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CanGRC Review

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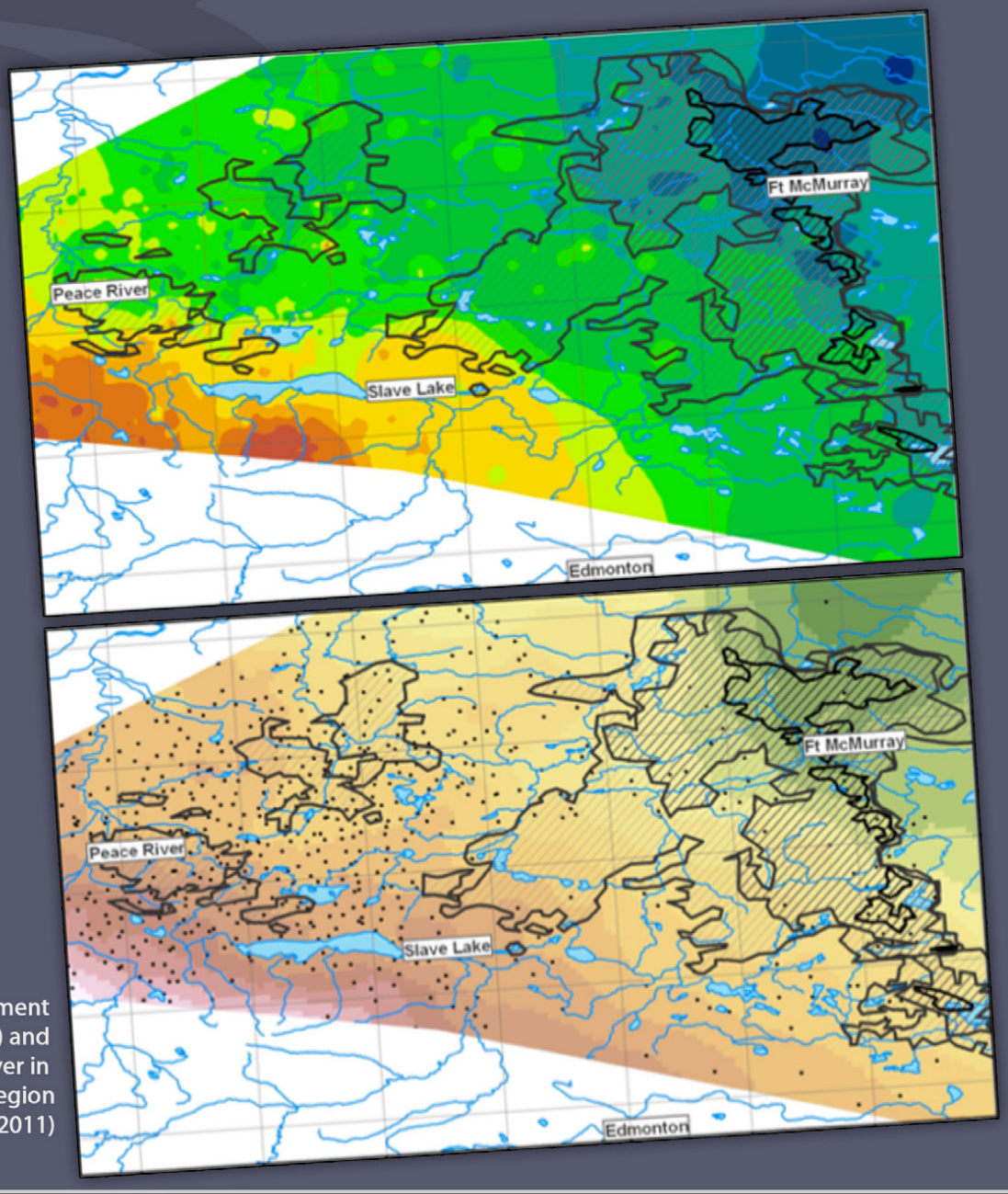

Maps showing basement temperature (top) and thickness of cover in the Athabasca Region (Majorowicz et al., 2011)

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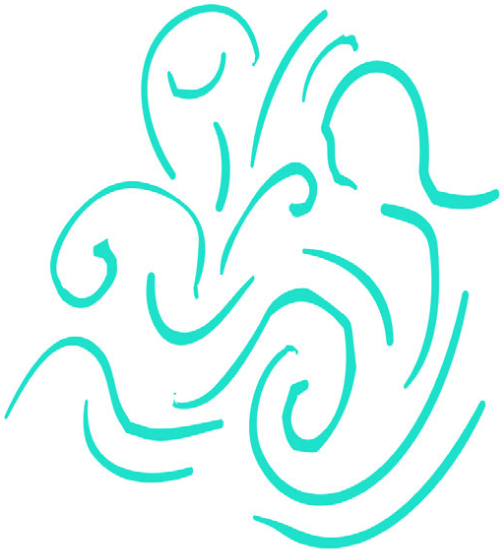

Canadian Geothermal Research Council Mission Statement

Written by Ryan Libbey, Yuliana Proenza and Lena Patsa
CanGRC Co-Founders

Geothermal technologies are clean and reliable energy sources that take advantage of the thermal properties of the Earth's subsurface for direct use heating and cooling applications and electricity generation. Canada has already begun to utilize these technologies for heating and cooling purposes; however, it remains one of the only countries on the Pacific Rim to not produce electricity from geothermal resources. Studies released by the Geological Survey of Canada show these untapped subterranean resources to be vast, and new reservoir technologies may make geothermal electricity generation feasible nation-wide. Needless to say, geothermal research in Canada is a pertinent and stimulating field of study.

The Canadian Geothermal Research Council (CanGRC) is a voluntarily-run organization dedicated to serving Canada's geothermal research community. It does not exist as a government lobby group, nor is it intended to represent a unified voice of the research community. Rather, CanGRC exists to raise awareness about geothermal research in Canada, to showcase Canadian geothermal research and to elevate communication within the research community.

CanGRC is an initiative by 3 graduate students from across the country - Ryan Libbey (McGill University), Yuliana Proenza (University of British Columbia) and Lena Patsa (University of British Columbia). CanGRC operations are guided by an esteemed Board of Directors, which includes geothermal scientists from academic, government and industry positions. Currently serving on this Board is Dr. Grant Ferguson (St. Francis Xavier University), Dr. Catherine Hickson (Alterra Power Corp.), Mr. Craig Dunn (Borealis Geopower) and Dr. Steve Grasby (Geological Survey of Canada / Natural Resources Canada / University of Calgary). Dr. Jasmin Raymond has been recently recruited to the CanGRC team as our GeoExchange Representative.

