Proceedings World Geothermal Congress 2020+1
Reykjavik, Iceland, April - October 2021

Geothermal Collaboration through the International Energy Agency Geothermal Technical Collaboration Programme

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Keywords: Technical Collaboration Programme, Geothermal TCP, IEA Geothermal, IEA-GIA, collaboration, geothermal energy, direct geothermal use, geothermal energy presentations, geothermal workshops, shallow geothermal, deep geothermal, supercritical geothermal, www.iea-gia.org.

ABSTRACT

The International Energy Agency (IEA) Geothermal Technical Collaboration Programme has thirteen nations, the European Commission, GEOPLAT and Ormat Technologies Inc regularly meeting to share advances occurring in geothermal technology; from shallow low temperature geothermal utilisation to high temperature supercritical geothermal research.

Working Group activity is focused on:

- Environmental Aspects,
- Direct Use of Geothermal Energy,
- Data Collection and Information,
- Deep Roots of Volcanic Geothermal Systems, and
- Emerging Geothermal Technologies.

High quality geothermal data, for electrical and direct use, is collected, collated, and shared through reports available from the IEA Geothermal website.

Seminars and workshops are organised for groups or nations where it is seen to be potential to promote the use and uptake of geothermal energy. Country experiences are shared and collaborative networks established. The presentations from these workshops are made available on the IEA Geothermal website.

There is much to be gained in sharing and working together and the IEA Secretariat has renewed the mandate for the Geothermal Technical Collaboration Programme through until end of February 2023. The paper canvasses the strengths of this geothermal technical collaboration programme, sharing recent highlights and advances.

1. INTRODUCTION

Geothermal energy use is growing around the globe. There is a real focus on using earth energy in direct heat applications with this sector growing at rates in excess of 10% per annum in recent years, whilst geothermal electricity capacity has grown at compound annual rates of about 4% between 2010 and 2018.

Direct geothermal use is booming. Geothermal in agriculture is increasing rapidly, such as in countries like the Netherlands where in the 10 years from 2007 to 2017 geothermal heat use in greenhouses has grown from nothing to 3PJ per annum (IRENA 2019). There is real interest in a number of nations as to how geothermal might assist in world food supply, in seeking to produce more in temperature controlled environments (e.g. greenhouses) as well as to dry and preserve food, seeking to reduce wastage. The UN Food and Agriculture Organisation and Boston Consulting Group reports one third of more than 4.5 billion tonnes of annual global food production is wasted (BCG 2018, FAO 2011).

Geothermal energy use in cities is growing. Smart energy networks are being installed to assist in reducing carbon emissions. Geothermal heat use is fundamental. An example is the vision of Stadtwerke München (SWM) in the proposed transition to 100% renewable district heat energy for Munich by 2040. Deep geothermal energy will be the predominant energy source. Low temperature smart thermal grids are being developed in a number of European cities. One example is in the city of Zurich in Switzerland, where the districts of Familienheim-Genossenschaft have embarked on a project interconnecting facilities, developing underground heat storage fields and using heat pumps to enable lower temperature energy to be used. The Netherlands success in geothermal energy use in horticulture has resulted in a surge of interest in geothermal energy use in the built environment. The city of Hague has at least four geothermal plants planned to heat some of the city, with a vision of 80% of the heat coming from geothermal by 2050.

Rock and groundwater are both natural energy stores that don't require sophisticated devices to recover or store heat. The heat transfer physics is well understood. With sound management, underground heat storage has an almost infinite life, with ground heat storage set to become a significant component of geothermal energy systems worldwide in the low carbon future.

Research and innovation programmes exploring very high temperature and supercritical geothermal conditions underground are seeking to realize the energy potential from these sources which is predicted to be an order of magnitude greater than typical current high temperature geothermal wells produce. Challenges in these aggressive environments include installing well casings and then obtaining a reasonable casing life, given the chemically aggressive and complex nature of the fluid. Two of the IEA Geothermal members; Iceland and Italy are very active in this area of work.

