

IGA ACTIVITIES

Message from the Executive Director

Greetings to all members of IGA and those that are reading this newsletter, we wish you all a healthy, happy and prosperous 2018.

It is my pleasure to start the new year in full speed regarding transitioning the IGA into an independent, financially stable organisation that unites the geothermal voice, connects the geothermal community and provides an excellent platform for all our affiliates, members and corporate entities to network, share best practices and to influence the Geothermal Agenda for the coming decade.

I am grateful for the trust given to me to execute the strategy the Board has successfully put together early in 2017. We are well underway regarding some strategic themes such as our Visibility and our Authority. In 2018 we will focus on our membership model and of course on our Financial Independence. Some big topics were discussed at Board meeting #67 in Santiago, Chile, amongst others the continuation of the IGA Academy and strategic initiatives regarding shaping our value proposition to future corporate sponsors. Great news to share with you is that we are progressing with the organisation of the next World Geothermal Congress which will be held in 2020 in Reykjavik, Iceland.

This month I will be focusing on our workprogramme for the coming year in line with the approved budget. The next Board meeting will be in Iceland, in April 2018, adjacent to the Iceland Geothermal Congress of 24-26 April.

I am very proud to have our President Alexander Richter speak at the IRENA National Assembly event in Abu Dhabi on 13-14 January (*see* photo in the next page), in which we were given the opportunity to engage with the public on Accelerating Geothermal Development. IRENA's Global Geothermal Alliance offers a great platform for the IGA to grow our network and be a visible partner to policy makers and influence the political agenda for the coming decade.

At the IGA Secretariat we have a fantastic team in place and I want to thank Karolina Andersson, Gregor Rumberg, Margaret Krieger and Julieta Schroer for all their hard work, commitment and enthusiasm for

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making the IGA a smooth, agile organisation ready to adopt new technology and features to serve all our members to the best of our ability.

Again, Happy New Year to all, I look forward to this exciting year.

Kind regards,

Dr. Marit Brommer, Executive Director, IGA –
marit.brommer@hs-bochum.de

67th BoD Meeting in Santiago, Chile

Peter Meier, Chair of the Information Committee, GeoEnergie Suisse

The 67th Meeting of the IGA Board of Directors (BoD) was held in the Centro de Excelencia en Geotermia de Los Andes (CEGA), located in the Geology Department of the University of Chile, in Santiago, on November 27 and 28, 2017. The 28th Annual General Meeting (AGM) of IGA took place on Tuesday morning, February 28, 2017.

IGA president Alexander Richter welcomed the IGA Board of Directors and called the 67th Board Meeting to order at 9:00 am. The participants introduced themselves, including the following Board members: Albert Genter, Alexander Richter, Bjarni Bjarnason, Bruno Della Vedova, Colin Harvey, Diego Morata, Gábor Szita, Jane Brotheridge, Kristín Vala Matthíasdóttir, Ludvik S. Georgsson, Paul Brophy, Paul Moya, Peter Meier, Peter Omenda, Rolf Bracke, Shigeto

Yamada, Surya Darma, Toshihiro Uchida and Massimo Verdoya. Additional participant was Marit Brommer, Executive Director.

The agenda included the following points: 1. Call to order, 2. Approval of the Minutes of the IGA Board Meeting No. 66, 3. Approval of the Agenda, 4. IGA Service Company: review and outlook, 5. IGA Strategy Update with the pillars: Visibility (launch visual identity), Membership, Authority, Independence, 6. New Zealand and Germany legal review, 7. Bylaws, 8. Business model and value proposition, 9. Governance, 10. Structure and Set-up of IGA, 11. Board composition & board term, 12. Engagement – councils and observers, 13. Sustainability, 14. Income, funding, project-based value creation, 15. Sponsorship/membership/WGC frequency and set-up, 16. Business Model review & outlook, 17. Annual General Meeting, 18. BoD reports of President, Vice President, Secretary, Treasurer, Exec Dir, Committee chairs of finance, Programme and Planning, Bylaws, Information, Education, Nomination, Membership, Resources and Reserves, Audit, Chairs of Branches, 19. Approval Budget 2018, 20. IGA & IGA Service Company: Conflicts of Interest/Code of Conduct, 21. Presentation/proposed date and place for next BoD Meeting, 22. Adjournment.

The main aspects and agreements of the meeting follow.

- Colombia has been approved as a new affiliate to the IGA, as well as a budget for the short course in Colombia.
- The shut-down of the European Branch has been decided because of the coexistence of several partly



Alex Richter, President of IGA, addresses at the IRENA's Assembly in Abu Dhabi.

overlapping organizations in Europe.

- The president of IGA to sign off the Agreement to Host regarding the WGC 2020 in Iceland.

- The new design of IGA logo and website will be launched in 2018.

- Resources and Reserves Committee: The Board approved a budget of US\$ 25,000 for the work of the four subgroups, especially to co-fund and leverage activities with ESMAP (World Bank) and IRENA for applying UNFC resource qualification and classification to up to three example countries.

- The Education committee to evaluate if the IGA Academy shall continue.

The next BoD Meeting will take place in Iceland, adjacent to the Iceland Geothermal Conference (ICG) and will be 27–29 April 2018. President Alexander Richter thanked the BoD and closed the 67th meeting on November 28 at 3:00 pm.

Most of the board members joined the field trip on November 29 to Chile's and South America's first geothermal power plant. The 48 MW Cerro Pabellón geothermal plant is located at an altitude of 4,500 m in the Atacama Desert in the North of Chile. This field trip was made possible by Enel Green Power and ENAP (Empresa Nacional de Petróleo), who developed the project together. We would like to extend our gratitude to IGA Board Member Diego Morata of the University of Chile and Guido Capetti of Enel Green Power and former IGA President for hosting us during

these days. A special contribution about the outstanding Cerro Pabellón project is under preparation for the next IGA News edition.

IGA Open Letter to Bill Gates

Dear Mr. Gates:

We wanted to thank you for your blog post of December 12 on the *4 Signs of Progress on Climate Change* and your commitment on finding solutions to Climate Change. We read this piece with great interest, specifically on your commitment towards “especially promising but also underfunded” areas in clean energy investments, including Geothermal Power.

We are extremely pleased to see this commitment towards Geothermal Energy and agree with your statement that it is “a phenomenal amount of energy stored up as heat under the Earth's surface”. We are the International Geothermal Association, and the undersigned 31 people are together forming its Board of Directors. We represent countries, companies, research institutes, and universities. All with a passion for geothermal energy and a dedication to see the Geothermal Industry thrive.

We love the efforts and the goal of Breakthrough Energy Ventures and the initial investment areas of focus. We share your view that heat stored near-surface in volcanic islands are the quick wins. We also take note that mature techniques, notably from the Petroleum Industry, help to unlock geothermal resources deeper in the subsurface.

This is exactly why we are engaged and committed to bring geothermal further: the quick wins are done. We need to push harder, collaborate together, and work effectively towards connecting those unexploited geographic areas to their phenomenal energy source beneath their feet. We are keen to work with you and your Breakthrough Energy Ventures to make this happen.

We have the following Vision:

- o We want to help the world economies to let go of the fossil-fuel addiction and let geothermal energy play its



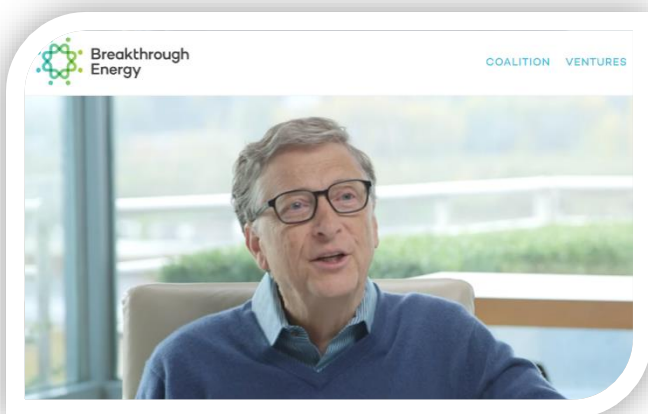
Participants in the IGA BoD meeting in Santiago (Photo by Marit Brommer).

part in replacing fossil-based heat and power generation.

- We want to turn geothermal prospects into bankable projects by creating an attractive investors environment.
- We support policy development, based on the value provided by geothermal and promote good governance of geothermal operations worldwide.

The unique opportunities presented by geothermal through:

- Local economic development: geothermal as local source of power through distributed development and decentralized economic development in rural areas.
- Replacing coal through deep geothermal applications.
- Cleaning up the air: replacing fossil fuels in the heating sector, improving air-quality, health and well-being (see China).
- Access to water and food: Geothermal provides access to water and heating for greenhouses, as well as cooling.



No other renewable energy and fossil-fuel based technology can compete on the unique and various attributes and opportunities offered by geothermal. We all know the transformative impact geothermal energy can have on communities and the planet and want to share that with others.

We kindly ask for the chance to meet you or the team of Breakthrough Energy Ventures to discuss ways to identify catalysts that can help push for increased geothermal development around the world. Only when we are collaborating and bundling efforts on pushing geothermal development worldwide, will geothermal energy be able to live up to its great potential in the important energy transition.

You can find the International Geothermal Association via its website at www.lovegeothermal.org.

Dr. Marit Brommer, Executive Director, IGA

The Board of Directors of the IGA:

Bjarni Bjarnason, Reykjavik Energy, Iceland

Andrea Blair, Women in Geothermal, New Zealand

Rolf Bracke, Bochum University of Applied Science, Germany

Paul Brophy, EGS, Inc., U.S.

Jane Brotheridge, Jacobs Engineering, New Zealand

Louis Capuano, Capuano Engineering, U.S.

Surya Darma, Indonesia

Bruno della Vedova, Fondazione Internazionale Trieste, Italy

Ariel D. Fronda, Department of Energy, Philippines

Albert Genter, Électricité de Strasbourg, Strasbourg, France

Ludvik Georgsson, UNU – Geothermal Training Program, Reykjavik, Iceland

Colin Harvey, Harvey Consultants, New Zealand

Georgina Izquierdo, Instituto de Investigaciones Eléctricas, Mexico

Beata Kepinska, Academy of Science, Poland

Kristin Vala Matthíasdóttir, HS Orka, Iceland

Peter Meier, GeoEnergie Suisse, Switzerland

Diego Morata, University of Chile, Chile

Paul Moya, West-Jec, Costa Rica

Juliette Newson, Iceland School of Energy, Iceland

Peter Omenda, Consultant, Kenya

Abadi Poernomo, Indonesia Geothermal Association, Indonesia

Alexander Richter, ThinkGeoEnergy, Iceland

Horst Rüter, HarbourDom, Germany

Andrew Sabin, Geothermal Program Office, U.S.

Ka Noel Salonga, EDC, Philippines

Gabor Szita, Porcio Ltd./Hungarian Geothermal Association, Hungary

Valentina Svalova, Institute of Environmental Geoscience RAS, Russia

Toshi Uchirida, AIST, Japan

Massimo Verdoya, University of Genova, Italy

Shigeto Yamada, Fuji Electric, Japan

Sadiq Zarrouk, University of Auckland, New Zealand

The U.S.' Geothermal Resources Council and Geothermal Energy Association to Be Merged

The Geothermal Resources Council (GRC) is the national affiliated association to the IGA in the U.S. It is also the largest of the IGA's national associations. Now, the GRC's membership has voted to join the GEA into one alone organization that will keep the GRC name in the meanwhile. Here is the official announcement from the GRC.

The Geothermal Resources Council (GRC) and the Geothermal Energy Association (GEA) are excited to announce their unification. Combining the GRC and GEA strengthens the voice of our industry with a single organization devoted to advancing the science, education, and development of renewable geothermal energy resources.

Members of both organizations voted on the decision to unify and the results were overwhelmingly in favor. They will benefit from an increased value for their dues and improved networking relationships as the geothermal community moves forward together.

The activities of the GEA will be transitioned into the GRC in early 2018. One of the key activities is already underway through the establishment of a special committee, the GRC Policy Committee. This committee will focus on educating and lobbying leaders at state and federal levels to expand their knowledge about the geothermal industry. The committee will also assist the geothermal community in its awareness of opportunities to expand renewable energy projects, building a stronger platform for the entire U.S. energy grid. All members are encouraged to join in this new effort.

"Together, the now unified GRC and GEA can advance the geothermal community in more ways to connect with the larger energy industry and create a clean environment for future generations to enjoy," stated Maria Richards, President of the GRC Board of Directors.

Doug Glaspey, President of the Board of Directors for the GEA said, "The members of GEA look forward to working within a single organization to advocate for and advance sound geothermal law and policy that will expand our industry. The unification of our two organizations will allow us to pursue this mission in the most efficient manner possible."

The GRC will continue as a non-profit, 501(c)3 corporation serving as the professional educational association for the international geothermal community, as a focal point for continuing professional development through outreach, information transfer and education services.

The GRC's Policy Committee will file an annual 501 (h) election, which allows them to conduct legislative and regulatory advocacy. An additional membership fee to join the Policy Committee will raise the funds for their activities. This provides the GRC with a mechanism to keep their primary members' dues and funding completely separate.

The headquarters for the unified organization will be in Davis, California and operate under the name "Geothermal Resources Council" until further discussion of a possible name change is completed.

Source:

https://geothermal.org/PDFs/News_Releases/2018/January_8-GRC_and_GEA_Announce_Unification.pdf

Thanks to Susan

Luis C.A. Gutiérrez-Negrín, Editor



During the last 16 issues Susan Fox Hodgson has been the patient and constant proofreader of our newsletter (IGA News). That meant four years of short but intense periods of work, almost always against a close deadline, battling to transform our more or less rough and quite often technical jargon, in a more comprehensible, clear and even refined

English text.

Retired years ago from the California Department of Conservation, Division of Oil, Gas and Geothermal Resources (DOGGR), Susan is a passionate geothermal historian who for quite some time contributes technical articles and news to the bimonthly Geothermal Resources Council (GRC) Bulletin. She also has published several books. Perhaps the best known is *Stories from a Heated Earth: Our Geothermal Heritage*, co-edited by Raffaele Cataldi and John W. Lund, and published by GRC and IGA in 1999.