Membership to CanGRC is completely free and includes a subscription to this semi-annual newsletter. We encourage everyone interested in geothermal research to join. If you haven't already done so, simply head to our website at www.cangrc.ca/members.html and fill out the form.

We greatly appreciate your interest and feedback, and hope that you enjoy this issue of the *CanGRC Review*.

Best wishes,
The CanGRC Team

Chief Editor. Ryan Libbey
Content Managers. Yuliana Proenza, Lena Patsa and Ryan Libbey
Graphic Design. Ryan Libbey

www.cangrc.ca

To contribute an article to the CanGRC Review, please email your submission to info@cangrc.ca. Submissions should be in .doc format. Please send all related images as separate high-quality attachments.

All are welcome and encouraged to submit. It is the intention of this publication to showcase members from a range of sectors and disciplines. Student submissions are welcome.

CanGRC Activity Update

Written by Yuliana Proenza, Ryan Libbey (CanGRC Co-Founders)
and Dr. Jasmin Raymond (CanGRC GeoExchange Rep.)

2011 was an active and successful year for CanGRC. After the official establishment of our organization in the summer, CanGRC recruited esteemed scientists from government, academia and industry for its Board of Directors, published the first issue of the 'CanGRC Review', spread our message to institutions, received coverage from ThinkGeoEnergy.com, established a website and social media outlets, presented and held booths at 3 national conferences and began welcoming an inspiring number of new members. Late in the year CanGRC recruited Dr. Jasmin Raymond to serve as our GeoExchange Representative. Jasmin will act as our liason to the GeoExchange research community and will represent us at conferences and meetings related to direct use and heat pumps. His experience makes him an asset to the team and we are glad to welcome him aboard.

Throughout the past year CanGRC has greatly benefited from the strong co-operative relationships that have been established with the Canadian Geothermal Energy Association (CanGEA) and the Canadian GeoExchange Coalition (CGC). We are excited to continue collaborative endeavors with our friends at CanGEA and the CGC in 2012 and beyond.

CanGEA's Annual Conference and Investment Forum – September 14-15, 2011. Toronto, ON.

CanGRC was invited to present and hold a booth at CanGEA's Annual Conference and Investment Forum, which took place last September in Toronto. Co-Founders Ryan Libbey and Lena Patsa represented CanGRC at this conference with Ryan giving a presentation that outlined CanGRC's objectives and also avenues for geothermal education in Canada. Dr. Stephen Grasby, serving on CanGRC's board of directors, also attended and presented on the geothermal resource potential in Canada. This conference was a fantastic opportunity to network and relay CanGRC's message to members of the geothermal community in Canada.

CanGEA's 3rd Geothermal Power Forum & Networking Event – Nov 4, 2011. Calgary, AB.

This year's one-day networking opportunity provided a meeting place to discuss the current state of Canada's geothermal resource potential while bringing together the oil & gas sector and representatives of the geothermal energy industry. The forum was held in conjunction with the Global Clean Energy Congress conference, held on November 1–3, 2011. Speakers had a chance to discuss in-depth topics on geothermal research, policy, technology, services and development.

CanGRC had the privilege to speak at this year's event. Co-founder Yuliana Proenza gave an enthusiastic presentation introducing our organization to seasoned industry representatives. Two of CanGRC's directors were also in attendance and both gave well-received presentations; Mr. Craig Dunn of Borealis GeoPower gave presentations on conventional hydrothermal resources and opportunities for the development of co-produced fluids. Dr. Stephen Grasby of the GSC/NRCan gave the day's keynote address on Canada's geothermal resource potential, thoroughly addressed in a GSC report published earlier this year. The takeaway message of this conference was that renewed research efforts are fundamental for reducing geoscience barriers and exploration risks for geothermal development in Canada.

Figure 1. CanGRC Co-Founder, Ryan Libbey, proundly holding the premier issue of the CanGRC Review at CanGEA's Annual Conference and Investment Forum last September. Photo taken by CanGRC Co-Founder Lena Patsa.

A tremendous amount of information was communicated throughout the day. CanGEA is working to bring together energy policy committees across the country to address the unique requirements for differing target groups in order to support geothermal exploration and development across the provinces and territories. A panel of speakers constructively discussed the usage of the Canadian Geothermal Code for Public Recording to improve investor confidence. In addition, the race for the first Canadian geothermal development is on! Keep an eye out for news from Borealis GeoPower and DEEP Earth Energy.

Other various speakers included representatives of DEEP Earth Energy, Yukon Energy, Alterra Power, Enbridge, Ormat Technologies and Canadian Advanced ESP. In addition, companies that participated included AltaRock Energy, provincial and government representatives, Cenovus, Processwest Magazine, EBA Consulting, Chevron, Imperial Oil, Solas Energy Consulting, Statoil Canada, Bloomberg, Alberta Innovates, National Bank Financial, China WindPower Group and LandSolutions.

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It was great to see such varied backgrounds and interest and CanGRC is excited to work alongside this emerging industry.

5th National GeoExchange Technical and Policy Forum – December 7-8, 2011. Markham, ON.

CanGRC attended and was an official partner of the 5th National GeoExchange Technical & Policy Forum this past December. This annual conference was organized by the Canadia Geoexchange Coalition (CGC) and was attended by industry representatives of the geothermal heat pump sector. Dr Jasmin Raymond represented CanGRC at this event, giving information about our association through a booth in the showroom. Many attendees where pleased to learn that our new association is ready to showcase geothermal research, bridging the gaps between industry and academics.

Figure 2. CanGRC's GeoExchange Representative, Dr. Jasmin Raymond, behind our booth at the National GeoExchange Technical and Policy Forum.

Among activities of interest to CanGRC at this meeting was the announcement of five scholarships given to students by CGC Bursaries Program. A total of $27,500 donated by CleanEnergy, Master Group, Groundheat, Enertran, and GeoSmart were given to master and doctoral students at the award dinner on December 7th. The students that obtained the scholarships are Massimo Cimmino (Ph.D., École Polytechnique de Montréal), Félix Robert (Master, Laval University), Chris Mamen (Master, Carleton University), Andrew Hall (Master, Laurentian University) and Hayley Shearer (Master, University of British Columbia). Get ready for next year's contest, as these scholarships will be offered again. More information about CGC Bursaries Program is available on the Web:
http://www.geo-exchange.ca/en/bursaries_p70.php.