There is significant expenditure proposed as part of upcoming geothermal energy research and innovation. The European Commission Strategic Energy Technology Plan includes eight innovative geothermal technology workstreams, four of which are considered flagship programmes. The four flagship programmes are:

- Geothermal heat in urban areas;
- Enhancement of conventional reservoirs and development of unconventional reservoirs;
- Integration of geothermal heat and power in the energy system and grid flexibility; and
- Zero emissions power plants

Implementation of the geothermal workstreams overall is estimated to require an investment of 936.5 Million Euros up to 2022, coming from the following:

- Industry €456m;
- National Technology Programmes €342m; and
- EU funds €138.5m

It is clear that substantial innovation in geothermal energy technology can be expected within the next five years.

This paper provides a perspective from the International Energy Agency Geothermal Technical Collaboration Programme as to activity occurring globally in the geothermal sector, and activities the group are undertaking to foster the uptake of geothermal energy around the globe.

2. HISTORY

2.1 International Energy Agency

The Technical Collaboration Programmes (TCPs) of the International Energy Agency (IEA) based in Paris, France, are about sharing knowledge and information, accelerating energy technology innovation, assisting nations to meet energy and climate goals, enhancing energy security, and supporting economic growth. The underlying ethos of a TCP is that stakeholders from the public and private sectors share knowledge and work collaboratively to deliver effective outcomes to common energy and climate challenges. These multilateral technology collaborations are established through the IEA Implementing Agreement framework where networks of professionals jointly agree to work together. 2020 marks the 45th anniversary of the establishment of the TCP framework with thirty eight operating TCPs now involving about 6000 experts around the world. A 2015 IEA video introducing TCP's provides insight into the framework, highlighting several TCP's. The breadth of expertise is a significant asset for the global community which can be accessed for relatively modest cost by nations or organisations joining as contracting parties to a specific Implementing Agreement. Much more information is available from the individual TCP web sites accessible through the IEA TCP web pages.

2.2 IEA Geothermal

IEA Geothermal was established in 1997 as a Technical Collaboration Programme of the IEA. At the time of World Geothermal Congress (WGC) 2020 the programme has been operating for 23 years under a formal Implementing Agreement, mandated by IEA Paris for specific time periods (terms). At the end of each term a summary of activity is recorded and participants in IEA Geothermal determine if they are going to conclude activity or apply for renewal to IEA. These end of term reports are available from the IEA Geothermal website. IEA Geothermal is now into its fifth term and Table 1 identifies the term periods which have been mandated by the IEA.

Table 1: IEA Geothermal mandated for 5 terms as at WGC 2020

Term	Start	End	Years
1	7 March 1997	6 March 2002	5
2	6 March 2002	31 March 2007	5.1
3	1 April 2007	28 February 2013	5.9
4	1 March 2013	28 February 2018	5
5	1 March 2018	28 February 2023	5

IEA Geothermal is managed by an Executive Committee (ExCo) comprising members that are participating for their nation, the European Commission, or as a sponsor member representing a national organisation or a company. Participants pay their own expenses associated with participation in ExCo and Working Group activities. The Executive Committee meets twice yearly and seeks to hold workshops and other meetings in conjunction with those meetings.

During the 1st Term the administrative work of the organisation was performed on a voluntary basis by the ExCo Members. As the activities grew the ExCo established a Secretariat to provide administrative support for the group. In March 2003 the IEA Geothermal Secretariat was moved to reside at GNS Science at the Wairakei Research Centre, Wairakei, New Zealand, under a contract with GNS Science. Expenses associated with operating the Secretariat are funded from members contributions. Dr Mike Mongillo was the Executive Secretary from March 2003 through until his resignation in August 2015 when Brian Carey took over the role. The Executive Secretary can be contacted through a link on the IEA geothermal website or through the email address in the title block of this paper.

IEA Geothermal has been an active participant at previous World Geothermal Congresses with papers on the work of the organisation presented in 2005 (Mongillo et al 2005), 2010 (Mongillo et al 2010) and 2015 (Mongillo and Bromley 2015).

2.3 IEA Geothermal Vision

Geothermal energy will contribute significantly to global energy needs as a clean, cost-competitive, renewable energy resource. It can provide baseload electricity, and heat for direct use applications, in a sustainable and environmentally-friendly manner and as an indigenous energy source assists with energy security.