Recently, Susan has asked us to end her IGA News proofreading effort, which we will miss enormously, in order to spend more time on other projects, though she promised to continue collaborating with eventual notes and watercolors; Susan is also a talented painter, as you can attest on page 29 of the IGA News Special Number (Sept. 2016), and on page 9 IGA News No. 106. As the

editor of the newsletter, I would like to express my personal gratitude to Susan, but also the acknowledgement of the Information Committee, of which Susan is a member.

AFRICA

Djibouti: Geothermal Activities Being Reassumed

The Djibouti Geothermal Energy Development Authority (Oddeg) was founded to push geothermal development. The organization is led by Dr. Kayad Moussa Ahmed, Director General of Oddeg. The goal of the entity is to “Provide the first megawatt to the grid in 2020,” he says.

Located on the northern tip of the African Rift, Djibouti would produce “5,000 MW on the twenty sites now listed in the territory,” says the specialist, who recalls that “the current national energy capacity is 120 MW”.

A long time has passed between the first attempts of the Bureau of Geological and Mining Research (BRGM), carried out in 1972, and the promises of the Assal-Fiale project today. French, Italian, American, Icelandic, Turkish and Japanese alongside the Djiboutians have been on multiple trips back and forth between the two salt lakes of the country, Assal and Abbot, before settling not far from the Goubet at Assal-Fiale.

In 1999 Ismail Omar Guelleh arrived to the power and in 2007 he created a team of specialists that met six years later at Oddeg.

While the French drilled up to a depth of 1,000 meters at Lake Assal, local engineers merely drilled between 300 and 600 m and fell on an intermediate geothermal reservoir, with temperature of 140°C, “which gives hope for finding an exploitable resource,” explains Moussa Ahmed. The project has just received US\$ 27 million from the Kuwait Fund for Development (FKD) and expects an identical amount from the Arab Fund for Economic and Social Development (Fades) to start drilling production and build a 15 MW geothermal plant by 2021.

For the new drilling campaign, Oddeg will be able to count on a new 125 ton drilling rig, delivered by Turkey. The company will launch an eight-hole drill program that together could produce between 10 and 15 MW. “With a potential of 100 MW, to be confirmed,” says its director general.

This is not the only project ongoing in Djibouti. The most advanced today is that of Assal-Fiale, initially started in 2007 with Icelandic participation. The project continued in 2012, with financial support from donors, American expertise and Icelandic material. The start of production is expected for 2018, on an identified reservoir of 50 to 100 MW.

A third drilling program is also scheduled to start at the Hanle-Garabayis site, near Lake Abbot in 2019, this time with the help of Japan, which pays for 80% of the costs. A prospecting program launched on Emirati funds is finally start in the Arta region.

Source: <http://www.thinkgeoenergy.com/geothermal-development-in-djibouti-full-steam-ahead/>

Ethiopia: EEP Signs Contract Agreements on Corbetti and Tulu Moye Projects

On December 2017, Corbetti Geothermal plc, the Government of the Federal Democratic Republic of Ethiopia and Ethiopian Electric Power (EEP) signed an implementation agreement (IA) and a power purchase agreement (PPA) for the construction of geothermal power plants in Corbetti and Tulu Moye localities, in the Oromia Regional State.

The contract agreement with Corbetti Geothermal is aimed to develop up to 500 MW in Corbetti locality, East Arsi zone, near Shashemene town. The total cost of the project is estimated at two billion dollars. The project implementation agreement was supposed to be signed in August 2016 but delayed due to various reasons.

Reykjavik Geothermal (RG), an Icelandic company specialized in geothermal energy development projects, signed a framework agreement with the then Ethiopian



Electric Power Corporation in October 2013 that enables it to develop 1000 MW of electricity from geothermal energy sources in Corbetti, Tulu Moye and Abaya localities in East Arsi Zone. Reykjavik Geothermal with its local partner Rift Valley Geothermal established Corbetti Geothermal Plc and brought along two major investors – Berkley Energy and Iceland Drilling—who have shown a keen interest to invest on the geothermal development project.

RG split the 1000 MW geothermal development project into two phases – the 500MW Corbetti project and the 500MW Tulu Moye and Abaya project – each costing two billion dollars. Corbetti Geothermal Plc, a special purpose vehicle company established by RG in Ethiopia, has been working on the Corbetti geothermal development project located 270 km southeast of Addis Ababa in East Arsi Zone. RG owns a 28.5 percent stake on Corbetti Geothermal Plc, Berkley Energy 53.5 percent and Iceland Drilling 18 percent. Corbetti Geothermal secured funding from major international financiers, including African Development Bank and European Investment Bank. Many other public and private investors from the US, the UK and other European countries are behind the Corbetti geothermal project. The project is also backed by the US Power Africa Initiative.

After a long negotiation Corbetti Geothermal and the EEP signed a conditional power purchasing agreement in July 2015 during former U.S. president Barack Obama visit to Addis Ababa. The company agreed to build the geothermal power plant and sell electric power for US\$ 7.53 cents per KWh for the national grid.

EEP also signed the second agreement for Tulu Moye geothermal power plant project with RG. Once ratified by parliament, the agreements will enable Corbetti to commence drilling the first production wells in 2018. It also lays the foundations for subsequent geothermal projects.

Sources:

<http://www.thereporterethiopia.com/article/power-co-sign-agreements-corbetti-tulu-moye-geothermal-projects>, <http://www.rg.is/en/frettir/the-government-of-ethiopia-and-ethiopian-electric-power-sign-key-agreements-with-corbetti-geothermal-plc>

Kenya: Geothermal-Electric Generation, New Project, KenGen Diversification

Geothermal Energy Provides 50% of Electricity Generation - During the third quarter of 2017, geothermal production increased its share in the energy mix in Kenya to about 50 percent, while hydro stands at 39 percent from a low of 21 percent. Thermal energy has declined to 15 from 32 percent during the first six

UPCOMING EVENTS

43rd Annual Stanford Geothermal Workshop

12-14 February 2018, Stanford, CA, U.S.

GeoTHERM – Expo & Congress

1-2 March 2018, Offenburg, Germany

3rd International Geothermal Congress & Exhibition

14-15 March 2018, Ankara, Turkey

25th Annual Congress of the Mexican Geothermal Association

18-20 April 2018, Morelia, Mich., Mexico

Iceland Geothermal Conference 2018

24-26 April 2018, Reykjavik, Iceland

Grand Renewable Energy 2018

17-22 June 2018, Yokoyama, Japan

GEOHEAT International Geothermal Conference

4-7 September 2018, Petropavlovsk-Kamchatsky, Russian Federation

GRC Annual Meeting & Expo

14-17 October 2018, Reno, Nevada, U.S.

Seventh African Rift Geothermal Conference (ARGeo-C7)

29 October – 4 November 2018, Kigali, Rwanda

Note: Please check the [IGA website](http://www.iga-world.org) for more events.

months of the year. Wind power, on the other hand, contributes only 0.4 percent, according to the Energy ministry.

The geothermal surge happened as the country stepped down production from thermal sources, which had risen in the past months due to erratic rainfall. The dry spell had forced the country to cut down power production from hydro sources to a low of 180 million KWh per month and compensate the drop with thermal power, whose generation had peaked at 274.3 million KWh.

The situation led to rise in power tariffs in the East African nation especially in the first half of 2017, with families that consumed 200 kWh in August paying up to US\$39 while those that consumed 50 kWh paid US\$6.4.

Geothermal power production has been on the rise since June, according to the Kenya National Bureau of

Statistics (KNBS) data. Geothermal power plants produced 415 GWh in August, the highest ever, in a sustained rise from 401 GWh in July and 376 million GWh in June. Similarly, hydropower generation was on the increase in the period surging to 251 GWh in August, from 193 million GWh in July and 180 GWh in June.

With the rise in production of both hydro and geothermal power, the bad times for consumers seem to be coming to an end as tariffs start to fall. In September, houses that consumed 200 KWh paid US\$36 down from US\$39 dollars in the previous month, according to the KNBS. On the other hand, those that used 50 KWh paid US\$5.8 dollars down from US\$6.4 in August.

The fall in power tariffs contributed to the overall decline in the inflation during the month. “The housing, water, electricity, gas and other fuels’ index decreased by 0.16 per cent. This was mainly due to notable decrease in the cost of electricity which outweighed observed marginal increases in the cost of house rents and cooking fuels,” noted KNBS.

Another consequence of the increase in geothermal generation, is that the region’s biggest economy has not experienced any blackouts or power shortages for over a year.

Source: <https://www.newsghana.com.gh/power-tariffs-fall-in-kenya-as-geothermal-production-peaks/>

New Project to Start in Turkana - Olsuswa Energy has received a grant totaling US\$980,000 from the African Union Commission (AUC), towards the development of its Turkana geothermal power plant. Manga Mugwe, the Olsuswa Energy director and the chairman of Mayfox Mining—currently prospecting for gold and other precious metals in Turkana—, said the funds will go towards co-funding the development of the 140MW geothermal project.

Olsuswa Energy is seeking to construct a power plant over five to eight years for transmission into the national grid. The total cost of the project stands at US\$420 million. AUC, through its Department of Infrastructure and Energy, and Olsuswa Energy signed the grant contract for financial support in early November 2017. The company had earlier said the first phase of 70MW would start operating in 2022.

The funds will be used to conduct a surface study and infrastructure upgrade program at the Barrier volcanic complex located in Turkana County. The geothermal field is one of the prospects in the Rift Valley and is situated south of the lake. The area covers 136 square kilometers.

The project’s capital is expected to be in the form of debt from development banks and other institutions, according to Olsuswa Energy. It was not clear whether the project has resolved permit issues with the Turkana County government. A Turkana County official had accused Olsuswa Energy of seeking to exploit geothermal resources without signing a memorandum of understanding with the county government, which stalled the project.

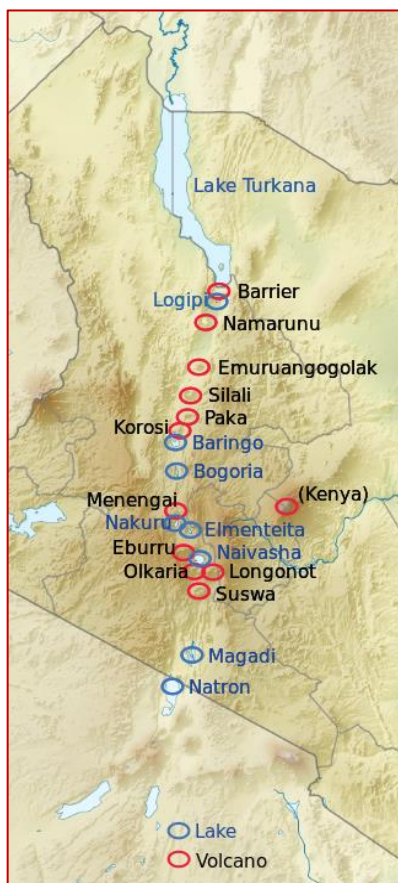
Source:

<http://www.businessdailyafrica.com/markets/news/Kanu-era-tycoon-secures-cash-for-Turkana-energy-unit/>

KenGen to Diversify its Business Offer - The Kenya Electricity Generation Company (KenGen) is diversifying its business to selling geothermal steam and commercial drilling services apart from its core business of electricity generation. The company plans to set up a subsidiary that will oversee its non-core activities that are proving to be critical revenue streams. The subsidiary will also offer consultancy services for players in geothermal, mining as well as oil in Kenya and the region.

KenGen says the subsidiary, named KenGen Energy Services (KES), will handle diversified business segments that will be hived off from KenGen, leaving the mother company to handle power production and sales.

KenGen has in the recent past diversified its revenue streams to include the sale of geothermal steam to flower firms in Naivasha, drilling geothermal wells for



Lakes and volcanoes in the Kenya's Rift Valley (Graph by Uwe Dederig, modified by Aymatth2 - <https://commons.wikimedia.org/w/index.php?curid=17846522>)

other firms, running its geothermal spa in Olkaria and a planned industrial park. It is also offering energy consultancy services to power sector players in the country and the region.

The cost of generation is pushing the company to diversify into other potentially new revenue streams. KenGen chairman Joshua Choge says the company is setting up a fully owned subsidiary to undertake commercial ventures such as sale of steam which could be used in homes or green house farming.

Chief Executive Rebecca Miano said the subsidiary would also explore other revenue streams as the firm looks to grow revenues while reducing reliance on energy generation. She said the initiative was also aimed at enabling KenGen to focus on its energy generation business, which would remain its core business.

The new firm, Miano said, would have its own management team. "There is a proposal to have its own structure but with oversight from KenGen. It will have a lean structure." Diversification is expected to enable the firm to grow revenues and shareholder returns at a time when there is an increased number of power producers coming into the Kenyan market and who are expected to start feeding electricity to the national grid in the next few years.

KenGen currently accounts for more than 75% of the country's total installed capacity as a result of intense energy generation projects, notably geothermal, whose total installed capacity is 533.8MW. The company seeks to generate at least 2,500MW of geothermal power by 2025.

Sources: <http://www.kbc.co.ke/business/kengen-diversifying-to-selling-steam-and-drilling-services/>,
<https://www.standardmedia.co.ke/business/article/2001261581/kengen-eyes-more-revenues-with-new-subsiary>

South Africa: Geothermal Areas of Interest

Local geologist Taufeeq Dhansay and a group of five fellow scientists from the Council of Geoscience and Nelson Mandela University believe that the government is overlooking significant volumes of buried Earth heat, which could be tapped to generate renewable energy.