The meeting ended with closing remarks by Denis Tanguay, the President and CEO of the CGC. Mr. Tanguay presented a road map for the Canadian geothermal heat pump industry defined through workshops earlier last year. The industry saw the need to create a research fund for geothermal heat pump innovations and Mr. Tanguay invited CanGRC to team up with CGC to participate into the creation of this research fund. This initiative is good news and we are ready to offer help.

Geothermal Geochemistry Session at the V.M. Goldschmidt Conference, MTL

Written by Dr. Nathalie Vigouroux (Alterra Power Corp.)

Plan to attend the Goldschmidt conference and submit an abstract to the geothermal geochemistry session! Abstracts due Feb. 1st, 2012.

Session 9f.- Innovative geochemical approaches to understanding geothermal systems

Under Theme #9: Earth's Resources: Origin, Evolution, Sustainable Exploitation and Remediation
Co-hosted by Theme #6: Subduction, the Mantle Wedge and Arc Volcanism: Early to Present-day Earth

Co-convenors:
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Geothermal energy, one of Earth's sustainable and renewal resources, has regained the attention of international governments, industry and researchers in the last decade as the search for alternative energy sources intensifies. The discovery and evaluation of geothermal resources relies largely on our understanding of their geochemical characteristics at levels ranging from the reservoir and heat source to the surface manifestations. Understanding the evolution of heat and elements within a geothermal system is crucial to correctly interpreting its surface geochemical signatures. We invite authors to present research related to understanding of the geochemical characteristics of geothermal systems. In particular, we encourage presentations that focus on: 1) the interpretation of geochemical signatures as measured at the surface (in gas, water and soil/rock samples), using data collected at depth and/or modelling, and 2) recent advances in the exploration tools used to record and interpret these geochemical signatures.

'Geothermal Energy, Technology and Geology' Textbook from U of Windsor Professor

Written by Dr. Jianwen Yang (University of Windsor)

- - *Geothermal Energy, Technology and Geology* (Spring 2012) - -
Book Description: Geothermal energy is reliable, sustainable and environmentally friendly with low greenhouse emissions, and therefore is drawing increasing attention due to its role in serving as a complement to fossil fuels and in mitigating global warming. This book is composed of 8 chapters written by 14 authors from 6 countries (Brazil, France, Mexico, Slovenia, Turkey and United Kingdom), reflecting the diversity of topical case studies in geothermal energy, technology and geology. The collection of topics aims to present recent advances in research and application of geothermal energy systems, including Ground Source Heat Pump systems and environmental pollution control (Chapter 1); Geological occurrence of the thermal aquifers in northeastern Slovenia (Chapter 2); Relationships between fracture zones, flow pathways and mineral precipitation corresponding to an enhanced geothermal system in France (Chapter 3); Geological and tectonic framework favoring the occurrence of geothermal systems in Western Anatolia, Turkey (Chapter 4); Joint inversion for evaluating deep thermal structure in geothermal areas (Chapter 5); Geophysical investigation of the thermal properties of Kayseri geothermal field, central Turkey (Chapter 6); Numerical simulation of solid particle erosion of geothermal turbines (Chapter 7); and Performance analysis of single-flash geothermal power plants (Chapter 8).

Is it feasible to use Engineered Geothermal Systems to produce Heat for Oil Sands Processing in Northern Alberta?

Written by Dr. Martyn Unsworth (unsworth@UAlberta.ca)
Dr. Jacek Majorowicz
Mr. Greg Nieuwenhuis

Department of Physics, University of Alberta, Edmonton, Alberta

HAI (Helmholtz-Alberta Initiative) Geothermal Energy Team Members:

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Ernst Huenges, Inga Moeck, Andrea Forster, Hans Forster, Oliver Ritter, Oliver Heidbach , Klaus Bauer, Simon Weides, and Marcin Pussak

The Athabasca oilsands are one of the largest hydrocarbon deposits on Earth, and about 20% of these deposits are accessible to surface mining. The separation of bitumen from sand requires large quantities of hot water, which is currently heated by burning natural gas. As a result, oilsands processing accounts for around 6% of Canada's natural gas consumption and incurs significant economic costs and environmental impact. Heating the volume of water required for current oilsands output by 1°C costs about $720,000 per year according to Suncor operation figures (EMR, 2008 website). At current oilsands production levels, this represents 50 million tons of annual carbon dioxide production. The remaining 80% of oilsands reserves are too deep to mine but can be extracted using in-situ techniques such as Steam Assisted Gravity Drainage (SAGD). This process also requires large quantities of steam to be generated by burning natural gas.

Geothermal energy has the potential to reduce both the production costs and greenhouse gas emissions associated with oil sands production in Alberta. The idea of using geothermal heat for oilsands processing was previously proposed by Alison Thompson, Michal Moore, Dan Yang, Peter McConnachie and others as part of the GeoPos consortium (Geopowering the Oilsands). The consortium was supported by Suncor, Shell, Nexen and other companies and finished in 2008. The idea is being investigated in more detail as one of the research themes of the Helmholtz-Alberta Initiative (HAI), (Theme 4), which is a research collaboration between the Helmholtz Association of German Research Centers and the University of Alberta.

The primary area of interest is in the Athabasca oilsands where the WCSB is relatively thin and the Phanerozoic sedimentary succession is thinning towards the northeast and sub cropping onto the Canadian Shield. In this area the Precambrian basement is at a depth of 0.5 km and is being currently studied by HAI scientists through the analysis of the geophysical logs, core, and rock chip samples from a deep well drilled into the granitic basement rocks. A series of detailed geophysical logs and boreholes studies have recently been collected. Borehole AOC GRANITE 7-32-89-10, hereafter referred to as the Hunt Well after its owner, is a 2.36 km well drilled into basement rocks just west of Fort McMurray. It is by far the deepest well drilled in the oilsands areas of Northern Alberta, and as such represents a unique opportunity to study the crystalline basement rocks of Northern Alberta. It thus provides important information for the geothermal investigations of Theme 4, since it allows direct thermal, stress and hydrogeological measurements at depth. A temperature gradient of 21.5 °C per kilometre and maximum temperature of 47.5°C were measured at 2324m in the well in July 2011.