2.4 IEA Geothermal Mission

IEA Geothermal promotes international cooperation in geothermal research and technology. It connects major national and industry programmes in exploration, development and utilization of geothermal resources by establishing links between industries, organisations and geothermal experts in the participating countries. Activities focus on sharing results and information gained from members' government and industry geothermal programmes, producing authoritative information and documenting best practices.

2.5 IEA Geothermal Strategic Plan

As part of preparation for the 5th Term IEA Geothermal developed a concise strategic plan which is shown graphically in Figure 1. The text associated with the plan and those of two earlier term strategic plans are available from the IEA Geothermal web site.

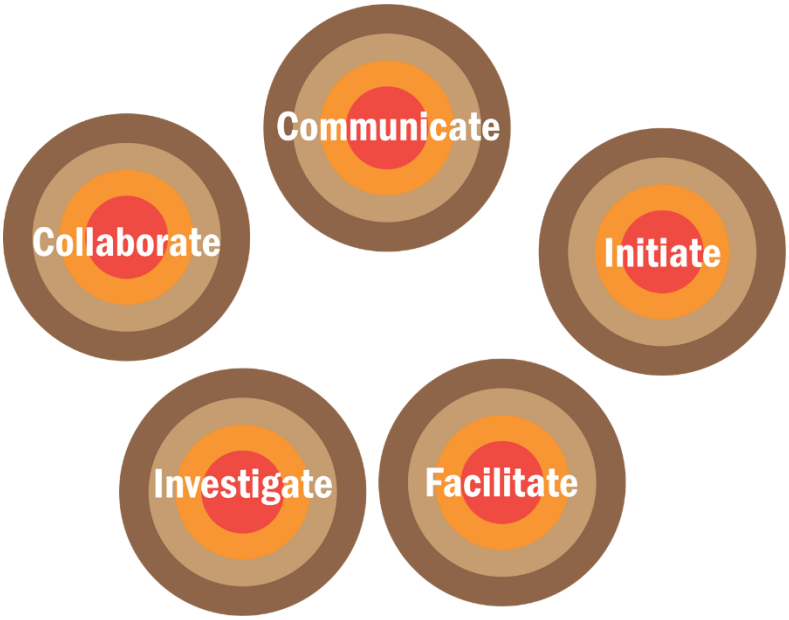

Figure 1: IEA Geothermal Strategic Plan Graphic

2.6 Website

An important part of the IEA Geothermal contribution to the international geothermal sector and the uptake of geothermal energy globally is information available from the IEA Geothermal web site. The website contains information on the activities of IEA Geothermal, provides access to geothermal data, information, publications, IEA Geothermal workshop presentations and details on upcoming workshops.

3. MEMBERSHIP

Membership of IEA Geothermal is as a Contracting Party or as a Sponsor. Contracting Parties include the European Commission, governments, or parties designated by their government. Sponsor members are organisations such as an industry organisation or a national association that choose to belong in their own right, not requiring government designation.

Membership currently stands at 16 participating members as shown in Figure 2. Membership peaked in 2011 to 2013 when a number of sponsor organisations joined IEA Geothermal.

During 2019 a Network Partner arrangement was mandated to give the opportunity for organisations or countries to join in activities for a two year trial period with the view that at the end of that period they would either move to formalise participation in IEA Geothermal or discontinue as a Network Partner.