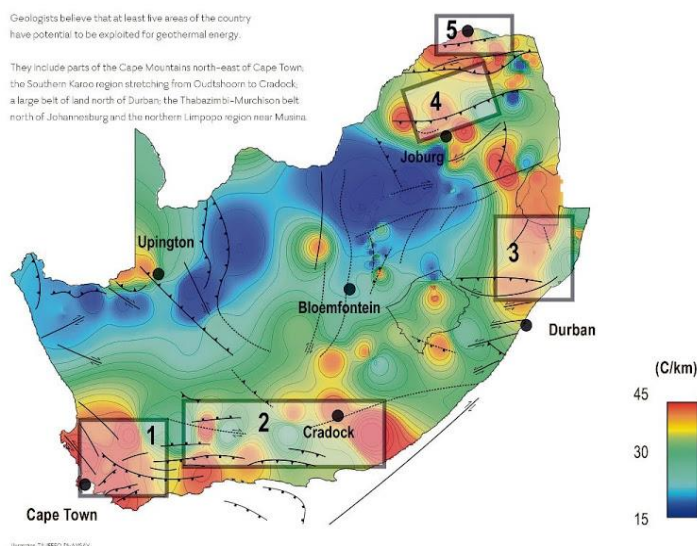
Writing in the latest volume of the South African Journal of Science, Dhansay notes that the country does not have active volcanoes or evidence of recent volcanic activity. Yet he believes a recent heat-mapping study suggests there is still enough heat and warmth beneath the land that could be used to generate steam and electricity, making use of recent technological advances in the field of low-enthalpy geothermal energy harvesting.

"The results of this study suggest that despite geothermal resources not being part of SA's renewable energy mix, the country does have some potential for harnessing low-enthalpy geothermal energy. We therefore recommend that South Africa seriously considers geothermal energy as another renewable option," Dhansay says.

But tapping heat from the Earth could imply serious catches. Quite apart from high costs of exploration and development, Dhansay and his colleagues acknowledge that there could be negative environmental effects — including pollution of scarce groundwater, subsiding land and an increased risk of mini-earthquakes.

In the latest South African study, Dhansay and his colleagues note that local rocks associated with high heat flow signatures often contain high concentrations of radiogenic elements such as uranium and potassium. In fact, it is these rocks, which are rich in heat-producing elements, which release heat during the decay of radiogenic elements. Nevertheless, the study has identified five regions that could be considered promising areas for geothermal energy projects.

They include parts of the Cape mountains north-east of Cape Town (1); the Southern Karoo region from Oudtshoorn to Cradock (2); a large belt of land north of Durban (3); the Thabazimbi-Murchison belt north of Johannesburg (4) and the northern Limpopo region near Musina (5; *see figure below*).



Most interesting geothermal areas in South Africa, according to Dhansay et al.

"South Africa may therefore have a realistic chance of developing geothermal energy, but will still need additional research and development including new temperature measurements and structural, hydrogeological and economic investigations," Dhansay concluded.

Source:

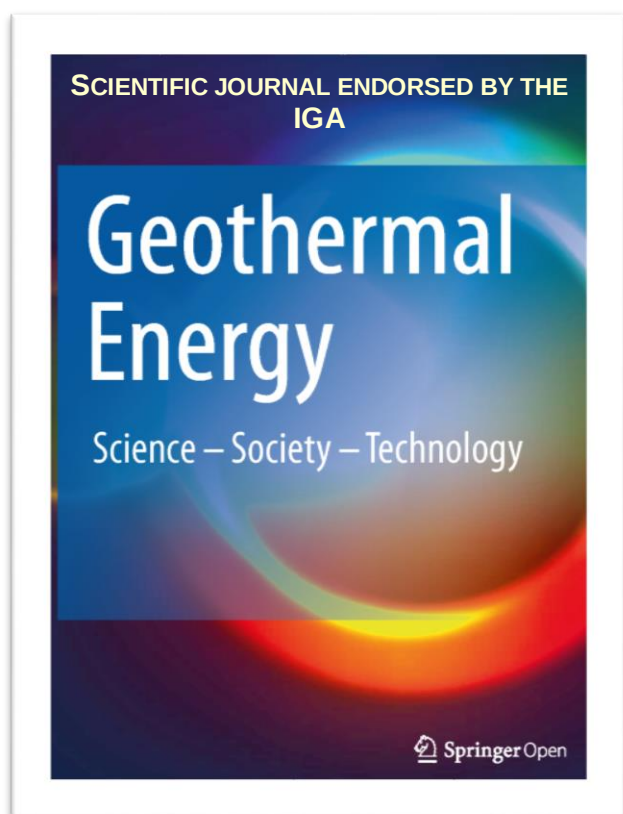
<https://www.businesslive.co.za/bd/national/science-and-environment/2017-12-05-scientists-urge-the-use-of-geothermal-energy/>

AMERICAS

Canada: Company to Be Sold, Geothermal PPA in Saskatchewan, Royal Consent

Alterra Power to Be Sold - Alterra Power Corp. (formerly Magma Energy) is going to be acquired by Innergex Renewable Energy Inc, a Canada-based renewable power producer. This company is a developer, owner and operator of renewable power-generating facilities with a focus on hydroelectric, wind power and solar photovoltaic projects.

Innergex and Alterra entered into an arrangement agreement pursuant to which Innergex will acquire all of the issued and outstanding common shares of Alterra for an aggregate sum of around US\$850 million, including the assumption of Alterra's debt. Alterra Power owns 53.9% of HS Orka, a geothermal power company in Iceland, which in turn owns 30% of the flagship spa center Blue Lagoon (see IGA News 109, pp. 32-33), as well as a majority share of the Reykjanes (54MW) and the Svarstsengi (49MW) power plants.



[TAKE A LOOK HERE.](#)

Pursuant to the transaction, Alterra shareholders will receive an aggregate consideration consisting of approximately 25% in cash and 75% in common shares of Innergex. Innergex will pay a premium of 58% to Alterra's 20-day volume weighted average price as of October 27, 2017. The Innergex Common Shares issuable to Alterra shareholders in connection with the transaction represent a pro forma ownership of approximately 19% of the combined company. One member of the current Board of Directors of Alterra will join the Board of Directors of Innergex upon closing of the Transaction.

"This is an excellent transaction for Alterra shareholders," said Ross Beaty, Executive Chairman of Alterra. "It offers a significant premium and the opportunity for Alterra shareholders to remain exposed to Alterra's assets, including our growth pipeline. Innergex is an outstanding Canadian clean energy company with highly complementary renewable energy assets to those of Alterra and a similar corporate culture. The combined company will have a lower cost of capital, stronger balance sheet, more diversified asset base and greater capacity to grow rapidly and efficiently. I look forward to tendering my Alterra shares into Innergex and remaining a significant shareholder for many years to come."

Alterra will complement Innergex's current operating, under construction and prospective projects, resulting in increased geographic and technological diversification through meaningful presence in the United States and Icelandic power markets as well as the addition of geothermal power generation to Innergex's production mix. Innergex's overall net power generation capacity will be of 1,606 MW, up over 40 %.

The Transaction is subject to approval of at least 66% Alterra Common Shares at a special meeting of Alterra shareholders to be called to consider the transaction. The Board of Directors of Alterra has unanimously approved the transaction and recommends that Alterra shareholders vote in favor of the Transaction. In addition to Alterra shareholders approval, the Transaction is subject to court and certain regulatory approvals in Canada and U.S., key third party consents and other customary closing conditions. Subject to the receipt of all required regulatory approvals and key third-party consents, closing of the Transaction is expected to occur in the first quarter of 2018.

Source: <http://www.thinkgeoenergy.com/alterra-power-corp-being-acquired-in-a-deal-valued-at-1-billion/>

SaskPower Explores Geothermal Power – It was unveiled that the Canadian utility SaskPower signed a power purchase agreement (PPA) with geothermal developer Deep Earth Energy Production (DEEP)

Corp. since May 2017, as part of its plan to double renewable electricity generation by 2030.

"If projections hold true, we're going to need to find over 2,000 megawatts of renewable power," Kirsten Marcia, president and CEO of DEEP, said.

"Geothermal is not the only solution here, but we hope to have a very significant place at the table."

With the PPA signed with SaskPower, DEEP hopes to build a five megawatt, zero emission power plant near Estevan, where subterranean water is the warmest in the Saskatchewan Province.

DEEP's first plant is expected to be built in two years. It's expected the aquifer will be able to support a capacity of roughly 200 megawatts with several units between five and 10 megawatts of power; multiple units would be required to generate the amount of power needed in Saskatchewan.

Source:

<https://globalnews.ca/news/3905709/saskpower-geothermal-power-plant-renewable-electricity-deep-corp/>

Royal Consent to Bill C-63 - Bill C-63, *A second Act to implement certain provisions of the budget tabled in Parliament on March 22, 2017 and other measures* has received royal assent and is now law. According to the Canadian Geothermal Energy Association (CanGEA), the Bill implies:

- Accelerated capital cost allowance has been extended to a broader range of geothermal projects and expenses (including eligibility for transmission equipment expenses);
- The range of geothermal energy project expenses that are eligible as Canadian renewable and conservation expenses, can be fully deducted in the year incurred;
- Geothermal projects can claim exploration wells and flow-through shares for all project types as well as other heat transfer equipment.

Those changes represent major policy victories for CanGEA in 2017, as they are a direct result of CanGEA's federal government outreach efforts.

Source: <https://www.cangea.ca/news-blog/royal-assent-of-bill-c-63-2017-federal-budget-policy-victory-for-cangea>

Caribbean: Exploration Well in Nevis, Geothermal Risk Mitigation Program

First Exploration Started in Nevis - On November 22, 2017, started the drilling of an exploration well in Nevis, which was expected to be completed in just 45 days, according to Mark Brantley, the Minister assigned to the geothermal project.



Nevis Renewable Energy International (NREI) has been contracted for the exploration of geothermal sources in Nevis. The drilling contractors DOSECC, based in Salt Lake City, Utah, have also partnered with NREI to conduct and complete the well installation.

Once completed, the well is expected to provide the geothermal reservoir data needed for design the turbine and production installations.

It is estimated that Nevis has up to 300 MW of geothermal power and some estimates calculate as many as 650 MW. As Nevis becomes energy self-sufficient, its renewable resources could benefit nearby island nations through the construction of a submarine cable. After recent Hurricanes Irma and Maria damaged parts of the Caribbean, it is the goal of the eastern Caribbean nations to implement more resilient renewable energy and geothermal can provide 24/7 power to support these efforts.

With an established goal to eliminate CO₂ emissions from power generation, Nevis is committed to leverage its proven geothermal resources and become the greenest island on the planet. Nevis will be the first Caribbean island to utilize Binary Organic Rankine Cycle (ORC) geothermal power generation that utilizes a closed-loop system with zero carbon emissions.

Minister Brantley said, “If we can achieve what we intend to achieve here, it would mean that Nevis will become fossil fuel free for this generation of electricity and it would put us in a category of our own in the Caribbean and perhaps the world in terms of being completely sustainable for our electricity supply.”

Sources: <http://www.thestkittsnevisobserver.com/local-news/geothermal-begin-wells-completed-january-2018/>, <http://www.thinkgeoenergy.com/exploration-drilling-to-start-for-geothermal-project-on-nevis-caribbean/>

Grant to Risk Mitigation Program to Help Geothermal Development – A new Geothermal Risk Mitigation Program for the Eastern Caribbean has been set up with funding by the European Union. The EUR 12 million (US\$14 million) funding will help five Caribbean countries (Dominica, Grenada, St Kitts-Nevis, St. Lucia and St. Vincent and the Grenadines) on their geothermal development efforts of up to 60MW of geothermal capacity.

The agreement was signed on behalf of the Caribbean Development Bank (CDB), by Warren Smith and the Commissioner in charge of International Cooperation and Development, Neven Mimica.

“The program will help to increase renewable energies in the Caribbean by supporting the development of geothermal energy,” said Mimica, adding that the grant will serve to jump start geothermal development through co-financing for higher-risk investments required at the early stage services of exploratory drilling which could leverage additional financing of approximately EUR 400 million (US\$490 million).

“It will decrease dependency on energy imports – reducing fuel import bills, electricity costs and help to decrease greenhouse gases emissions and other pollutants,” Mimica added.

Smith said that the CDB welcomes the EU-CIF’s contribution to geothermal energy development in the Eastern Caribbean. “This funding will add momentum to our on-going efforts to transform the energy sector in the Region, and support our borrowing member countries in harnessing their renewable energy resources. The signing of this agreement represents a strengthening partnership between CDB and the European Union.

“We look forward to collaborating further to support economic growth and competitiveness, and creating a more sustainable future for the people of our region,” he

added.

The funding will be used to provide investment grants at the exploration phase, as well as technical assistance to support capacity-building initiatives and studies that explore opportunities for, and the feasibility of, interconnection between islands to facilitate the export of electricity by geothermal energy producers, the CDB added.

Source: <http://www.thinkgeoenergy.com/new-eu-grant-to-risk-mitigation-program-to-help-caribbean-geothermal-development/>

Chile: Geothermal in Last Power Auction, Solar and Storage in Cerro Pabellón

33MW Geothermal Project Wins in Last Power Auction - Enel S.p.A., acting through its subsidiary Enel Generación Chile, has been awarded the supply of 1180 GWh per year to a number of Chilean distribution companies through the tender launched by the country’s National Energy Commission (Comisión Nacional de Energía), and aimed at meeting the energy demand of regulated market customers over the 2024-2043 period. The Group won 54% of the 2200 GWh per year offered in the tender, which will be provided by a mix of new renewable projects comprising of 116 MW of solar, 93 MW of wind and 33 MW of geothermal for a total capacity of 242 MW.

The 242 MW of new renewable capacity are based on solar and geothermal plants located in the Antofagasta region, in Northern Chile, as well as on a wind farm located in the Araucanía region, in Southern Chile. Enel did not inform which project or projects comprise the 33 MW of geothermal power to be constructed in Northern Chile, but Think GeoEnergy considers it will be an expansion of the 48MW Cerro Pabellón geothermal power plant, for which the company already sought a permit to expand the capacity.

The tender was launched following Chile’s General



Panoramic view of Cerro Pabellón. Photo by EGP.

Power Service Law (Ley General de Servicios Eléctricos) No. 4 from 2006, shaping the regulatory framework for public tenders in order to provide distribution system operators with long-term power supply contracts with generators that would enable them to meet the power consumption needs of regulated market customers in their concession areas. It is important to mention that the weighted average price of the energy in this tender was US\$32.5 per megawatt-hour –a new minimum international record, with the lowest solar-price priced at US\$21.5/MWh.