Figure 1. Preparing for geophysical logging of the Hunt Well in July 2011.

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A second study area is located around Peace River where the WCSB is around 2 km thick, and data from the Phanerozoic section are being analyzed. The research is focused on an evaluation of potential heat sources for oilsands processing in areas with existing leases. Revised maps of the temperature at the top of the Precambrian basement confirm that temperatures greater than 60 oC could be found within the sedimentary strata in the Peace River oil sands area as shown in Figure 2.

Different modeling approaches were investigated to determine the amount of energy produced from hot dry rock (HDR). The most suitable numerical and analytical models were determined by history matching to example field data. The heat generation capacity of different regions containing heavy oil/bitumen deposits in northern Alberta was determined using these models, and the use of this energy (in the form of hot-water) for surface extraction processes was evaluated by a team of engineers and geophysicists.

Original temperature gradients were applied as well as realistic basement formation characteristics through an extensive hydro thermal analysis in the region including the Hunt well. Existing natural fractures and possible hydraulic fracturing scenarios were evaluated from the heat generation capacity and the economic points of view. The main problem was modeling difficulties, especially determination and representation of fracture network characteristics. A sensitivity analysis was performed for the selected high temperature gradient regions in Alberta. In this practice, the characteristics of hydraulic fractures, injection rate, depth, the distance between injection and production wells and formation thickness were used as variables and an optimization study was carried out based on these variables. The results showed that the hot water (50-60 °C at surface) needed in Fort McMurray for extraction could be obtained from 80-100 °C 4-5 km deep artificially fractured granite, and can be economically competitive with the generation of the same amount of heat using natural gas.

Reference:
J. Majorowicz, M.J. Unsworth, T. Chacko, A. Gray, L. Heaman, D. K. Potter, D.R. Schmitt and T. Babadagli, (2011), Geothermal energy as a source of heat for oilsands processing in northern Alberta, Canada, in: Heavy Oil/Oil Sands Petroleum Systems in Alberta & Beyond, edited by F. J. Hein, D. Leckie, S. Larter and J. Suter, American Association of Petroleum Geologists, Memoir, Chapter 28, (39 p., 18 Figs, 2 Tables) to be published by the American Association of Petroleum Geologists, Tulsa, OK, USA.

More information :
Helmholtz Alberta Initiative : http://www.helmholtzalberta.ca/
Video about this project: http://www.youtube.com/watch?v=T0WRNJX7r5w

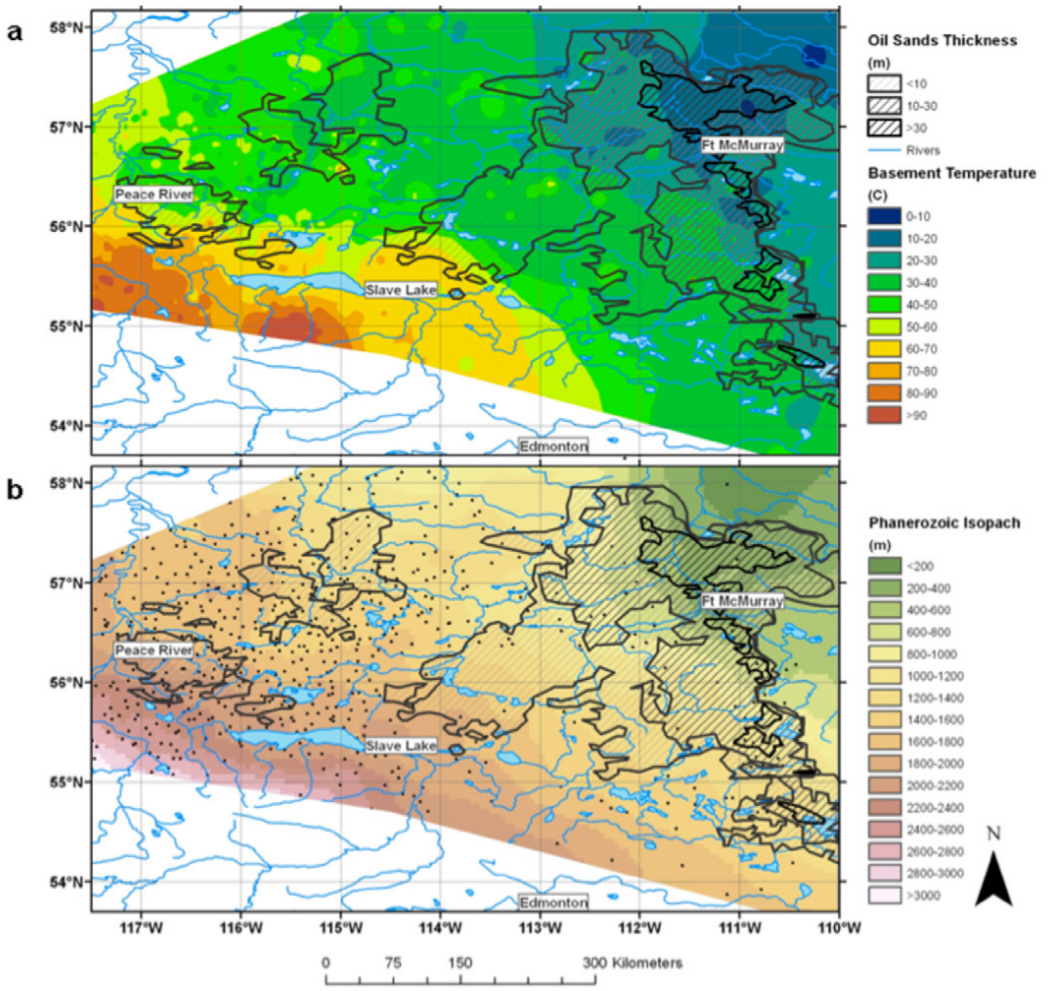

Figure 2. a) Map of estimated temperature at the top of the Precambrian basement (in °C). Oilsands area boundaries and thickness are shown as hatched areas. b) Precambrian basement depth (Phanerozoic thickness), from Majorowicz et al., 2011 (in press).

