1) of the **Schulich School of Engineering** in room **ENC 070**. The room can be accessed from multiple entrances - CCIT building access point, ENG building access point, or ENC building itself. Signage will be posted throughout the engineering complex to guide the attendees to the right location.

Breakfast and coffee breaks will be offered on the platform of ENC 070 theatre.

Lunch will be served on the second floor of the main engineering building (G Block) in room **ENG 207**. The **G Block** is the new part of the building with predominantly yellow walls, and the room can be accessed from multiple entrances - CCIT building access point, ENB building access point, ENC building access point, or ENG building itself. Signage will be posted throughout the engineering complex to guide the attendees to the right location and volunteers will be available for additional guidance.

Interactive room finder is available on the following **link** for ease of finding different buildings on campus.

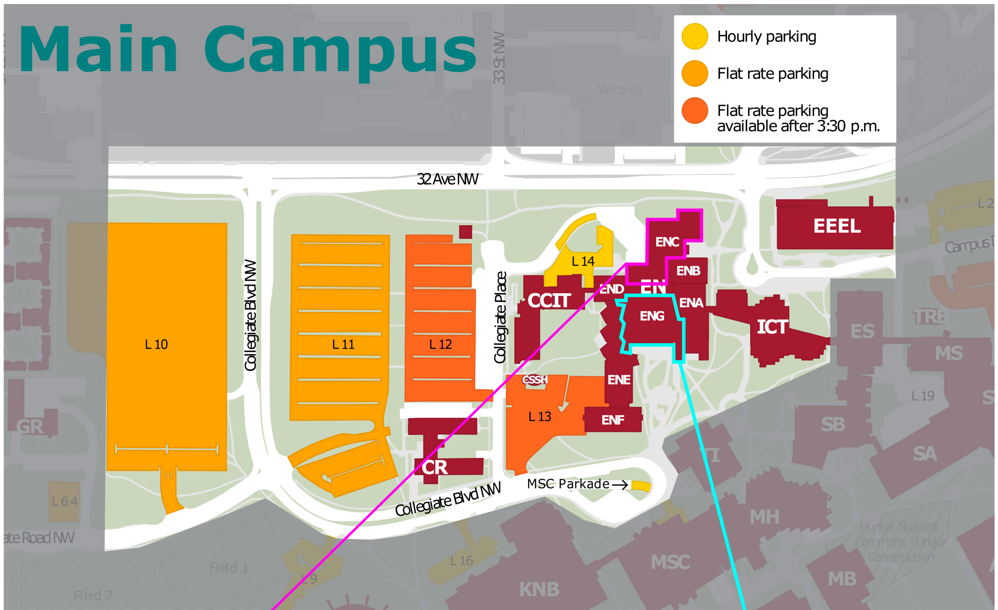
Wi-Fi will be available during the Workshop at the University of Calgary campus via the **airuc-guest** and **eduroam** networks.

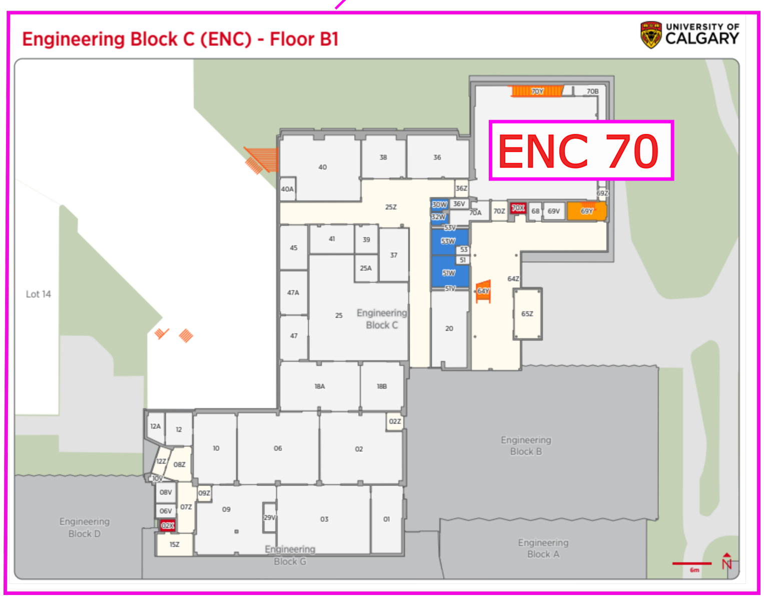
How to get to the Schulich School of Engineering?