As far as it is known, this is only the second time a geothermal project is among the winning projects in a public power auction, being the first a 25MW power plant in the Los Azufres geothermal field, Mexico (see IGA News 105, p. 14, and IGA News 109, pp. 45-46).

Sources:

<https://www.enelgreenpower.com/es/medios/press/d/201711-enel-wins-242-mw-of-new-solar-wind-and-geothermal-capacity-in-chiles-tender.html>,
<http://www.thinkgeoenergy.com/enel-wins-tender-on-33-mw-geothermal-capacity-addition-in-chile/>,
<https://renewablesnow.com/news/average-prices-in-chilean-power-tender-fall-to-usd-325mwh-589701/>

Geothermal, PV and Hybrid Storage in Cerro Pabellón – The Cerro Pabellón plant is located at a remote and uninhabited place in the Atacama Desert, in the Antofagasta region of Chile. It's at 4,500 meters above sea level, in one of the most arid places in the world, with temperatures varying from -20°C at night and 30°C during the day and, in some areas, it has not rained for centuries.

Besides the 48MW geothermal power plant, there is an energy storage system that provides constant electricity to the small village of Ollagüe and, since January 2017, also a hybrid system that integrates a solar plant with a lithium ion battery and hydrogen storage.

The hybrid storage system integrated with the photovoltaic field is the latest innovation connected to the plant. It was designed to provide clean energy 24/7 to the Cerro Pabellón base camp, which hosts Enel Green Power technicians working at the plant. The project, completed in the first quarter of 2017, was officially inaugurated on 31 May and passed definitively to the management of our Operation & Maintenance team on 11 October.

The project created for the Cerro Pabellón base camp can function in both off-grid and on-grid modes and is managed by an advanced control system to optimize energy flows and to guarantee a constant supply clean energy.

Source:

<https://www.enelgreenpower.com/stories/a/2018/01/chile-on-the-frontier-of-innovation>

Mexico: New Power Plant & Results of Third Power Auction

Mexico's Federal Electricity Commission (CFE), the government-owned electricity utility, announced on 22nd November 2017 the official inauguration of a 25MW geothermal power plant. It is Los Humeros III – Phase A, a single-flash condensing plant of 25 megawatts of net capacity installed at the Los Humeros, State of Puebla, geothermal field. Los Humeros is the third largest and oldest field in Mexico, and is operated by the same CFE.

CFE said US\$47 million was invested in the construction of the new facility, which was planned to replace three old back-pressure units of 5MW each to use more efficiently the same amount of steam. With this plant, the installed capacity in Los Humeros reaches 94 MW.



The CFE's General Director during the inauguration ceremony.

The company said that currently, about 20% of Mexico's electricity comes from clean energy sources, of which CFE generates three quarters. Mexico aims to generate 35% of its electricity from clean energy sources by 2024 and has just completed its third long-term power auction, which will lead to the construction of 2562 MW capacity –1323 MW of solar plants, 689 MW of wind farms and one 550-MW clean-gas plant, representing 1.8% of annual generation. The average price of clean electricity plus clean energy certificates (CEL) was US\$ 20.57 per MWh+CEL, the lowest globally at that moment.

This third long-term implies about US\$ 2.37 billion to be invested in the next three years in 15 new power plants. Solar photovoltaic (PV) was the leading

technology, securing 55.35% of the power supply contracts, while wind won 44.65%. Solar and wind also secured 1.69% and 13.95%, respectively of the firm capacity component of the competition, where the dominant technology was gas.

Sources:

<http://saladeprensa.cfe.gob.mx/boletines/show/8477/>,
<https://renewablesnow.com/news/mexicos-prelim-tender-results-show-average-price-of-usd-2057mwh-591263/>

U.S.: Tungsten Power Plant, Awards for Geothermal Technologies

Tungsten Mountain Power Plant Started to Operate - Ormat Technologies Inc. announced that the 24MW Tungsten Mountain geothermal power plant located in Churchill County, Nevada, began commercial operation on December 1, 2017. Tungsten Mountain will sell its power under the 26-year Ormat Northern Nevada Geothermal Portfolio Power Purchase Agreement (PPA) with the Southern California Public Power Authority (SCPPA), which was announced in June 2017. SCPPA resells the entire output of the plant to the Los Angeles Department of Water and Power (LADWP). The power plant is expected to generate approximately US\$15 million in average annual revenue.

design became available. This reduced the CapEx invested in manufacturing and constructing the power plant, and is expected to significantly reduce the power plant's operating costs. The new and innovative turbine design will increase the OEC efficiency, capacity, and availability.

Isaac Angel, CEO of Ormat Technologies said, "Commercial operation of the Tungsten Mountain project brings our operating portfolio to a total of 800 MW, demonstrating double-digit growth of our portfolio since the beginning of the year. This growth will provide a meaningful contribution to our results in 2018 and beyond. The innovative Tungsten Mountain geothermal power plant is the first power plant to sell power under the portfolio PPA with SCPPA that we announced earlier this year. The Tungsten Mountain power plant is a greenfield project that was built at a record pace, demonstrating again Ormat's competitive advantage as the only vertically integrated company in the geothermal industry. Our unique capabilities of both developing resources and utilizing proprietary technology enables us to deliver on time and on budget, while constantly improving our technology to maximize efficiencies."

Source:

<http://investor.ormat.com/file/Index?KeyFile=391543763>

Two R&D 100 Awards for Geothermal Technologies - Los Alamos National Laboratory (LANL) is a United States Department of Energy (DOE) national laboratory based in New Mexico. By middle November 2017 it was announced that eight innovations developed by LANL had won R&D 100 Awards. The R&D Awards are deemed as the 'Oscars of Invention' and are granted annually by the R&D Magazine. The awards honor the latest and best innovations and identify the top technology products of the past year. The R&D 100 Awards span industry, academia and government-sponsored research organizations. Two of the 2017 awards were for geothermal energy applications:

Discrete Fracture Network Modeling Suite (dfnWorks): Transforming simulations of flow and transport through fractured rock – This is a computational suite that simulates and predicts the flow and transport of fluids through underground fractured rock. It covers length scales that range from millimeters to kilometers, can run on computers as small as a laptop and as large as a supercomputer and requires minimal effort to create representative models. Applications for dfnWorks include helping catch rogue nations performing underground nuclear tests and maximizing the extraction of natural gas, oil and geothermal wells while minimizing environmental impacts.



The Tungsten Mountain geothermal power plant utilizes Ormat's latest turbine design, and is the largest Ormat Energy Converter (OEC) ever installed. Utilizing the new generation of Ormat turbines will allow the Tungsten Mountain project to generate an average net output of 24MW from a single OEC instead of two OECs, as would have been required before this new

High-Temperature Electric Submersible Pump Motor (HT-ESP): Keeping pump motors cool in deeper, extremely hot environments – HT-ESP is rugged and reliable, offering improved thermal performance compared to conventional submersible pumps used in deep underground and extremely hot environments. Whether electric submersible pump motors are used in drilling deeper for oil and gas reservoirs or tapping into geothermal resources of energy, they must operate in harsh, extremely hot environments. Current pump motors overheat and must be replaced often. To solve this, the Los Alamos and the Chevron Energy Technology Company research team developed two technologies for HT-ESP to lower the internal operating temperature of the motor. Los Alamos submitted the HT-ESP as a joint entry with Chevron. Todd Jankowski led a Los Alamos team of Dallas Hill, Britton Lambson, James Stewart, Robert Bourque and Coyne Prenger. Chevron collaborators include Jose Gamboa, Daniel Hunt, Max Bough and Yamila Orrego.

Source: <http://www.lanl.gov/discover/news-release-archive/2017/November/1120-rd-100-awards.php>

ASIA/PACIFIC RIM

China: Sinopec Exploration in Xiongan, Geothermal Industry Alliance

Sinopec Targets Xiongan for Geothermal - On late November 2017, the state-owned China Petroleum & Chemical Corp, known as Sinopec, said it will further develop geothermal energy in Xiongan New Area, Hebei province, as it seeks to make the smog-ridden region smokeless.

Sinopec Star Petroleum Ltd, Sinopec's geothermal energy development arm, said it would increase the geothermal and other new-energy heating area in Xiongan by 10 square kilometers (km²) to 16 million m² in 2017.

In 2016, by replacing coal with geothermal energy, the geothermal heating area in Xiongan county, part of Xiongan New Area, reached 4.5 km², making it the first region to achieve its smokeless city plan.

Lyu Dapeng, director of the publicity department of Sinopec Group, said the oil giant and the Hebei provincial government agreed early 2017 to promote the use of geothermal energy in Xiongan New Area.

"We aim to make the region an example of geothermal energy utilization for the world," said Lyu.

The company wants to create 20 smokeless cities during the 13th Five-Year Plan period (2016-20), covering 100 km².

"The country accounts for one-sixth of the world's geothermal energy. At present, available geothermal power each year is equivalent to 640 million metric tons of standard coal, which can reduce carbon dioxide emissions by 1.3 billion tons," Lyu said.



In 2016, to promote clean energy development and improve the environment, China launched the 13th Five-Year Plan for geothermal energy, the first such plan in this field. According to the plan, the country plans to increase its installed geothermal energy capacity by 500 gigawatts by 2020.

Source:

http://europe.chinadaily.com.cn/business/2017-11/27/content_35042451.htm

Geothermal Industry Alliance - In other news, it was unveiled that on December 8, 2017, the China National Nuclear Corporation (CNNC) has founded a geothermal industry alliance. The alliance is an attempt to meet China's demand for the exploitation and utilization of geothermal energy, accelerate the development of the geothermal industry, implement the national strategy for constructing a green and beautiful country, and eventually to benefit all of humanity.

CNNC Geothermal Industry Alliance is an unincorporated body with the purpose of boosting the geothermal industry and promoting the exploitation and utilization of China's geothermal energy.

The allied association is guided by national industrial policies and is oriented to market demand. It aims to create a resource sharing platform for the company's geothermal energy exploitation, innovative research and development, and industrial coordination and application. It's expected to build a clean, low-carbon, safe and efficient energy system in the near future.

Source: http://en.cnn.com.cn/2017-12/14/c_119804.htm

Indonesia: Demonstration Power Plant, RE Potential, Risk Mitigation Facility, New Tariff Regulation

Commissioning of a Geothermal Low-Temperature Demonstration Power Plant - In September 2017, the first geothermal low-temperature demonstration power plant in Indonesia has been successfully commissioned at the geothermal field in Lahendong close to the village Pangolombian, North Sulawesi. The demonstration plant is in test-operation.

The concept of the demonstration power plant has been developed by the Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences, in collaboration with the Indonesian project partners BPPT (Agency for the Assessment and Application of Technology) and PGE (Pertamina Geothermal Energy). The project was funded by the German Ministry of Education and Research (BMBF). The aim of this collaboration is to demonstrate reliable and efficient low-temperature power generation at a geothermal site in Indonesia and to create the basis for a broader application in Indonesia.

The demonstration plant is designed to cool down part of the unused geothermal brine from 170°C to 140°C and thus generate electricity. During the test-operation, the temperature of the geothermal fluid is 145°C, which results in an electric power output of approximately 300 kW. In normal operation, an electrical capacity of up to 500 kW shall be reached. Assuming the average electric power consumption in Germany, this is enough to supply electricity for 1,200 households.

The geothermal demonstration plant is based on an Organic Rankine Cycle (ORC) connected by closed water intermediate circuits (a hot water and a cold water intermediate circuit) to the geothermal heat source and the environment as heat sink.

Building on the experience of the development and operating phase of the demonstration power plant, the implementation of low-temperature power plant technology for Indonesia can be decisively advanced. With the establishment of this technology, it is possible

to extend the electrical capacity of existing geothermal sites and, above all, to provide an option for the decentralized energy supply in Indonesia.

The research and demonstration operation of the low-temperature power plant is to be continued under the leadership of the GFZ until the middle of 2018. The demonstration plant will then be handed over to an Indonesian partner organization.

Source: <http://www.gfz-potsdam.de/en/media-communication/news/details/article/inbetriebnahme-des-geothermischen-niedertemperatur-demonstrationskraftwerks-in-lahendong-indonesien/>

Potential of Renewable Energy - Indonesia, with the world's fourth largest population, has an aggressive goal to increase the share of renewable energy in the country's energy mix to 23% by 2025. Indonesia will serve as a model for clean energy deployment, especially for island nations, while providing a growing market for advanced renewable energy technologies worldwide.

With an expected population of 285 million by 2025, the greatest challenges of Indonesia to achieve universal electrification is their remote regions and islands that currently heavily depend on high-cost diesel fuel that is often imported and transported over long distances.

Here are the total estimated potential for several renewable energy sources, and targets for 2025 and 2050, according to the Ministry of Energy and Mineral Resources:

New & Renewable Energy Sources	Capacity Power Plants (GW)		
	Total Potential	2025 Target	2050 Target
Geothermal	29.5	7.2	17.5
Hydro Power	75.0	21.0	45.0
Bioenergy	32.0	5.5	26.1
Solar	532.0	6.5	45.0
Wind	113.5	1.8	28.6
Other	--	3.1	6.4
TOTAL	782.0	45.1	168.6

Source: MEMR, 2017

Source: RE4I, Renewable Energy for Indonesia Conference (<http://www.there4i.org/>)

Geothermal Risk Mitigation Facility Planned for Indonesia - With support from the World Bank (WB) and other partners, the government of Indonesia is planning a new Geothermal Risk Mitigation Facility. This would leverage several billion dollars in private sector funding, unlocking investments through risk mitigation for exploration and early production drilling.

This would allow investors to prove sufficient resources to attract commercial finance for large-scale development. Over the next seven years it is expected that the facility will lead to the development of more than 1 GW of new geothermal capacity.