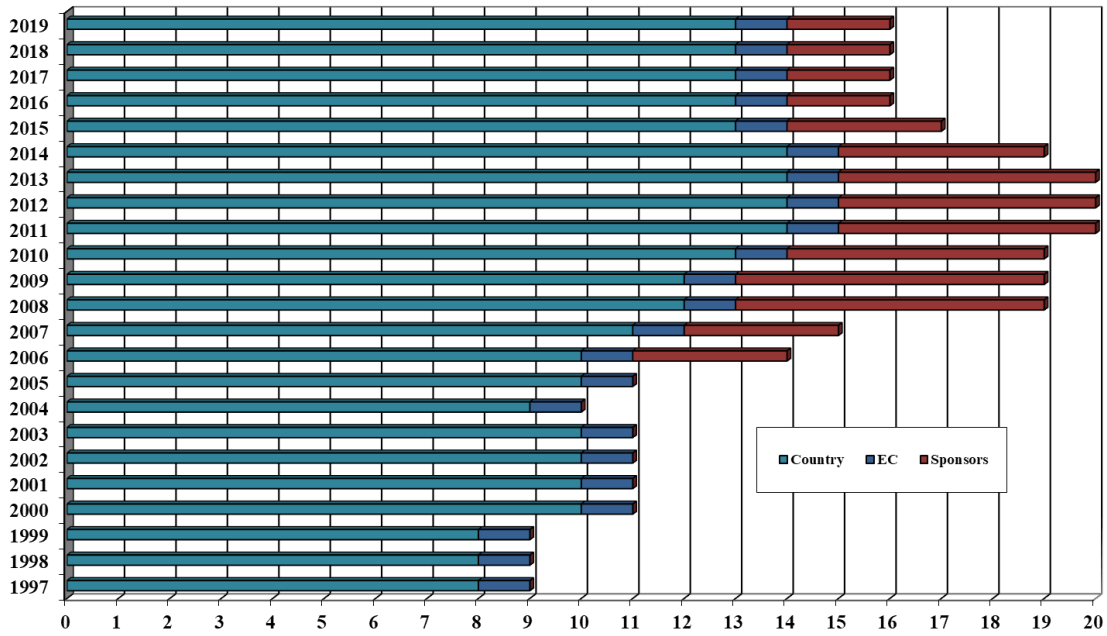

Figure 2: IEA Geothermal Membership since 1997

At the end of 2019 there are 16 members: the European Commission, 13 nations; Australia, France, Germany, Iceland, Italy, Japan, Mexico, New Zealand, Norway, Republic of Korea, Switzerland, the United Kingdom and the United States, and two Sponsors; the Spanish Geothermal Technology Platform (GEOPLAT) and Ormat Technologies Inc. These are shown on a world map in Figure 3.

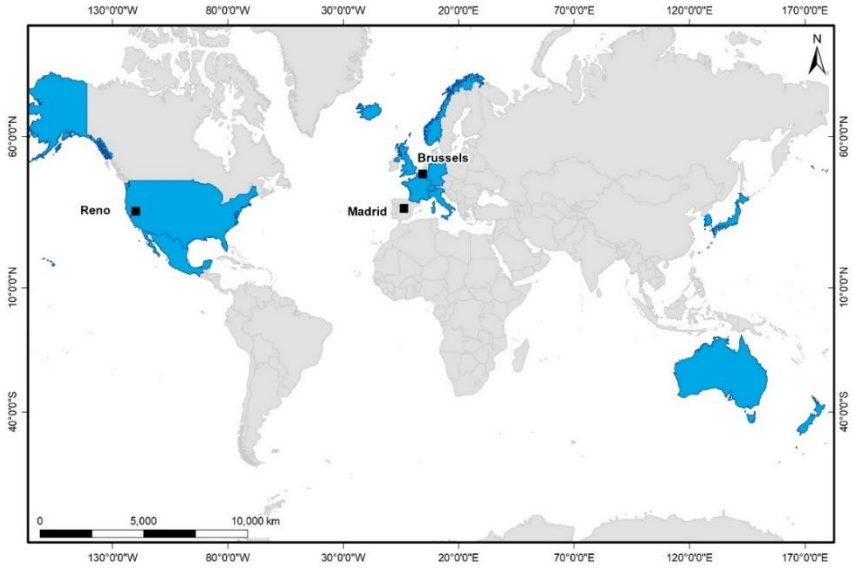

Figure 3 IEA Geothermal participant member countries in blue, Location of the headquarters of the European Commission and Sponsor organisations; GEOPLAT and Ormat Technologies Inc shown as black squares.

3.1 Working Groups

Working Groups (WG) focus on work streams that participants wish to pursue. Participants scope up the activities producing task shared outputs, where participants resource and also provide personnel time to conduct their portion of the work at their own expense. There are five WGs identified below, with each WG having a number of Tasks that they are working on.

- Environmental Aspects (WG1)
- Direct Use of Geothermal Energy (WG8)
- Data Collection and Information (WG10)
- Deep Roots of Volcanic Geothermal Systems (WG12), and
- Emerging Geothermal Technologies (WG13)

Detail on the WG activity, the tasks underway and the outputs produced can be found in the Working Group section of the website.