The Story of PCGER: Fostering Geothermal Education in Canada

Written by Lena Patsa
(CanGRC Co-Founder, founder and technical lead of PCGER)
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The Province of British Columbia lies directly on the Pacific Ring of Fire, an area of intense magmatic activity that spans five continents and is home to vast geothermal resources. Geothermal energy has been used for centuries in applications ranging from direct utilization of thermal waters to the production of clean, sustainable electricity. Despite the promise and the opportunity, geothermal utilization in Canada is limited. In essence, this broadly available, clean and sustainable energy source is severely underutilized, a fact that undermines Canada's efforts towards energy independence and carbon footprint reduction. At the heart of the problem lies the lack of education in the field of Geothermics in Canada, a lack of public and government understanding, as well as a scarcity of local expertise.

The Pacific Centre for Geothermal Education and Research (PCGER) is an interdisciplinary group of UBC students and professors who have come together with the support of the UBC Teaching and Learning Enhancement Fund to work on a single objective: Bringing UBC to the forefront of geothermal education while facilitating the development of our Province's vast geothermal resources. PCGER is a student-run initiative and as team members, we share a common passion for clean energy development and technical education. The Centre was first established in 2009 under the auspices of the UBC NBK Institute for Mining Engineering and it builds on the University's reputation of excellence and leadership in sustainability.

Strategically, our primary objective is to create a series of courses covering fundamental aspects of geothermal energy utilization, namely in the fields of exploration, resource assessment, geothermal power generation, district systems and direct use. These courses will be addressed to the existing student body of UBC, both graduates and upper level undergrads in a multiple of backgrounds, as well as help attract high-caliber students from around the world in search of geothermal training. Course content will be designed to address the issues affecting existing and projected developments as well as needs and requirements of current geothermal professionals in search of further accreditation.

At the core of our goals and objectives lie the values of sustainability (in clean energy production), student learning and knowledge dissemination (through course creation), international and intercultural engagement (through networking and collaboration with geothermal experts from across the globe), and community engagement (through our forged relationships with the geothermal industry). Together, these values combine to create an exceptional incubator of geothermal expertise and student learning at the University of British Columbia. The aim is three-fold; enhance the rate of public acceptance of geothermal as a viable energy source, while creating work opportunities for engineers throughout British Columbia and facilitating the exploitation of a truly sustainable, locally produced and consumed energy resource.

Figure 1. PCGER founder/Technical Lead and CanGRC Co-Founder Lena Patsa.

These past two years, our activities focused primarily on three comprehensive goals: addressing the complete lack of geothermal energy courses within the UBC curriculum; creating viable bonds between Canadian geothermal experts in academia and industry; and engaging and educating UBC students on the merits and realities of the development of this truly sustainable, locally produced and consumed energy resource. To-date, our team has been able to meet a series of important goals that have brought us closer to achieving PCGER's long-term objectives. Important accomplishments include but are not limited to:

- Establishing PCGER and creating its identity
- Forging working relationships with key players locally and internationally, in academia and industry
- Creating and delivering the very first University courses in Canada, exclusively dedicated to geothermal energy development
- Promoting UBC and PCGER at events across the globe, attracting potential students and sponsors
- Building a substantial collection of educational materials that form the basis of course development
- Collaborating with CERC in tailoring course content and finding avenues to integrate our courses with theirs

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- o Recruiting the participation of local industry experts in the form of visiting lecturers
- o Transferring existing courses online and opening avenues for teaching and learning across the board
- o Succeeding in demonstrating the need and student interest for additional course offerings in geothermal energy.

What we have accomplished thus far is fundamental to our goals: we have created and are in the process of delivering the first (and currently only) course at a University level in Canada exclusively dedicated to geothermal energy development. Piloted in Spring 2011, the course covers the fundamentals of geothermal energy systems and has been taught in-class as well as online to 59 graduate and undergraduate students to date. This year, we are migrating all content online in the hopes that we can create new learning opportunities on both UBC campuses (UBC-Vancouver and UBC-Okanagan) and foster new teaching and learning collaborations with partner institutions from across Canada.

Additionally for this year, we are organizing the 1st UBC Student Competition on Geothermal Energy. The competition has the primary objective of engaging student participation, stimulating the creation and exchange of ideas and giving back to the students in the form of awards. It is open to all undergraduate and graduate students, as well as current post-doctoral fellows. All contestants are asked to address this topic: "What should Canada do within the next 2 years to foster the development of geothermal energy systems, including electricity generation and direct geothermal use (including industrial, agricultural, commercial and domestic applications)?" A total of $6,000 in cash prizes will be awarded.

For more information on PCGER and for full contest details, including eligibility, rules and regulations, format, evaluation criteria and deadline, visit http://geothermal.mining.ubc.ca.

CGC Congratulates Canada's Research Community on Creation of CanGRC

Written by Denis Tanguay (CEO) and Ted Kantrowitz (VP)
Canadian GeoExchange Coalition

The Canadian GeoExchange Coalition (CGC) – Canada's association for geothermal heating and cooling - has for the last ten years been the collective voice of Canada's geothermal HVAC industry. In our activities CGC has built industry infrastructure (such as the worlds first and most comprehensive quality program, a major standards revision, municipal code documents), developed information (e.g. a residential / commercial building owner buyer's guide, a web site attracting 1m visitors annually and our sector's first-ever in-depth statistical report), and engage constantly in government relations with departments and ministries at all levels. A ten-year report will be issued in early February.

With a long history of incremental innovation, CGC member firms have been on the forefront of geothermal development in Canada and at times globally. At the same time there is a strong research community in Canada which CGC has interacted with over the years. We therefore welcome the foundation of the Canadian Geothermal Research Council, as a complementary research organisation that provides an important value for the geothermal research community in Canada. We are particularly pleased that the national associations representing Canada's geothermal energy industry - CanGEA and CGC - agree with CanGRC on the need for collaboration of all players in the geothermal energy sector, be it on the industry side or within the research community: only a unified voice will allow us to effectively promote geothermal energy in Canada.

In a recently published report by the Geological Survey of Canada, Canada is described to have "enormous geothermal resource potential". Low-temperature resources matter here: according to the report and previous research, enough geothermal energy exists in Canada to power and to heat our current population essentially indefinitely. To help in the development of those resources, CGC affirms CanGEA and CanGRC's position: we all need to work together.