This new facility builds on a long engagement around geothermal energy in Indonesia. In 2012 the WB supported the government through a grant from the Global Environment Facility (GEF) to undertake key reforms to enhance the investment climate for geothermal development. It also helped Pertamina Geothermal Energy (PGE) to kick-start its ambitious geothermal expansion program through a US\$175 million IBRD loan, along with concessional financing of US\$125 million from the Clean Technology Fund (CTF).

More recently, in 2017, the WB provided US\$55.25 million in grants to support the Geothermal Energy Upstream Development Project in Indonesia, which aims to facilitate investment in geothermal power generation in the country. The Clean Technology Fund (CTF) is contributing US\$49 million to support infrastructure development and exploration drilling. The Global Environment Facility (GEF) contributes an additional US\$6.25 million to support technical assistance aimed at building capacity in geothermal exploration, including safeguards due diligence. The Ministry of Finance and PT. Sarana Multi Infrastruktur, a state-owned infrastructure financing company, will match the CTF funding for the Project.

Indonesia has a target of increasing the share of new and renewable energy in its primary energy mix to 23 percent by 2025, including by adding 5.8 GW of geothermal capacity. According to the WB, the Geothermal Risk Mitigation Facility will help Indonesia meet this target by leveraging billions of dollars in commercial financing to develop more than 1 GW of new geothermal capacity. Indonesia currently has around 1.8 GW of geothermal electricity; its total potential is 29 GW. Using Indonesia as a model, other countries can potentially apply a similar approach to scaling up the use of geothermal energy.

Source:

http://www.worldbank.org/en/results/2017/12/01/geothermal?cid=CCG_TT_climatechange_EN_EXT

Pertamina Elaborates New Scheme for Geothermal Electricity Tariff Regulation - PT Pertamina (Persero) is supporting the new government regulation as stipulated in Ministerial Regulation No. 50 of 2017 on the Development of New and Renewable Energy (EBT) which opens opportunities for the process of determining tariffs by way of business-to-business (B2B) between state electricity company PLN and independent power developers (IPP).

Pertamina President Director Elia Massa Manik welcomed the regulation. According to him in the next few years, Pertamina will still develop geothermal energy and this regulation will accelerate the development of renewable energy, such as geothermal, biomass, hydro, solar, and others.



Elia Massa Manik, Pertamina's President Director.

"Investment-friendly regulation and support for future clean energy creation is positive. We have built a geothermal power plant with an installed capacity of 587 MW. The potential is huge, out of a total of 29 gigawatts, newly installed one is still less than 3 gigawatts. Therefore, regulation has an important role in the development of geothermal energy in the future," said Massa in a written statement on middle December 2017.

Likewise, the Director of Geothermal of Directorate General of New Energy, Renewable Energy and Energy Conservation of the Ministry of Energy and Mineral Resources Yunus Saefulhak said the new regulation enables the B2B scheme if the average production cost of electricity generation is deemed inadequate.

He pointed out the Rantau Dedap Geothermal Power Plant project located in Muara Enim and Lahat regency, Pagar Alam City, South Sumatera, in the end its electricity price is determined through a power purchase agreement (PPA) amendment process.

"From the target of renewable energy mix of 23 percent in 2025, about 7,200 MW or 16 percent will come from geothermal... first and foremost the regulation must provide support," explained Yunus.

Source:

<http://www.en.netralnews.com/news/business/read/16222/pertamina.elaborates.new.scheme.for.geothermal.electricity.tariff.regulation>

Philippines: Maibarara Expansion in Operation, Draft Rules on Renewables

Maibarara 12MW Expansion Commissioned in December - Maibarara Geothermal Inc. said its 12-megawatt geothermal expansion project in Batangas met the December 2017 target for commercial operation. The expansion brings Maibarara's total capacity to 32 MW.

MGI power plant manager Paul Morala said the company, along with National Grid Corporation of the Philippines (NGCP), installed the revenue meter of Maibarara-2 on September 30.

He said Maibarara and Manila Electric Co. engineers successfully completed on October 24 the testing of Maibarara-2's protection relays and circuit breakers.

"We commend the highly professional and helpful cooperation we have received from NGCP and Meralco. We anticipate such cooperation to continue and to extend as well to other agencies such as the DoE (Department of Energy), ERC (Energy Regulatory Commission), and PEMC (Philippine Electricity Market Corp.) as the unit's commissioning and testing enter their final phases," Morala said.



First Unit of Maibarara. Photo by MGI.

Maibarara's existing 20 MW Unit-1 in Sto. Tomas, Batangas, meanwhile, reached its 600 GWh generation mark during the billing period ending October 25. Maibarara said the milestone was achieved three years and eight months from the start of the facility's commercial operation on February 8, 2014. The first phase of the Maibarara project was the first geothermal

power station built in Luzon in 16 years and the first renewable energy project declared commercial by the Energy Department under the Renewable Energy Law of 2008.

Source: <http://thestandard.com.ph/business/power-technology/250648/maibarara-expansion-to-meet-december-goal.html>

DoE Asks for Comments on Draft Rules - The Department of Energy (DoE) has solicited comment from the industry on a proposed circular that seeks to amend previous rules governing the transparent and competitive system of awarding renewable energy service contracts. In the draft circular, the DoE has included biomass projects as one of two renewable energy technologies that may be owned by foreign corporations, besides geothermal projects.

"In the case of the exploration, development or utilization of biomass and geothermal resources, the applicant may either be a Filipino or foreign, natural or juridical, citizen," according to the draft, which has a January 2018 target issuance date.

The proposed department circular (DC) amends DC 2009-09-0011 or the guidelines governing a transparent and competitive system of awarding renewable energy or operating contracts. Under DC 2009-09-0011, only the development of geothermal resources is listed as open to foreign ownership.

The draft circular also does away with the 'blocking system' of subdividing the Philippine territory by the DoE into blocks of half minute of latitude and half minute of longitude, covering an area of 81 hectares with a designated block number, which is used exclusively in identifying the coverage of a contract area.

The draft circular has retained much of the qualification set for who may apply for renewable energy (RE) contracts, or a service agreement between the government, through the President or the DoE, and an RE developer over an appropriate period as determined by the department. That period gives the developer the exclusive right to explore, develop or utilize a particular RE area.

A provision on the eligibility of an RE applicant — or any entity, whether individual or juridical, local or foreign, including joint venture or consortium of local, foreign, or local and foreign firms — has required the President's approval on geothermal resource development.

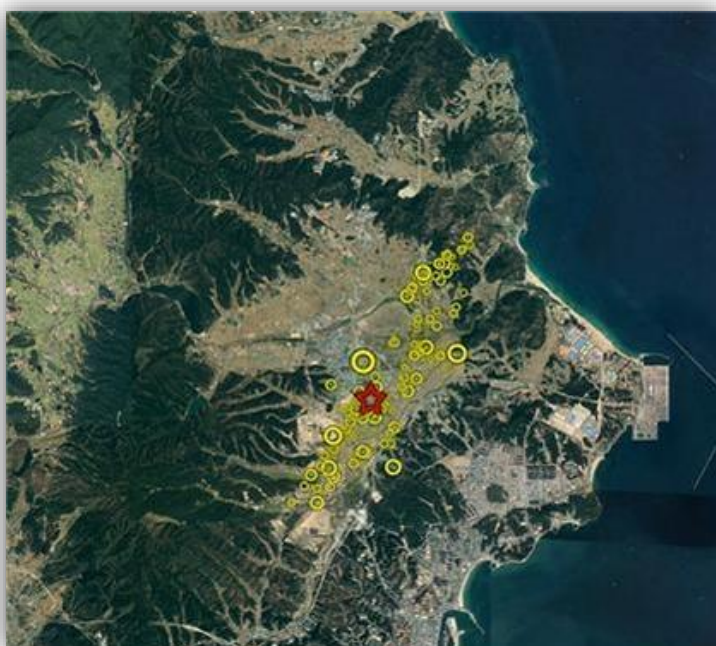
Source: <http://bworldonline.com/doe-draft-rules-allow-foreign-ownership-biomass-projects/>

South Korea: Investigation on Possible Correlation of

Geothermal Activities with Earthquake

On 15 November 2017 an earthquake with a magnitude of 5.4 occurred near Pohang in South Korea. This earthquake is the second-largest on record in Korea after the magnitude 5.8 Gyeongju event, which occurred in 2016, 40 km from Pohang. It triggered numerous aftershocks in the following months.

There may be concerns regarding a connection between the November 2017 earthquake and the nearby Pohang geothermal project due to the close proximity and shallow depth of the earthquake. Analysis is underway regarding the injection activities in the two deep boreholes (4.3 km and 4.2 km) at Pohang.



The epicenter of the Pohang Earthquake (red) along with the aftershocks (yellow) (Provided by Korea Institute of Geoscience and Mineral Resources, and taken from the first source).

Following the three previous hydraulic stimulations at this site, the DESTRESS team, composed of international experts, conducted hydraulic stimulation in August 2017, followed by flow-back of 100% of the injected water. This treatment did not induce any seismic activity larger than magnitude 2.0. It was followed by additional injections, which ended on 18 September, two months before the recent Pohang earthquake. Even though no larger seismic events were observed during this treatment, the DESTRESS team said is willing to collaborate with South-Korean partners and authorities to investigate the possible link between the 15 November earthquake and the previous injection activities at Pohang.

“Injecting water into the earth can reduce friction on a fault line, causing movement and potentially triggering a major earthquake in an area that is already under pressure. There have been steady reports of similar incidents overseas,” said Lee Jin-han, a professor at the department of earth and environmental science at Korea University.

“The fact that a small amount of water was injected at the geothermal plant at Pohang and that a large number of micro-earthquakes had occurred previously prevent us from concluding that the Pohang earthquake occurred because of the geothermal plant,” said Hong Tae-gyeong, a professor in the department of earth system science at Yonsei University.

The Pohang geothermal plant has injected a total of 12,000 m³ of water on four or five occasions since 2016 and then removed some of that water, and currently about 5,000 m³ remains underground.

“Analyzing the moment tensor, which expresses the phenomena that brought about the seismic waves as a combination of forces, shows that the Pohang earthquake could have been an earthquake that occurred on a complex fault plane, unlike ordinary earthquakes. But the possibility that it was affected by high-pressure liquid appears to be low,” said Lee Jun-gi, a professor of geological and environmental science at Seoul National University.

Sources:

http://english.hani.co.kr/arti/english_edition/e_national/820906.html,

<http://www.thinkgeoenergy.com/correlation-on-geothermal-work-with-recent-earthquake-being-investigated-in-south-korea/>

Taiwan: Nuclear Plants to Geothermal Plants, Exploration in Mt. Datun, Feed-in Tariffs

Nuclear Facilities to Be Transformed into Geothermal Plants - The Atomic Energy Council (AEC) was considering to launch a plan by the end of 2017 that would see nuclear power plants transformed into geothermal power generation facilities, according to the AEC Minister Hsieh Shou-shing.

The three operating nuclear plants in Taiwan are to be decommissioned one after the other until 2025 and this retirement is proceeding as scheduled, Hsieh told the legislature’s Education and Culture Committee, adding that the council has also funded efforts to study ‘green’ energy in recent years.

Democratic Progressive Party (DPP) Legislator Rosalia Wu said the council should be tasked with the

development of geothermal power, given that a viable source can be found about 20km beneath the Guosheng Nuclear Power Plant in New Taipei City's Wanli District. One of Wu's references was an article by Wang Shou-cheng published on TechNews in March 2017, in which Wang encouraged the government to set up a geothermal energy development zone in Wanli and Jinshan districts, where two nuclear power plants are located.

If Taiwan hopes to generate 20 percent of its electricity from renewable sources, geothermal power should not be marginalized in consideration of different sources, Wu said. The government should consider launching a more progressive plan to make use of the geothermal energy stored beneath the Guosheng plant, Wu said, adding that the AEC must play a more active role in such a plan.

Also expressing his support for geothermal power, Hsieh promised to propose a preliminary plan to develop sources of geothermal energy beneath nuclear power plants by the end of December 2017.

Source:

<http://www.taipeitimes.com/News/taiwan/archives/2017/11/07/2003681827>

Probable Exploration Study in Mt. Datun in 2018 -

State-run oil refiner CPC Co., Taiwan (CPC) is currently developing new techniques to directly extract geothermal heat from underground and plans to study the feasibility of these techniques on Mt. Datun, in suburban Taipei, next year, the company's new head has said.

"Technology can leap," said CPC Chairman Tai Chein, who assumed the office in November 2017, when asked about the company's response to the government's nuclear-free homeland policy, which aims to close all Taiwan's nuclear power plants by 2025.

Tai mentioned CPC's failed terrestrial heat exploration program in Yilan County, where the company drilled its first geothermal heat well in 1976.

Although that program led to the inauguration of Taiwan's first terrestrial heat-propelled power plant in 1981, inefficiency resulted in the closure of the plant in 1993.

Tai said that in the intervening period new technologies have been developed and advanced facilities established. Meanwhile, in accordance with the government's green energy policy, CPC has also resumed research into new technique that will allow the generation of electricity using geothermal heat drawn from wells without water (Enhanced Geothermal Systems).

Taiwan's research into geothermal heat was relatively superficial in the past, Tai said, but following the

development of relevant technologies by other individuals or institutes, Taiwan may be able to extract heat energy from underground more efficiently.

Tai said that as part of the CPC's renewed research, the company plans to conduct a study of the Datun volcano group in northern Taiwan next year.

Source:

<https://www.taiwannews.com.tw/en/news/3322505>

Increase in Geothermal Feed-in Tariffs - In other news, by middle December 2017 it was unveiled that to accelerate geothermal energy system installations, the Ministry of Economic Affairs has increased the feed-in tariff to NT\$ 6.1710 (US\$ 0.205) per kilowatt-hour from the proposed NT\$ 5.6447 (US\$ 0.188) for the first 10 years of the installations' subsidiary period, explaining that the new tariff aims to help operators reduce their initial risk. The tariff would drop to NT \$3.5685 (US\$ 0.119) per unit for the remaining 10 years of the 20 year subsidiary period, lower than the NT \$4.4465 (US\$ 0.148) per unit previously proposed.