3.2 Support for nations requesting geothermal advice

The Geothermal TCP provides ad hoc advice and expertise. For instance, in 2016 Mexico requested support from the IEA Secretariat in Paris for Geothermal Expertise to assist in a National Geothermal Energy Road Mapping exercise. IEA Paris requested support from the Geothermal TCP who were able to recommend expertise that provided invaluable input to a workshop held in Mexico City in June 2016.

3.3 Connections

Individual members of the Geothermal TCP are well connected into IEA activities and other international organisations that are working on geothermal energy. The list below illustrates some of those connections. It is structured so the organisation is identified, followed by the IEA Geothermal person(s) involved, followed by the country they represent on IEA Geothermal in brackets.

- IEA Renewable Energy Working Party (REWP) – Gunter Siddiqi (Switzerland) is the Chairperson
- IEA Gas and Oil Technologies TCP (GOT) – Christian Minning (Switzerland) is a member of the Executive Committee.
- IEA Heat Pump Technologies TCP (HPT) – Yoonho Song (South Korea) for IEA Geothermal. WG 8 is connected into the HPT TCP Annex 52 contributing to the work on monitoring of Geothermal (GSHP) Heat Pump Installations – www.heatpumpingtechnologies.org/annex52/.
- IRENA Global Geothermal Alliance – Lothar Wissing (Germany) and Gunter Siddiqi (Switzerland), country members.
- International Geothermal Association (IGA) – Peter Meier (Switzerland) is on the Board of Directors and he chairs the IGA Information Committee.
- European Technology and Innovation Platform on Deep Geothermal (ETIP-DG) – Jiri Muller (Norway) is a steering group member.
- Geothermica is an organization coordinating European Union Geothermal R and D - Manuela Richter (Germany) is a member of the Geothermica coordinating team.
- International Partnership on Geothermal Technologies (IPGT) – Gunter Siddiqi (Switzerland), Lauren Boyd (USA) and Peter Meier (Switzerland) are members of the steering committee.
- European Energy Research Alliance - Joint Program on Geothermal Energy (EERA JPGE Geothermal) - Jiri Muller (Norway) is a participant.
- Geothermics – Chris Bromley (New Zealand) is Co-Editor-in Chief.

The connections and cross over are invaluable in sharing activity occurring in the various groups and how IEA Geothermal might add value to that activity, embellishing achievements.

3.4 Data and Information

Sound and timely statistics are key to inform decisions, policies and expenditure. IEA Geothermal holds a repository for Geothermal Data that is regularly updated with trends analysed and outputs reported through the IEA Geothermal website. Working Group 10 manages this aspect of the IEA Geothermal work and this is reported more fully in Weber and Wissing (2020) in the WGC 2020 proceedings.

3.5 Annual Reports and Other Publications

Participating countries and IEA Geothermal produce Annual Reports which cover activity that has occurred on a calendar year basis. These publicly available reports can be downloaded from the Annual Report page or the individual Member pages of the IEA Geothermal web site. The most recent Annual Report covers the 2019 calendar year.

There are extensive reference listings in the Working Group chapters of the Annual Reports which provide ready access to scientific and technical material.

Special publications since WGC 2015 include a WG1 sponsored Virtual Special Issue of Geothermics titled ‘Environmental Aspects and Social Acceptability’ (for more detail see Bromley et al , 2020, a WG1 paper in the WGC 2020 proceedings).

4. COLLABORATION

Collaboration as part of IEA Geothermal provides members with important benefits and produces opportunities for members to contribute to the international geothermal community. Strength derives from pursuing international cooperation, connecting and sharing geothermal technology and research activity through national and industry groups, and the networks established and maintained by the geothermal experts in IEA Geothermal or attendees at IEA Geothermal events. IEA Geothermal is active in partnering with a range of organisations in running workshops, with 15 being run since WGC 2015 (Table 2). These are collaborative events that IEA Geothermal organises with other groups. Seventeen organisations have been part of the collaborations for the 15 workshops.