Both the power and HVAC sides of the geothermal equation will require human resources over the coming years and to that end CGC has been involved in the Electricity Sector Council's project Building Bright Green Futures, a multi-year human resources study of all renewable energy industries, which we hope will include industry and academic points of view.

Finally, it was with great pleasure that we recently announced Canada had won, with CGC as host organisation, the 11th International Energy Agency Heat Pump Conference. The premier global event for the geothermal heat pump industry, the conference draws official delegations from 14 countries and visitors from 30. As we have at our national conference, we will look to CanGRC and its members to help us populate the agenda with appropriate research at this prestigious event. The event will take place in 2014 in Montréal.

All of us – power and space conditioning - need the research community involved in the growing geothermal market globally. We therefore congratulate the founders of the Canadian Geothermal Research Council on the establishment of the organisation and wish all the best with its ambitious goals. We will gladly support those efforts wherever possible.

Denis Tanguay (CEO) and Ted Kantrowitz (VP) on behalf of the Canadian GeoExchange Coalition, with thanks to Alexander Richter (Executive Director) and Alison Thompson (Chair) at the Canadian Geothermal Energy Association (CanGEA).

Incorporation of Enhanced Geothermal Systems into Ontario's Feed-In-Tariff Program

Written by Aaron Libbey (LLM, Harvard Law School)
Ryan Libbey (PhD Candiate, Geology, McGill University)

1. Introduction

The Ontario Government designed and implemented its Feed-in-Tariff Program (FIT Program) to promote the development of renewable energy projects in the province. The objectives of the FIT Program, a regulation governed by the Green Energy and Green Economy Act (GEGEA), include "fostering the growth of renewable energy projects, which use cleaner sources of energy, … removing barriers to and promoting opportunities for renewable energy projects and … promoting a green economy."

These are laudable objectives. To fit within the ambit of "promoting a green economy", the technology we advance through the FIT Program must not only satisfy us as environmentally sound and sustainable, but must also be viable in a competitive market. While this is a lot to ask of an energy producing technology, certain geothermal technologies have the potential to surpass this high standard and deserve to be included in the FIT Program. Enhanced Geothermal Systems (EGS) technologies have the potential to be economically viable and environmentally unassailable. EGS operates through a clean energy production method, with negligible carbon emissions, harnessing a renewable resource without significant disruption of the natural environment. Canada's geology fits the criteria to develop EGS partically nationwide. These systems are relatively inexpensive to establish and cheap to operate, compared with nuclear, coal and gas power plants. And, importantly, EGS is the only non-nuclear clean energy source that offers significant baseload generation capabilities.

Yet, strangely, Ontario's FIT Program excludes EGS. This exclusion makes energy generation from EGS artificially more expensive than other clean technologies and is thus a significant deterrent to investors and entrepreneurs otherwise interested in developing technologies to exploit this viable, clean and sustainable energy source in Ontario. This makes bad economic, energy and environmental policy sense. The Ontario Government ought to amend the FIT Program Rules to include EGS in the scheme.

2. What are Enhanced Geothermal Systems?

The term Enhanced Geothermal Systems (EGS) refers to any geothermal operation where accessory fluids are injected into the earth to maintain economic rates of energy production. This term encompasses Hot Fractured Rock (HFR) and Hot Dry Rock (HDR) technologies, where fluids are injected and heated through a permeable heat exchanger (a large volume of rock) and subsequently extracted through a production well for use in a binary power plant. In binary systems, extracted fluids transfer heat energy to secondary volatile working fluids in a closed loop system. The vapourized secondary fluid, which is used to drive a steam turbine, is commonly an organic compound or ammonia-water mixture (Organic Rankine Cycle and Kalina Cycle, respectively) and can effectively generate electricity from waters with temperatures as low as 70°C.

EGS is gaining currency around the world. Projects are underway in the United States, Japan, France, Germany, Switzerland, Australia and the United Kingdom. The magnitude of untapped EGS resources is such that EGS has the potential to be a significant producer of global energy in the near future. By including prospective EGS resources in the global estimate for geothermal power generation capacity, the generation potential jumps from 72 GW to 138 GW (McLarty et al., 2000). EGS technology is particularly relevant as it opens up the possibility of generating geothermal power in areas devoid of volcanic activity, provided a proper heat exchanger is available. And in many cases, suitable resources are situated nearby major urban centres.

In Hot Fractured Rock geothermal systems, the fractured rock mass that fluid is passed through is labeled the heat exchanger. This rock is generally, but not exclusively, a large basement crystalline body (on the order of several square kilometers) thermally blanketed by low conductivity strata and buried to a depth of a few kilometers to take advantage of the natural thermal gradient of the Earth. The basement rock is chosen for its high heat productivity. Therefore, rocks that contain minerals with high abundances of radiogenic elements (such as granite) are desirable.

The true determinant of a successful Hot Fractured Rock geothermal system lies within the nature of the fracture system itself. At the preliminary stages of power plant construction, natural fractures in the basement rock are enhanced via the injection of high-pressure fluids. The progressive opening of fluid flow paths within the rock is mapped by tracing the resulting microseismic events. This information is then used to determine the best location for production (extraction) wells.

3. The Potential for EGS in Ontario

The geology of Southern Ontario and the St. Lawrence Lowlands fulfills the requirements to be considered for the exploration of enhanced geothermal resources. The most attractive areas are areas where deep crystalline basement rocks of the Grenville Province are blanketed by a thick sequence of younger, relatively flat-lying sedimentary rocks. These younger

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sediments serve to insulate the underlying crystalline basement, trapping in heat produced by the natural decay of radioactive elements (namely U, Th and K). These elements, which are characteristically incompatible, are mobilized during metamorphism and transported by fluids to upper crustal areas, regions that have largely been lost to erosion within the Grenville Province. Uranium is mobilized at granulite facies metamorphism; therefore, rocks of the Central Gneiss Belt (CGB, Figure 1) in the Grenville Province characterized by this high metamorphic grade are of low interest for EGS prospecting, as their heat producing elements have likely been leached during past metamorphic episodes. The Central Metasedimentary Belt (CMB, Figure 1) of the Grenville Province is comprised of 1.3-1.2 Ga terranes that were thrust northwest (present-day) over rocks of the CGB, and were subsequently intruded by granitic plutons (Carter et al., 1996). Many of the metavolcanic, metasedimentary and intrusive rocks within the CMB are characterized by lower metamorphic grades (greenshist to ampibolite) than the CGB. For this reason, buried felsic rocks in the CMB are more attractive targets for EGS in Ontario. Fault-controlled deep fluid convection may also augment the geothermal potential of EGS targets.