The feed-in tariffs for other renewable energy installations were cut by less than initially planned to speed up the nation's 'green' energy goals.

Source:

<http://www.taipeitimes.com/News/biz/archives/2017/12/16/2003684029>

Vietnam: Minister Urges Geothermal Research

Vietnam's national energy development plan does not include geothermal sources, but a senior official said that it was time to study their potential in the country. Nguyễn Linh Ngọc, Deputy Minister of the Ministry of Natural Resources and Environment (MoNRE), was speaking at a conference held in Hanoi on geothermal energy in the Asia-Pacific region. The conference was



Nguyễn Linh Ngọc addresses in the conference. Photo: MoNRE.

organized by the Vietnam Institute of Geoscience and Mineral Resources and the Geothermal Implementing Agreement (IEA Geothermal). It is an initiative of the International Energy Agency (IEA) aimed to boost international cooperation on geothermal energy production and use.

Ngọc said that small-sized hydropower plants provide 70 per cent of the country's total energy output, leaving biogas/biomass a distant second at 14 per cent, while renewable energy, including solar and wind energy, both account for about 6 per cent. Meanwhile, geothermal energy has remained a complete no-show. Feasibility studies were only recently conducted in the central provinces of Quảng Bình and Quảng Trị.

Ngọc said that energy production accounted for the release of 30 per cent of global greenhouse gas emissions, but in Vietnam the figure was more than 50 per cent because of pollution from fossil fuels-based energy plants.

In 2015, at COP21, the UN Climate Change Conference in Paris, Vietnam pledged to unconditionally cut its greenhouse gas emissions by 8 per cent by 2030 compared to business-as-usual (BAU) projections, or by up to 25 per cent if international support was forthcoming.

In the conference, experts and scientists from many countries discussed direct use of geothermal power and ground-source heat pumps (GSHP), the benefits of geothermal energy and geothermal power production, and technologies for the treatment of geothermal reservoirs to enhance electricity generation.

The many socio-economic benefits of geothermal energy were also highlighted, including energy security, improved ecology and low emissions.

Source:

<http://vietnamnews.vn/society/417492/deputy-minister-urges-geothermal-research.html#GDICiObbv4DA9kmV.97>

EUROPE

Europe: EGEC Supports Renewable Energy Report



The geothermal sector has expressed support for Spanish MEP José Blanco López' report on the Renewable Energy Directive adopted on late November

2017 in the European Parliament's Committee on Industry, Research and Energy (ITRE), which strongly backs a 35% target for renewables and 40% energy efficiency in the European Union by 2030.

Philippe Dumas, European Geothermal Energy Council (EGEC secretary general, said: "The level of ambition shown by the parliament on renewables and efficiency is good, but it is only a minimum threshold to stay consistent with the Paris Agreement."

It also provides investors with a better long-term perspective, which is needed to plan significant investments by reinforcing the commission proposal on support schemes. Such measures are essential to maintaining the dynamism of European renewable energy industries, including geothermal.

The committee, under the impulsion of rapporteur Blanco López, and with broad support, builds on the commission proposal to deliver ambitious provisions for the heating and cooling sector, giving guidelines for an accelerated deployment of renewables in the largest segment of Europe's energy consumption.

"For Europe to be a true climate and energy leader, the de-carbonization of the heating and cooling sector must be undertaken, and this report provides sound basis for this," Dumas added.

Meanwhile, the Energy Efficiency vote validated a strong ambition level, supported by robust provisions in continuing the energy savings obligations inherited from the previous version of the Directive, while still allowing the subsidy of fossil fuel appliances in the name of marginal efficiency gains –with effect of locking in fossil fuel dependency.

"But the ITRE committee did not manage to act on the issue of fossil fuel subsidies awarded to fossil appliances in the name of efficiency. It must be pointed out that a new fossil boiler locks dependency to gas, oil or coal for decades. Renewables for heating and cooling are the solution. We hope to see the Council taking this responsibility" concluded Philippe Dumas.

Source: <https://www.egec.org/media-publications/geothermal-sector-welcomes-targets-renewables-energy-efficiency-adopted-parliament-vote/>

Belgium: CHP Geothermal Plant Starts Construction in Balmatt

In early October 2017 started the construction of a combined heat and power (CHP) geothermal plant at the Balmatt site in Mol. During an academic meeting, the committed Ministers of the Flemish government and their partners Atlas Copco, Eandis and IOK, unveiled a memorial plaque at the Balmatt site, where a

third exploratory well is being drilled. With this well, VITO's experts want to research the geothermal potential of the earth's strata dating from the Devonian.

On September 2015, VITO (the Flemish institute of technological research) launched the project for providing the Kempen region with sustainable heat and electricity through geothermal energy. In 2016, two wells at a depth of 3,610 m and 4,341 m respectively, were drilled. The pump test in the first drilling well showed that the output and temperature of the water are more than sufficient to reach that goal. In September 2016, the researchers performed tests to check the possibility to inject the previously pumped water in the limestone via the second drilling well. The results were positive.

After the injection tests, the activities shifted to the topsoil: the construction of the geothermal energy plant, the installation of heat exchangers and pumps and the creation of a heat grid to the premises of VITO, SCK•CEN and BelgoProcess. The creation of the heat grid has already been completed and on 9 October 2017, the official laying of the foundation stone of the first geothermal energy plant for heat and power in the Benelux took place.

The official opening of the finished geothermal energy plant will follow by mid-2018. After that, the premises of VITO, SCK•CEN and BelgoProcess will be heated with geothermal heat, followed by the broader Kempen region.

VITO continues to do research into the deep Kempen subsoil. To this end, the third exploratory drilling started in November 2017. This well will reach a depth of at least 4,400 m and a total length of almost 5 km, as it will be a directional well. The results will follow in the course of the first few months of 2018.

Source: [https://vito.be/en/media-events/press-](https://vito.be/en/media-events/press-releases/deep-geothermal-energy-in-the-kempen-what-s-next)

[releases/deep-geothermal-energy-in-the-kempen-what-s-next](https://vito.be/en/media-events/press-releases/deep-geothermal-energy-in-the-kempen-what-s-next)

Denmark: Compensation Guarantee for Geothermal Projects

To encourage the pursuit of geothermal energy sources, a compensation guarantee has been put in effect per 2015 for projects in Denmark. The compensation guarantee comprises a user charge, correlating to a percentage of the budget: 13.5% for the first well, and 9% for each following well. In return, the insurance policy covers three guarantees in total:

- Drill Risk Guarantee: coverage of budget overruns while drilling (*see* Figure 1).

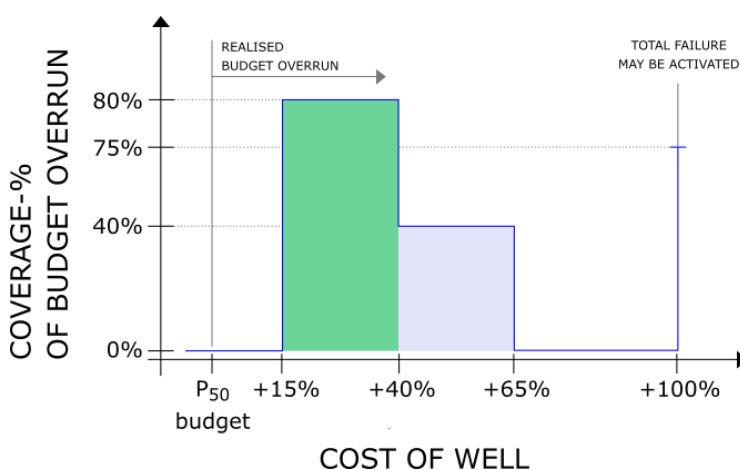


Figure 1. a) For budget overruns between 15% and 40% of the approved budget, the Danish Compensation Guarantee may cover 80% of the budget overrun. b) Between 40% and 65%, 40% of the budget overrun may be covered. c) If the well fails or the budget overruns >100%, 75% of the budget overrun may be covered.



Drilling rig in Balmatt. Photo taken from the source.

- Total Damage Guarantee: partial coverage of drilling costs, provided the project must be abandoned due to technical problems (Figure 1).

- Reservoir Risk Guarantee: partial coverage of drilling costs, provided that the reservoir does not perform as expected (*see* Figure 2, next page).

The implemented legislation on the Danish Compensation Guarantee –available on www.retsinformation.dk– was based on a document compiled by WellPerform for Energistyrelsen. WellPerform is a Danish firm headquartered in Copenhagen, providing drilling services like Project Management, Well Engineering, Drilling

Supervision, Drill Pad Design, Safety Management, Well Examination, Logistics and Contracts.

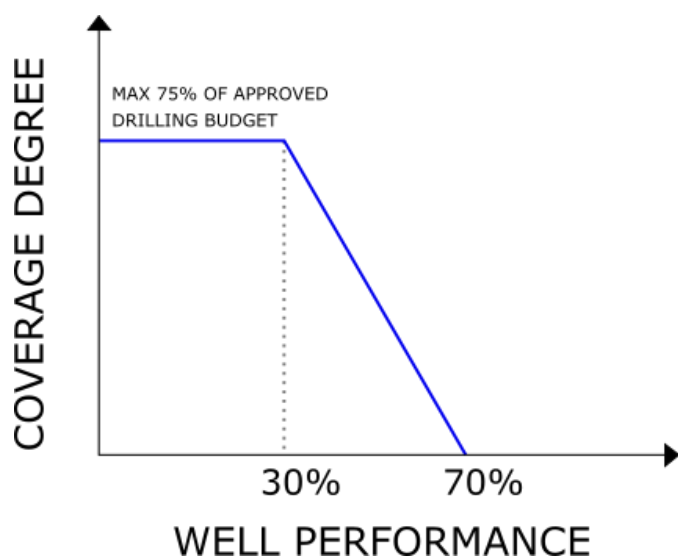


Figure 2. a) If the performance of a production tested reservoir is <30% of the expected, 75% of the approved budget may be covered for the first well drilled. b) If the performance of a production tested reservoir is $\geq 30\%$ but <70% of the expected, a partial amount of the budget may be covered for the first well drilled. c) The coverage may not amount to more than the economic loss that the license holder suffers as a consequence of a reduced performance of the geothermal plant in conjunction with estimates of the expected performance.

Source: <http://www.wellperform.com/geothermal-development-the-danish-compensation-guarantee/>

Finland: Drilling at Espoo Geothermal Project Reaches 5,200 Meters

Excerpts from a report by Peter Malin, Adjunct Faculty in the Huffington Department of Earth Sciences of the Southern Methodist University (SMU).

In September 2017 drilling recommenced on the St1 Deep Heat Project in Finland. Well OTN-III, which had been drilled to 4,500 m using air drilling, switched to water drilling. Over the course of 60 meters, three drill bits were consumed. The decision was made to switch to rotary drilling. Rotary drilling commenced and a “J” incline to 35° began.

At 5,020 m, with an inclination of 20°, a fault zone was encountered. The fault zone caused a 3-week delay in drilling as the drill bit became stuck several times. After the drill bit was freed the first time a Jar device was

attached to help release the bit on subsequent occasions. During this process the well was cemented and re-drilled at least 6 times. During one of the recovery efforts for the drill bit an earthquake occurred, with a magnitude of -0.8 to -1.

After making it through the fault zone, rotary drilling continued. By October 15, the well was at 5,200 m depth with an inclination of 30°. The next step is logging of the well from 3,500 m to 5,200 m followed by continued drilling at the 30° incline. The goal is to drill to 6,200 m. Stimulation at 6,200 m is scheduled for December 2017 or January 2018.

St1 is going to be drilled 7 km down to the Espoo bedrock, deeper than ever before in Finland. The aim of the St1 Deep Heat Pilot project is to build Finland’s first industrial scale heating plant, Fortum, operating as a sales partner in geothermal energy. The heating plant itself is due to be completed in 2018 and is designed to cover 10% of Espoo’s district heating needs, which currently sum 40MW thermal –all provided by fossil fuel. Once the pilot project succeeds, technology can be introduced elsewhere in Finland.

A self-made billionaire having made a \$1.5 billion fortune on fossil fuels, Mika Anttonen, is behind the St1 project. He’s said to be among the most passionate renewable energy champions in his native country Finland. His company, St1 Oy, is a Finnish energy company owning the St1 service stations’ chain in Finland, Sweden, Norway and Poland. The company was established in 1995 and has now around 1,500 petrol stations. Anttonen has made a big bet on wind power, biofuels and now on geothermal energy.

“It sure is exciting, since nobody has ever done anything like that before. This is a bit like Jules Verne on the Journey to the Center of the Earth”, said Mika Anttonen.

Sources:

<http://blog.smu.edu/geothermallab/2017/10/12/rotary-drilling-st1-deep-heat/>,
<http://www.thinkgeoenergy.com/finnish-billionaire-behind-pioneering-geothermal-heating-project-in-finland/>

Greece: MOU on Geothermal Development on Santorini Island

On early December 2017, it was announced that the development of the geothermal fields of the island of Santorini and the management of the urban waste of the region were awarded to the Greek company PPC Renewables, following a Memorandum of Understanding (MOU) signed between the Deputy Minister of Shipping and Island Policy, Nektarios

Santorinis, Mayor of Thera, Anastasios-Nikolaos Zorzos and the CEO of PPC Renewables, Elias Monachia and approved by the Municipal Council of Thira.

PPC Renewables will undertake the possibility of developing geothermal energy on the island for power generation, heating, cooling, seawater desalination and use for hot springs.

The development of a geothermal power plant with the exploitation of the geothermal potential, aims to cover the current and future needs of the island, even in a peak period, ensuring the energy autonomy and stability of the island's network. Using geothermal energy will definitively solve the issue of providing high-quality drinking water to residents and visitors.

In addition, cooling-heating needs for hotels and irrigation needs can be covered by the desalination method, giving opportunities for development and the agricultural sector.

The development of geothermal fields will be in accordance with national and European legislation, gradually and in full co-operation with the Municipality of Thira and the local community, which will give even greater impetus to tourism development, but also to prolong the tourist season in one of the most popular tourist destinations in the world, such as Santorini.