5. WORKSHOPS

Workshops are a feature of the work undertaken by IEA Geothermal and the fifteen workshops tabulated in Table 2 have been run by IEA Geothermal since the last WGC in April 2015 in conjunction with other collaborators. These workshops are run free of charge to participants. Presentations from the workshops can be downloaded from the IEA Geothermal website using the link to the Workshop Presentations web page.

Table 2: Geothermal Workshops organized by IEA Geothermal since WGC 2015, April 2015

Date	Workshop	Collaborators	Location
April 2020	Mine Water Energy Workshop	BGS	Edinburgh, Scotland
February 2020	Geothermal Symposium	GeoTHERM Expo and Congress	Offenburg, Germany
November 2019	Central American Workshop	GIZ / ICE	San Jose, Costa Rica
April 2019	International Workshop on Geothermal Energy	GEOPLAT / ITC	Gran Canaria, Spain
February 2019	Baltic Sea Nations Geothermal Symposium	GeoTHERM Expo and Congress	Offenburg, Germany
November 2018	Geothermal Direct Use for a Green Economy	KIGAM / AIST	Daejeon, South Korea
May 2018	Development of Geothermal Applications	Wien Energie	Vienna, Austria
February 2018	Asia Geothermal Symposium	IGA / GeoTHERM Expo and Congress	Offenburg, Germany
November 2017	Geothermal Energy Development for a Green Economy	VIGMR	Hanoi, Vietnam
May 2017	Common Statistics Workshop	IGA	Florence, Italy
February 2017	Latin America Geothermal Symposium	IGA / GeoTHERM Expo and Congress	Offenburg, Germany
November 2016	Direct Use Workshop	IGA / KIGAM / AIST / DGR / CCOP	Chiang Mai, Thailand
September 2016	Munich Molasse Workshop	SWM / BMWi	Munich, Germany
April 2016	Central and South American Workshop on Geothermal Energy	IIE	Cuernavaca, Mexico
October 2015	New Concepts – New and Innovative Applications of Geothermal Energy	Geothermal ERA-NET	Geneva, Switzerland

The location of the workshops around the globe are plotted as black squares in Figure 4. The red squares are locations were conference booths or other events have been organised.

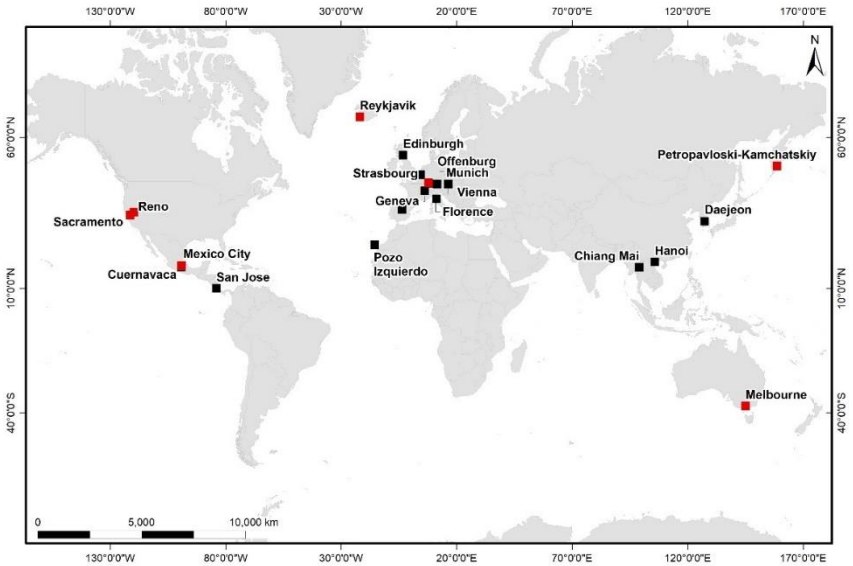

Figure 4: IEA Geothermal Workshops – Black squares and IEA Geothermal Booths or Events – Red Squares

The 17 Collaborators with whom IEA Geothermal have worked to deliver the workshops around the world are tabulated in Table 3:

Table 3: Workshop Collaborators

Short Title	Organisation	City / Country
AIST	National Institute of Advanced Industrial Science and Technology	Japan
BGS	British Geological Survey	United Kingdom
BMWi	Federal Ministry for Economic Affairs and Energy	Germany
CCOP	Coordinating Committee for Geoscience Programmes in East and Southeast Asia	Thailand
DGR	Department of Groundwater Resources	Thailand
GEOPLAT	Spanish Geothermal Technology Platform	Spain
Geothermal ERA-NET	European Union Funded Project 2012 to 2016	Iceland
GeoTHERM Expo and Congress	Offenburg Professional Conference Organisers	Offenburg, Germany
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH	Germany
ICE	Instituto Costarricense de Electricidad	Costa Rica
IGA	International Geothermal Association	Germany
IIE	Instituto de Investigaciones Electricas	Mexico
ITC	Instituto Tecnológico De Canarias	Spain
KIGAM	Korea Institute of Geoscience and Mineral Resources	South Korea
SWM	Stadtwerke München	Munich, Germany
VIGMR	Vietnam Institute of Geosciences and Mineral Resources	Vietnam
Wien Energie	Wien Energie GmbH	Vienna, Austria

5.1 Booths and Networking Events

Locations shown as red squares in Figure 4 are where IEA Geothermal has run booths, networking events or spoken in an invited capacity since WGC 2015. These include activity detailed in Table 4.

Table 4: Details of IEA Geothermal Booths, Networking events and support to other organisations

Date	Activity	Event	Location
April 2020	Booth	WGC 2020	Reykjavík, Iceland
September 2018	Key note	GeoHeat 2018	Petropavlovsk-Kamchatsky, Russia
October 2016	Booth	European Geothermal Congress	Strasbourg, France
October 2016	Direct Use Networking Event	GRC 2016	Sacramento, USA
June 2016	Expert Support	IMP Geothermal Roadmap Workshop	Mexico City, Mexico
September 2015	B2B Networking Event	GRC 2015	Reno, USA
April 2015	Booth	WGC 2015	Melbourne, Australia

5.2 IEA Geothermal Contribution to WGC 2020, Reykjavik, Iceland

IEA Geothermal has an exhibition Booth (#39) at WGC 2020, in the Harpa Exhibition Centre, where conference participants can engage with members of the group. A web page (www.iea-gia.org/event) has been set up to allow access to information about IEA Geothermal conference activities at WGC 2020 and there are members and experts available to talk about geothermal energy – identifiable through the IEA Geothermal logo (Figure 5).



Figure 5 : IEA Geothermal logo

Eleven papers prepared by IEA Geothermal Working Group members, in conjunction with other geothermal experts, have been prepared for presentation at WGC 2020. Table 5 provides information on the topics the papers cover, the WGC 2020 conference stream and a hyperlink to the paper reference.

Table 5: IEA Geothermal Papers presented at WGC 2020

Topic	WGC Conference Stream	Prepared	Paper Reference
Overview of IEA Geothermal	International Collaborations	Executive Secretary	Carey and Wissing
Permitting and resource monitoring	Policy, Legal and Regulatory Aspects	Working Group 1	Ketilsson et al
Environmental, social and mitigation best-practice	Environmental Aspects	Working Group 1	Bromley et al
Costs of geothermal heat pump	Geothermal heat pumps	Working Group 8	Link and García-Gutiérrez
Overview of IEA Geothermal direct use activities	Other	Working Group 8	Link and Carey
Geothermal heat pump data and statistics	Geothermal heat pumps	Working Group 8	Song et al
Energy in mine waters	Resource assessment	Working Group 8	Farr and Busby
Geothermal data, statistics and trends	Other	Working Group 10	Weber and Wissing
Supercritical	Advanced Technology	Working Group 12	Bromley et al
Geothermal play type classification	Resource Assessment	Working Group 13	Moeck et al
Induced seismicity	Geophysics	Working Group 13	Bromley et al

5.3 Upcoming Events

Upcoming is an IEA Geothermal North American Geothermal Workshop which is being held in conjunction with the 44th ExCo meeting in Canada in the 4th quarter of 2020.

6. CONCLUSION

Since the 2015 WGC IEA Geothermal has been very active around the globe fostering the uptake of geothermal energy using the organisation's powerful collaborative networks. Joining IEA Geothermal enables participants to share information for mutual benefit and to discuss geothermal energy opportunities with others around the globe.

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