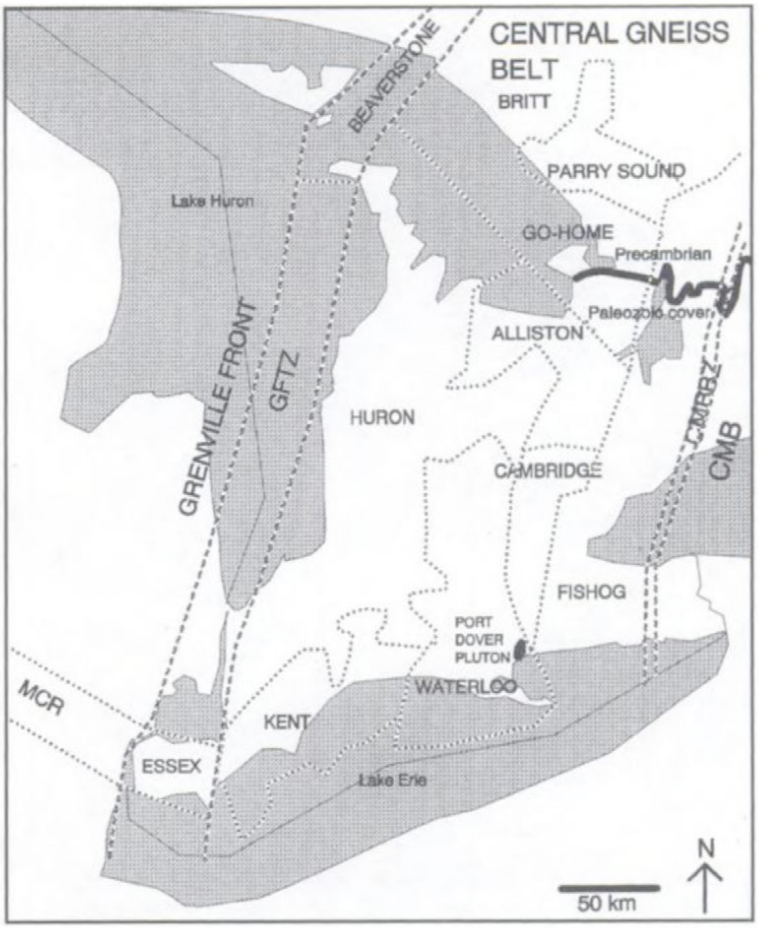

Figure 1. Geology of the Precambrian basement beneath Southern Ontario. Heavy line shows the outcrop boundary of the Grenville rocks. MCR=Mid Continent Rift, CMB=Central Metasedimentary Belt, GFTZ=Grenville Front Tectonic Zone (Carter et al., 1996).

The incorporation of enhanced geothermal projects into the provincial FIT Program would encourage research and development of these resources in Ontario, which could add a new source of reliable renewable energy to Ontario's energy profile. Geothermal has the distinction of being the only renewable energy technology capable of delivering baseload power supply. This characteristic makes geothermal energy an attractive technology for easing Ontario's dependence on controversial nuclear and fossil fuel sources. While a feed-in-tariff is not the only option available to kick-start EGS in Ontario, it is telling that numerous countries are currently using these programs to successfully spur growth in EGS and that the number of such countries is proliferating. France, Germany, Italy, Switzerland, Croatia, Czech Republic, Turkey, Taiwan, Spain, Greece, Slovakia and Slovenia have successfully implemented feed-in-tariff programs to aid in the development of geothermal technologies. It would be a shame for Ontario to pass on the investment, research and job creation opportunities and the economic and environmental benefits that could stem from promoting EGS.

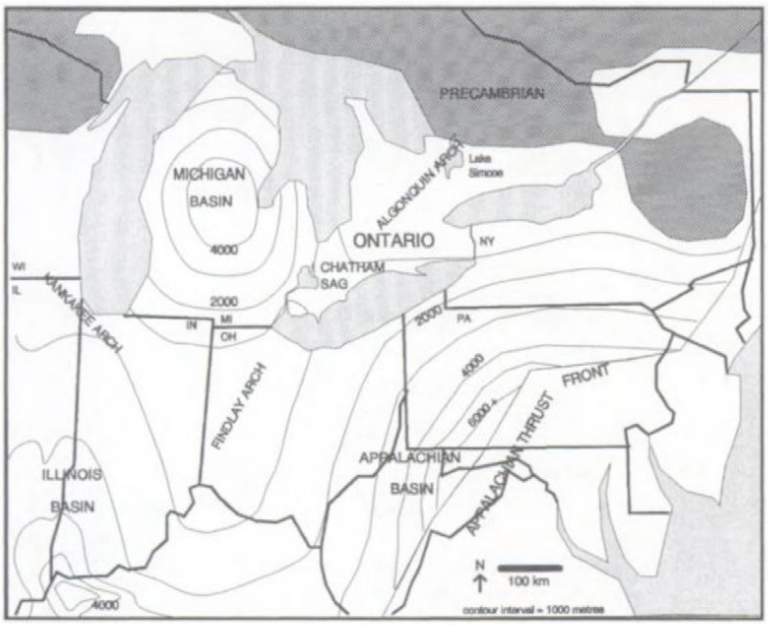

Figure 2. Depth to basement, in meters, showing Findlay Arch and Algonquin Arch. Dark grey area represents exposed Precambrian basement (Carter et al., 1996).

4. Enhanced Geothermal Systems and the FIT Program's Regulatory Context

In spite of the clear potential for a green and economically viable EGS industry in Ontario, the FIT Program, in its current state, excludes geothermal altogether. This is a curious omission. It is an omission that brings the FIT Program Rules out-of-alignment with the GEGEA, and more importantly, that eschews a viable resource that could provide energy security, generate jobs in a green economy, and lower the aggregate economic and environmental costs of energy for Ontarians.