At the same time, PPC Renewables will contribute to the study and management of urban waste in the area, as well as to the development and construction of a plant using the optimal environmental and financial management system to produce energy. Not only the big problem of urban waste disposal will be tackled, but Santorini will emerge as a model island that exploits the waste, instead of having it, outside of national and European policy.

Source: <http://www.thinkgeoenergy.com/ppc-renewables-signs-mou-on-geothermal-development-on-island-of-santorini/>

Iceland: Theistareykir and Hellisheidi Power Plants

First Phase of Theistareykir Plant Commissioned in November - The 45MW first phase of Theistareykir geothermal power plant was commissioned on 17th November 2017, during a ceremony attended by high ranking government and municipal officials as well as Landsvirkjun and contractor staff. The plant is the

third geothermal plant of the Iceland national power utility Landsvirkjun. The second phase of the plant, of another 45MW, will be on-line in April.

Five exploration wells were drilled in 2002 and 2003. The first production well drilled in 2002 was promising and yielded 6 MW. In 2016 and 2017, 10 production wells were drilled, including one in the Krafla area, making the total number of wells at the Theistareykir 18, providing enough steam for over 100MW.

The Icelandic engineering and consulting firm Mannvit played an important role in the project development on behalf of Landsvirkjun. Mannvit prepared project design reports, designed wells, oversaw technical supervision of the drilling of the current wells and evaluated the size of the geothermal area. Mannvit also carried out project design for high voltage lines and substations, as well as evaluating the environmental impact (EIA) and performing a joint EIA of high voltage lines and power plants in the area. Mannvit, in collaboration with Verkis, handled the overall design of the power station and preparation of tender documents. Tark-architects and Landslag-landscape architects were also a part of the main contractor group. The turbine, generator and cold-end were constructed and installed by Fuji Electric and Balcke-Durr.

Claus Ballzus, project manager, stated: "There are many challenges due to the location of the plant. Theistareykir is an uninhabited area, more than 300 m higher than sea level, where there is heavy snow. Despite this, construction work could be done during the winter, thanks to the good roads that had been built. Construction of the plant's powerhouse commenced in May 2015."

Landsvirkjun is owned by the Icelandic state and is the country largest electricity generator, processing 75% of all electricity used in Iceland from hydroelectric power, wind and geothermal energy. Landsvirkjun operates 17



View of Theistareykir. Photo by Mannvit.

power stations in Iceland, including now three geothermal-electric.

With this first unit in operation, the total geothermal installed capacity in Iceland is 709.4 MW.

Sources: <http://www.mannvit.com/news/theistareykir-geothermal-power-plant-commissioned/>, <http://www.mannvit.com/projects/theistareykir-geothermal-power-plant/>

Hellisheidi Power Plant Is the First ‘Negative-Emissions’ Facility - A groundbreaking project was initiated at the Hellisheidi geothermal plant in Iceland. In cooperation with Iceland’s multi-utility company Reykjavik Energy (RE), the Swiss firm Climeworks has installed for the world’s first time a technology combining safe and permanent geological storage with highly scalable carbon removal technology through direct air capture (DAC). The pilot plant is part of the CarbFix2 project, which has received funding from the European Union’s Horizon 2020 research and innovation program, under grant agreement No. 764760.

The project is centered around one of the world’s largest geothermal power plants in Iceland, where CO₂ is currently injected and mineralized at an industrial scale. The Climeworks DAC module captures CO₂ from ambient air for permanent storage underground, thus creating a carbon removal solution which some scientific studies indicate is essential to achieving the two-degree climate target.

The DAC module has been installed on site, and it has started a testing phase during which it’s expected to see how the technology is operating in the weather conditions of South West Iceland. The general process is as follows:

- The Climeworks DAC module captures CO₂ from ambient air;
- The CO₂ binds to the Climeworks patented filter;
- Once the filter is saturated with CO₂, it is heated by low-grade waste heat from the geothermal plant;
- The CO₂ is released and bound to water;
- The carbonated water is pumped more than 700 meters underground;
- Here, it reacts with the basaltic bedrock, forming solid minerals;

Then, a permanent, safe and irreversible storage solution is created.

According to Climeworks, the CarbFix2 project imitates natural processes and speeds them up rapidly. The potential of scaling up this technology in combination with this effective CO₂ storage is enormous, since it

unlocks possibilities in Iceland and numerous other regions in the world where there is a similar geological foundation of basalt.

Sources: <http://www.climeworks.com/climeworks-and-carbfix2-the-worlds-first-carbon-removal-solution-through-direct-air-capture/>, *The EGEC Newsletter*, October 2017.

Italy: First Greenhouse for Algae Cultivation Heated by Geothermal Plant

A new greenhouse heated by geothermal energy for the cultivation of Spirulina, a type of algae which is highly nutritious and rich in iron and protein, was opened on 15th October 2017 in Chiusdino, Italy. The innovative pilot project is the first example of geothermal heat supplied by a nearby geothermal power plant and used for Spirulina cultivation.



The greenhouse will use both geothermal heat and carbon-free CO₂ from the adjacent geothermal power plant, a product of the geothermal energy production process and a substitute for natural emissions, useful for fostering the cultivation of algae. The project, which is part of an agreement between ENEL Green Power and Co.Svi.G. for experimenting on the uses of geothermal energy in algae cultivation signed earlier in 2017, aims to demonstrate the possibility of developing high-value commercial cultivation near existing geothermal power plants, therefore increasing the economic impact associated with geothermal energy.

The greenhouse is another example of the many direct-uses of geothermal energy in agricultural and food industry, which is increasingly turning to geothermal energy as it meets many of the sectors’ requirements.

Source: <https://www.egec.org/first-greenhouse-algae-cultivation-heated-geothermal-plant-launches-today/>

Portugal: 4MW New Power Plant Starts to Operate in Terceira Island

A 4MW binary cycle geothermal power plant was officially inaugurated on 20th November 2017 at Pico Alto, Terceira Island, in the Azores. The plant was designed and built by the Italian company EXERGY and the Portuguese company CME for EDA RENOVÁVEIS, owned by EDA, the Azores power utility company.

The 4MW unit utilizes a geothermal high enthalpy resource, exploiting the heat available both in steam flow and geothermal brine. For this challenging project located in a remote site, in the center of Terceira Island, 1500 Km off Portugal mainland, the Consortium EXERGY-CME supplied a turnkey solution, including the engineering and construction of the gathering systems, the air cooled ORC unit equipped with EXERGY Radial Outflow Turbine and all balance of plant equipment.

Its tailored design has made it possible for the turbine to reach the highest possible conversion efficiency producing up to 4.9 MW of electricity, with an average of 4.5 MW, thus over-performing on the values guaranteed to the client.

By means of the Pico Alto geothermal plant, EDA Renováveis is now providing a sustainable and reliable source of electricity to more than 56,000 inhabitants of Terceira, meeting up to 10% of the island electricity needs.

Participating at the inauguration ceremony, chaired by the President of the Regional Government of the Azores Mr. Vasco Cordeiro, Marco Bonvini COO of EXERGY commented: “We are very proud of the

successful completion of this challenging project. Pico Alto represents for us a great example of how innovation in greentech can provide sustainable solutions to satisfy people energy needs and contribute in improving the energy economics in remote and isolated site of the planet. We see many opportunities to apply our technology in remote environments and Pico Alto is a good starting point and an excellent reference”.

Carlos Alberto Raposo Bicudo Ponte, member of EDA Renováveis Board of Directors declared: “The Pico Alto Geothermal Power Plant inauguration is the first milestone for the commercial geothermal exploitation start up in Terceira Island, increasing the diversification of the power generation mix and boosting the contribution from renewables. The construction project was a technical and management challenge, with several contractors working at same time and, in some occasions, in harsh climate conditions. This was effectively overcome thanks to the close cooperation from all the high-specialized teams, where EXERGY assumed successfully the lead role. We are very pleased with the initial production results. For the first two months of operation, the Pico Alto power plant have been providing a stable and reliable supply of 4MW of electricity to the grid. Maintaining this high performance in 2018, the annual production of Pico Alto power plant will likely surpass the estimative made before the construction of the power plant. Thus, geothermal contribution will probably exceed 10% of the electricity needs of Terceira, relieving this part of the power production from thermal groups, where fossil fuels are consumed, hence ensuring savings to the economy of the Azores, as well as environmental benefits, reducing the greenhouse gas emissions to the atmosphere.”

Source: <http://exergy-orc.com/communication/news/exergys-pico-alto-4-mwe-geothermal-plant-now-powering-up-terceira-island-in-the-azores>



View of the Pico Alto plant. Photo by EXERGY.

The Netherlands: Green Light for First Geothermal Station in The Hague

The green light was given on early October 2017 for the so-called Haagse Aardwarmtecentrale Leyweg (HAL). Starting next year this geothermal station will supply power to homes in The Hague Southwest.

The HAL will supply sustainable energy as of 2018 from wells lying more than 2,000 meters under the

ground. Between now and the coming five years at least four geothermal stations will become operational in The Hague. This number will increase to more than 10 stations in the future. Thanks to The Hague's location, the power can be found just beneath the earth's surface and this geothermal energy is an excellent source of alternative energy.

The geothermal project in The Hague Southwest is being restarted. The company Haagse Aardwarmte Leyweg (HAL) took over two geothermal wells drilled in 2010 to supply heat. It is the first urban-based geothermal station in The Hague and in the Netherlands.

The Hague aims to become climate-neutral by 2040 and pushes all homes in the city to be disconnected from the gas grid. The Hague has decided upon geothermal power as the most important alternative source of sustainable energy.

More than half of the electricity consumed by The Hague each year is generated by burning natural gas. The gas is used primarily for heating buildings, showering and cooking. Altogether gas burning counts for more than 40% of The Hague's annual carbon dioxide emissions.

In order to make all of The Hague's homes gas free and sustainable by 2040, an average of 10,000 homes per year need to be insulated and connected to alternative energy sources starting now. In addition to geothermal energy, The Hague is also deciding in favor of wind and solar energy and heat pumps. Newly constructed homes will no longer get a gas connection.

An energy plan will be drawn up for each neighborhood of The Hague. The plans will be made together with residents, housing corporations, power companies and experts.

Source: <https://www.den Haag.nl/en/in-the-city/news/first-geothermal-station-in-the-hague-in-2018-.htm>

Turkey: Kuyucak Power Plant, 1053 MW of Installed Capacity, Production of Spirulina and Tomatoes

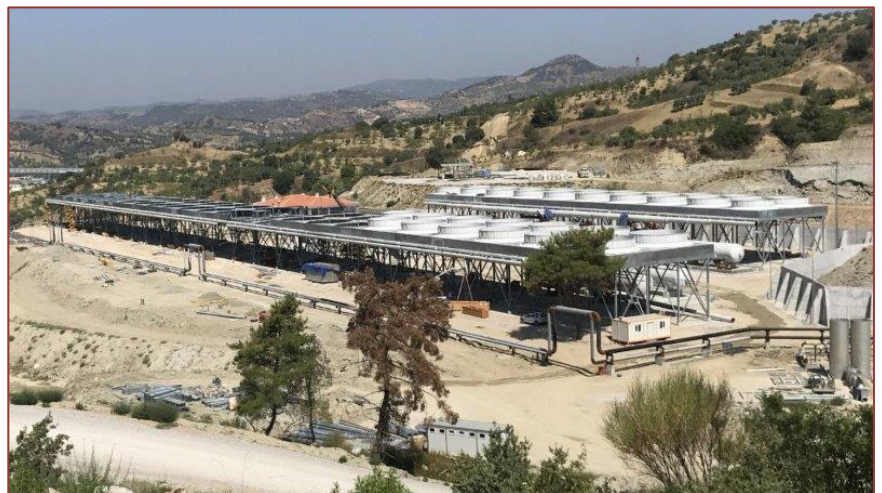
Kuyucak Geothermal Power Plant Has Started Operation - A new unit of 8 MW of the Kuyucak geothermal power plant has started operations in early December 2017. The first unit of 10 MW has been provisionally accepted on October 27. Thus, the power plant has now 18 MW in capacity, according to the

license received by Turcas Kuyucak Geothermal Electricity Generation Co. (TKJ) in 2016.

The first production drilling and short-term well flow tests were completed in November 2014 in the business license area of Aydin Kuyucak District of Aydin Province. Between 2014 and 2016, the project drilled seven wells, of which are 5 production and 2 reinjection wells. The last well was successfully completed in early 2017. In 2016, production potential was determined and the first phase production module was ordered. The temporary regulatory acceptance was completed as of December 7, 2017.

The first-phase electricity production capacity has a production license of 18MW in total. The plant is operated in a joint venture by Turcas Petrol, through Turcas Energy Holding Inc. (TKJ) holding 92% and Alte Enerji (8%).

On March 1, 2016, TKJ and Türkiye Sinai Kalkinma Bankasi A.S. (TSKB) signed a 14 years loan agreement with cash and/or non-cash loans amounting to US\$ 15 million and US \$ 40.5 million and non-cash loans with a maximum of 30 months principal amounting to TL 10 million. The loan has been used to finance the investment of the Kuyucak geothermal power plant, totaling US\$ 71.25 million (including financing costs).



Turcas Kuyucak geothermal plant, Aydin/ Turkey (source: Turcas Kuyucak Jeotermal Elektrik Üretim A.S., Mehmet Salim Karpuzoglu. Taken from the source.)

Turcas Kuyucak JES will sell electricity within the scope of YEKDEM (Renewable Energy Support Mechanism of Turkey) starting to sale electricity from January 1, 2018 for a period of 10 years. The plant will earn US\$0.118/ kWh feed-in-tariffs, with additional incentive to use domestic equipment for electricity generated during the first five years. In the following second five-year period, the electricity to produce the plant is entitled to sell at a price of \$0.105/ kWh.

Source: <http://www.thinkgeoenergy.com/18-mw-turcas-kuyucak-geothermal-power-plant-starts-operation-in-aydin-turkey/>

1053 MW of Installed Capacity, According to JESDER - Mehmet Şişman, vice chairman of the Association of Geothermal Power Plant Investors (JESDER), said the geothermal-electric capacity in the country has risen to 1053 megawatts, and that Turkey is now fourth among countries with the most geothermal energy, following the U.S., the Philippines and Indonesia. He said that it targets to be the top in geothermal energy in the very near future.