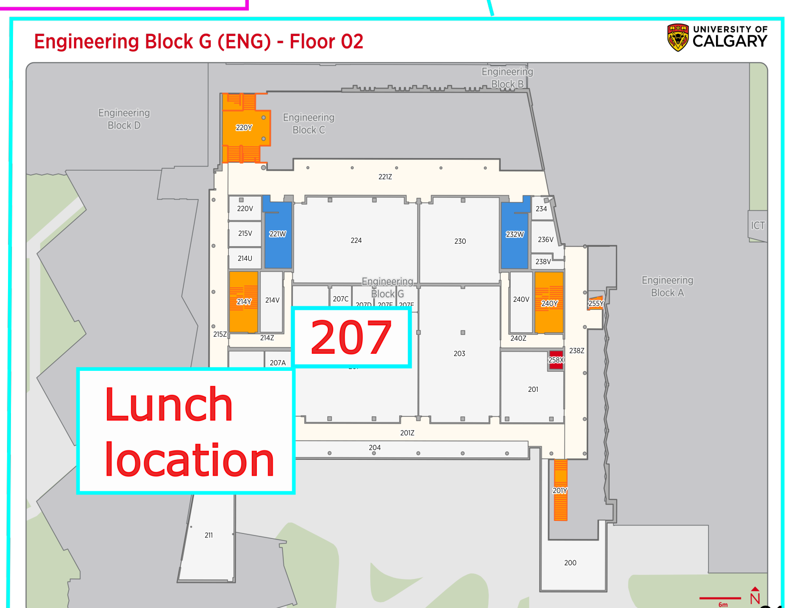
The engineering complex is located on the north side of campus, within walking distance of the University CTrain station.

Parking is available at several locations, on hourly or flat rate basis:

- **Lot 10**: public flat rate, $9/day. Payment available at parking pay station or through the Parkedin app (**Zone ID: 1368**)
- **Lot 11**: public flat rate, $9/day. Payment available at parking pay station or through the Parkedin app (**Zone ID: 1369**)
- **Lot 12**: public parking starts at 3 p.m., flat rate, $9. Payment available at parking pay station or through the Parkedin app (**Zone ID: 1377**)
- **Lot 13**: public parking starts at 3 p.m. Payment available at parking pay station or through the Parkedin app (**Zone ID: 1375**)
- **Lot 14**: public parking starts at 3 p.m., flat rate, $9. Payment available at parking pay station.


Main Campus
Hourly parking
Flat rate parking
Flat rate parking available after 3:30 p.m.
32 Ave NW
EEEL
ENC
ENB
L 14
END
ENA
ENG
CCIT
ICT
ES
TRB
MS
L 10
L 11
L 12
Collegiate Blvd NW
Collegiate Place
CSSH
ENE
L 13
ENF
SB
L 19
SA
GR
L 64
CR
MSC Parkade
Collegiate Blvd NW
MH
MSC
KNB
MB
L 16
Field 1
Field 7


Engineering Block C (ENC) - Floor B1
UNIVERSITY OF CALGARY
ENC 70
Lot 14
Engineering Block C
Engineering Block B
Engineering Block D
Engineering Block G
Engineering Block A


Engineering Block G (ENG) - Floor 02
UNIVERSITY OF CALGARY
Engineering Block D
Engineering Block C
Engineering Block B
Engineering Block A
Engineering Block G
207
Lunch location

Funding Agencies and Industry Partners

GeoS would like to thank our industry partners and funding agencies for their generous support of our research program.

Special thank you to this year's industrial sponsors of the Geothermal Workshop.

Workshop Sponsors

Premier Sponsors:

Eavor™ KALiNA Clean. Energy. FRONTIER Project Solutions

Supporters:

E2E ENERGY SOLUTIONS GEO-X RESOURCES LTD A Geothermal Supply Company

Funding Agencies

NSERC CRSNG ALBERTA INNOVATES Mitacs

Government Partners

Industry Partners