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Ontario's FIT Program is explicitly tailored to favor certain renewable energy generation technologies. Section 2.1, which sets out the program's Basic Eligibility Requirements states that to be eligible to participate in the FIT program, a proposing generating facility must constitute a "Renewable Generating Facility". The FIT Program Rules define "Renewable Generating Facility" as a facility in Ontario that generates electricity in line with the purposes of the FIT Program using a "Renewable Fuel", which is defined as any of "wind, solar (PV), Renewable Biomass, Biogas, landfill gas or waterpower." Geothermal power is conspicuously absent from the text of the FIT Program Rules and the definitions.

Milan Seres (2011) aptly notes that the FIT Program Rules employ a different definition for the type of facility that will be considered a renewable source than the governing legislation, the GEGEA. Whereas the GEGEA employs the defined term "renewable energy generation facility", which is dependent on the definition of "renewable energy source", the FIT Program Rules are centered on the defined term "Renewable Generating Facility", which is dependent on the definition of "Renewable Fuel".

The GEGEA definition of "renewable energy generation facility" has the same meaning as in the Electricity Act, 1998:

> a generation facility that generates electricity from a renewable energy source and that meets such criteria as may be prescribed by regulation and includes associated or ancillary equipment, systems and technologies as may be prescribed by regulation, but does not include an associated waste disposal site, unless the site is prescribed by regulation for the purposes of this definition[.]

The GEGEA defines "renewable energy source" as

> an energy source that is renewed by natural processes and includes wind, water, biomass, biogas, biofuel, solar energy, geothermal energy, tidal forces and such other energy sources as may be prescribed by the regulations, but only if the energy source satisfies such criteria as may be prescribed by the regulations for that energy source[.]

The FIT Program Rules, on the other hand, define "Renewable Generating Facility" as

> an Electricity generating facility located in Ontario that is owned and leased for the Term, as well as operated by the Supplier, which generates Electricity exclusively from one or more Renewable Fuels and delivers that Electricity through a meter in accordance with all Laws and Regulations to the IESO-Controlled Grid, a Distribution System or a Host Facility.

The FIT Program Rules, "Renewable Fuel" definition, as mentioned above, does not include geothermal, in stark contrast to corresponding the GEGEA definition.

This difference in the definition of the applicable renewable sources is significant, as the GEGEA's "renewable energy generation facility" definition does not imply that the regulations it governs may arbitrarily stray from the "renewable energy source" list. While the GEGEA's "renewable energy generation facility" definition includes the language "that meets such criteria as may be prescribed by regulation", this merely qualifies "renewable energy source". This indicates that the GEGEA contemplates the full range of renewable energy sources to qualify as renewable energy generating facilities, subject to exceptions where regulations impose criteria that certain sources do not meet.

It is conceivable that in certain situations, regulations ought necessarily only apply to certain renewable energy sources. However, it would seem strange for the GEGEA to sanction the exclusion of a viable renewable energy source from a regulation that was designed broadly to "encourage and promote greater use of renewable energy sources". The FIT Program Rules' definitional engineering, as Seres states, "is an attempt at creating a distinction without a difference that undermines the objectives of the GEGEA."

We strongly suggest that the Ontario Government rethink the exclusion of geothermal energy, and in particular EGS, from the FIT Program. By taking down the barriers to investment in geothermal and enhanced geothermal systems in Ontario, the Government will spur research, investment and development in the province, create high-paying jobs for a new economy, lower dependence on expensive and dirty fossil fuels in the future, increase Ontario's future ability to generate (and even export) energy, and take a significant step forward in greening Ontario's future.

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Canadian Geothermal Energy Association (CanGEA): Targets for 2012

Written by Alexander Richter (Director, CanGEA)

An eventful year comes to an end. The challenges for the industry continue, but at the same time CanGEA is proud to say that three of its member companies are working on actual geothermal power projects in Canada, with the first one scheduled to go online in 2013.
CanGEA has been quite active this year and worked closely with its member companies to promote geothermal energy in Canada and Canadian business interests abroad. As policy is one of the cornerstones of CanGEA's activities, CanGEA continued its activities reaching out and lobbying on behalf of the industry.

CanGEA got the chance to present geothermal energy and its potential in Canada at the Senate's Standing Committee for Natural Resources and Energy in Ottawa and has been in close connection with several administrative bodies, such as the Privy Council of the Prime Minister, CanMET of Natural Resources Canada and several provincial institutions. We are currently in preparations of work on a Geothermal Technology Roadmap, for which we are now in final discussions regarding funding for at least the start of the work. This is a huge step for the Canadian geothermal energy industry, as it would mean concrete and government funded efforts on pushing geothermal development in Canada, while including industry in efforts for R&D and project deployment. This effort will be driven by CanGEA with the support of industry and government.

For the first time, CanGEA had access to GOA funding through International Trade Canada and has seen not only support through funding, but also through help in international markets through the agency. This is an important gain for CanGEA and our members, as it provides local access in international markets that can help in development and business generation for Canadian companies abroad. We hope to be in a position to gain funding again for 2012/ 2013.

CanGEA organized two events this year: the CanGEA Annual Conference in September in Toronto (as part of the event we also opened the Toronto Stock Exchange), and the annual CanGEA Geothermal Power Forum in Calgary in November. Both events were very successful and provided great networking opportunities for Canadian and international attendees. At the same time it provided a great platform for discussions with government representatives, particularly at our Calgary event. CanGEA also continued to represent the Canadian geothermal energy industry at several events, including the GRC Annual Meeting, the GEA Geothermal Finance Forum, the World Petroleum Conference, several First Nations events, the Global Clean Energy Congress and others.

We are also now initiating our membership renewal campaign for 2012 and urge you to help CanGEA by renewing your membership timely via http://www.cangea.ca/join-cangea/

Furthermore we are very glad to again joined forces with the Canadian Geo-Exchange Coalition in finding the best way of moving our different spectrums of the industry forward to the benefit of development of our industry in Canada and internationally.

Some of the **key tasks** CanGEA targets in 2012:

- Geothermal Technology Roadmap
- Geothermal Mapping
- Policy inroads in the key provinces of geothermal development in Canada
- Continued support through International Trade Canada
- Event representation within the industry and beyond
- Promotion of geothermal energy
- Cooperation with international geothermal energy associations as part of our International Geothermal Business Coalition
- Promotion of the Canadian Geothermal Reporting Code and efforts to promote codification of geothermal resources in tandem with the same efforts of the Australian geothermal energy industry
- General promotion of geothermal energy in Canada