At a meeting with a group of journalists on December 2017, the JESDER vice chairman said that the geothermal energy industry has grown by 60 percent to 70 percent annually since 2007. “Our installed power in geothermal energy in 2007 was approximately 25 megawatts, but now we have reached 1053 megawatts, and we will end the year with 1086 megawatts,” he said. The official website of the Ministry of Energy and Natural Resources reports 860 MW of geothermal capacity as of June 2017.

“We expect an investment of around US\$1 billion in the industry in 2018,” he said, adding that installed capacity in energy power plants is 83,000 megawatts as of late November 2017, with nearly 1.2 percent of it being covered by geothermal power plants.

Turkey will end 2017 with electricity production of 289 terawatts-hour, with geothermal energy power plants providing 6 TWh, or 2.1 percent of overall production.

“With the electricity we have produced in these power plants, we have been able to prevent natural gas imports of approximately US\$650 million. Geothermal energy is a completely domestic resource and we are happy to have explored the sleeping ore from under the ground thanks to a law that was passed in 2007,” he said.

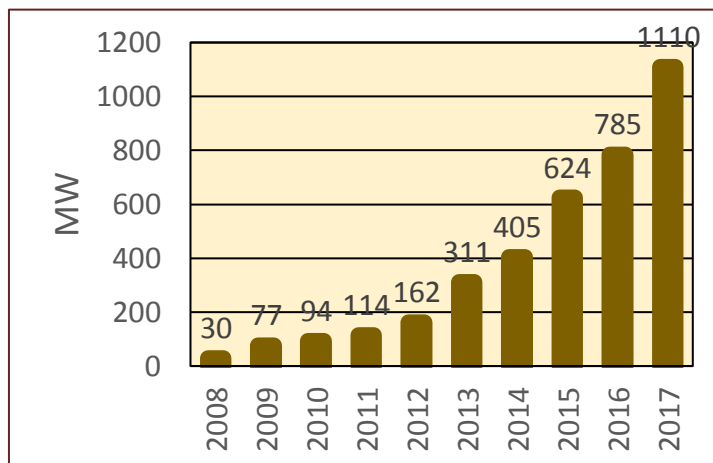
Şişman said that this success was achieved through public-private cooperation. He also said that Turkey can become the largest geothermal energy producer in the world with government assistance. He added all the players in the industry are locals, and that the use of domestic parts is accompanied by additional contributions, citing that past year three to four power plants benefited from domestic product incentives.

Şişman said the support mechanism to be implemented in the geothermal industry after 2020 needs to be announced very soon. He also stressed that it is necessary to take precautions and deploy support mechanisms today in order to ensure that plant investments that will require at least three years to be installed continue so that they can be commissioned after 2020 as well.

In related news, ThinkGeoEnergy published interesting data showing the pace at geothermal has growth in the last decade, passing “From a power generation capacity of 30 MW in 2008 to 1,100 MW in 2017...” (see the graph below).

Sources:

<https://www.dailysabah.com/energy/2017/12/19/geothermal-industry-to-receive-1b-investment-in-2018>,
<http://www.enerji.gov.tr/en-US/Pages/Geothermal>,
<http://www.thinkgeoenergy.com/indonesia-vs-turkey-the-different-path-of-growing-a-geothermal-market/>



Increase in the geothermal installed capacity in Turkey in the last decade (with data from ThinkGeoEnergy).

Project on Production of Algae from Hot Springs Started in Yalova - A new project on the production of spirulina from geothermal hot springs in Turkey, was officially opened in Yalova, on late November 2017.

The ‘Water and Spirulina (Microalgae) Production from Different Geothermal Waters’ project has been sponsored by Yalova University Armutlu Vocational School and supported by General Directorate of Agricultural Researches and Politics (TAGEM) of Ministry of Food, Agriculture.

Yalova University Instructor Associated Betül GÜROY stated that the project was realized with the participation of researchers from Gaziantep University and İzmir Kâtip Çelebi University and with the assistance of Armutlu Municipality, Incirliova Municipality and Ankara Metropolitan Municipality in the direction of Yalova University.

In his presentation, GÜROY talked about Spirulina cultivation conditions, benefits and usage areas. He said that the purpose of this project to produce together with geothermal water from natural renewable energy sources and to lower the production cost. GÜROY stressed that it would be possible to increase the interest in domestic spirulina production, reduce its widespread distribution and imports, and thus enable geothermal

water to be registered as an indigenous and natural food environment for spirulina breeding.

Source: <http://www.thinkgeoenergy.com/project-on-production-of-algae-from-geothermal-hot-springs-started-in-yalovaturkey/>

Geothermal Resources Boost Production of Turkish Tomato - Turkey's largest tomato exporter hopes to further exploit boiling subterranean geothermal waters in order to become the world's leading exporter.

Agrobay, a company based in Dikili-Bergama in the Aegean province of İzmir, currently produces 15,000 tons of tomatoes from greenhouses that utilize thermal waters dotted across western Turkey.

The Dikili-Bergama region sits on one of hundreds of geothermal fields where underground waters can reach temperatures of up to 287°C, according to the U.S. Stanford University.

Hasanbey Farm, the Agrobay's precedent, was originally founded as an organic garden in 2001, with several greenhouses constructed on 15 acres (6 hectares) of land. The company has extended to 173 acres (70 hectares) today, making it the largest in Europe and the second largest in the world after Mexico," said the Agrobay CEO Arzu Şentürk, adding that she aimed to increase the total land area to 247 acres to boost production and exports.

Agrobay currently exports 90 percent of its tomatoes to Russia and the EU. Among the modern techniques used on the farm, which employs around 1,000 staff, is a closed irrigation system that allows Agrobay to save fertilizer, energy and water.

The used water is collected and returned to underground geothermal reserves, cutting costs and helping the environment.

"We save water and energy," the Agrobay website states. "We prevent the decrease of water over time in the geothermal resource, which is our national heritage, and this resource is transferred to future generations," it adds.

Source: <http://www.hurriyetdailynews.com/top-turkish-tomato-exporter-looks-to-hot-springs-to-lead-world-market-124009>

Oceania

Australia: Towns to Start to Use Geothermal Fluids

Winton Shire Council is on the verge of opening Australia's largest geothermal energy plant, which will power the town's key council buildings and potentially

the whole community, bringing savings of up to AD\$15 million (US\$12 million) in energy consumption. Set to open in December 2017, the Winton geothermal power plant, designed by the consultancy Local Government Infrastructure Services, will avoid changing the geological or chemical composition of water supplies in the region, by using hot water from existing bores, which will be converted into a sustainable long-term energy source.

It will be a welcome addition to the rural community, which has been hit hard by drought, and will allow funds to be directed towards other local priorities. The move to sustainable energy was the vision of long-serving Winton Chancellor and Mayor Graham "Butch" Lenton, who died recently.

Council chief executive Alan Rayment says the power plant will serve as a legacy for Lenton, who "always looked outside the box for ways to help the community". "He realized that as a community, to survive and succeed, we need to keep looking for new opportunities like geothermal power and approach them with rigor and process," Rayment says.

Four other rural and remote councils will also embrace the technology, with the Local Government Association of Queensland borrowing AU\$35 million (US\$28 million) for plants in Quilpie, Thargomindah, Normanton and Longreach. It is estimated that over 20 years, the plants will save the state government up to AU\$120 million (US\$ 96 m) in power supply subsidies.



The completed Winton generators are ready to be shipped to the western Queensland site. Photo provided by Jari Ihalainen.

Jari Ihalainen, CEO of Technical and Advisory Services, said the Winton project is a small pilot plant but the aim is to eventually provide 100 per cent of power to the community. He said other geothermal plants are being explored, and there are around 20 potential sites.

Thargomindah, approximately 1,000 kilometers west of Brisbane, is at the end of the line on the electricity grid,

and residents say it causes frequent blackouts. In order to tackle the power issue the local government has decided to establish a geothermal power plant, and work to flip the existing formula by pushing energy back into the network from the west to the east.

“In layman’s terms what we’re looking at is a glorified steam turbine with a solar load-following operation... so we’re taking the water out of the ground which is the Great Artesian Basin at 83 to 86 degrees Celsius, and then running that through a power plant which converts the heat into energy,” Bulloo Shire Council CEO Edwina Marks said. Dr Marks said the project has reached the concept design stage, and has attracted some state government help with an AU\$3.6 million dollar (US\$2.8 m) grant.

Sources: <http://www.theaustralian.com.au/national-affairs/state-politics/town-will-soon-start-to-run-on-hot-water/news-story/b3500646ae2c4496b92684cb01ba4a7c>, <http://www.abc.net.au/news/2017-11-06/geothermal-power-in-western-queensland/9116698>

New Zealand: Drilling to Start for Ngawha Expansion

Earthworks preparing the geothermal well drilling site have begun on farmland bought by Top Energy near Ngawha Prison. Drilling itself is due to start early 2018 in charge of the company Iceland Drilling, which will send a specialist team and be based in Northland for one year from April 2018.

Top Energy, which already operates two geothermal power plants totaling 25 megawatts (MW) at Ngawha, east of Kaikohe, had been weighing to expand the current capacity of its station, and utilize all the available geothermal resources, depending on the New Zealand electricity market conditions (*see* IGA News 109, p. 38).



Now the company has gained consent for a two-stage expansion, which could eventually boost capacity to around 81MW. The resource consents were granted for the project in July 2017, and are valid for 35 years.

Providing a viable geothermal resource is found, the next stage will be earthworks for the power station itself. Stage 1 of the project, building a 28MW power plant, was due to be completed in June 2021.

Top Energy chief executive Russell Shaw said the company had now passed the final hurdle in the way of construction, which was getting major transaction approval from the Top Energy Consumer Trust and Top Energy Board.

A bank loan of NZ\$175 million (US\$119 million) had been secured to pay for the project. It'll constrain in the short term the Top Energy's ability to spend on other capital projects, but it means ownership of the power station. The other option would have been using equity funding by selling off part of the existing power station to pay for the new one.

It would be clear by September 2018 whether the geothermal resource is viable. Once that is clear the company could finalize contracts for the transmission connection, supplying the station, and the fluid conduction system.

The Israeli company Ormat has the contract to design, build and supply the power station which will be commissioned in 2021. Ormat has a long history with the operations at Ngawha supplying the original 10 megawatt power station, which was commissioned in June 1998 and then expanded to 25 megawatts in 2008.

Mr. Shaw said it had been a “long and convoluted road” to reach a point where the company was confident the project would go ahead. The power station expansion was one of the most significant projects ever undertaken in the New Zealand's Far North, and could ultimately secure the district's energy independence, he said.

The Far North's peak power demand is 70MW. Currently the Far North, and Northland as a whole, imports the bulk of its electricity, making it vulnerable to outages and power price hikes.

Sources:

http://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=11942772,
http://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=11957571

Other

Climate Change: Syria Joined Paris Agreement, Isolating U.S.

Syria signed up to the Paris agreement at the COP23 climate summit in Bonn, leaving the U.S. as the only country out of the global pact to prevent climate catastrophe.

The declaration was made by a Syrian delegate at a plenary session of the Bonn conference.

Since 2012, Syria has been embroiled in a bloody civil war that has claimed 300,000 lives. Its greenhouse gas emissions in 2011 added up to 88.19 million tons – or 0.19% of the world total – according to U.S. Aid.

Nicaragua, which gets half of its energy from renewable sources, had also been withholding its signature until stronger measures were in place. But the small Central American state relented in October 2017, leaving just two countries standing opposed to the climate pact. And now there is one.

The U.S. will plough a lonely furrow at the Bonn summit, as it prepares to leave the Paris agreement within three years.

Kelly Love, a White House spokeswoman reportedly commented: “As the president previously stated, the United States is withdrawing unless we can re-enter on terms that are more favorable for our country.”

Safa’ Al Jayoussi, executive director of Jordanian NGO IndyACT, said the Syrian delegation announced they would join during a meeting of the working group on the Paris deal. She said the organization understood that the Syrian government intended to both sign and ratify the deal in the coming months.

It was important, she said, that all 22 countries from the Arab region would now be part of the deal.

Paula Caballero, the global director of the World Resources Institute: “With Syria on board, now the entire world – save one country – is resolutely committed to advancing climate action. This should make the Trump administration reflect on their ill-advised announcement about withdrawing from the Paris Agreement.”

This article originally appeared on Climate Home News.

Source:

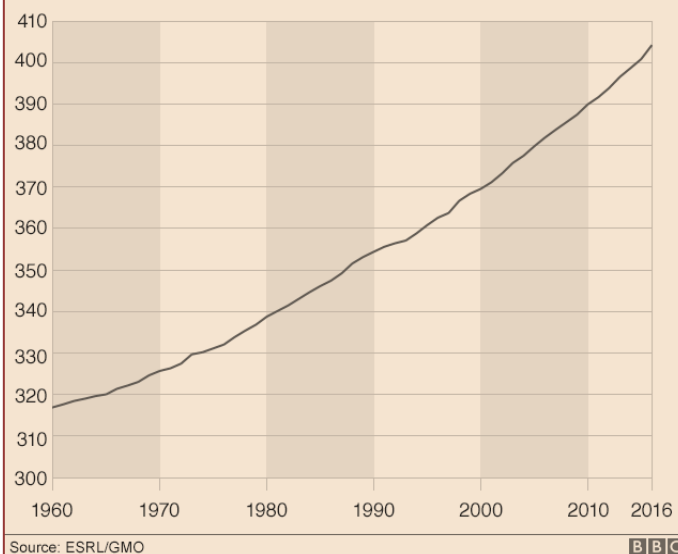
<http://www.climatechangenews.com/2017/11/07/syria-join-paris-agreement-isolating-us/>

Climate Change: Record Surge in Atmospheric CO₂ in 2016

Concentrations of CO₂ in the Earth’s atmosphere surged to a record high in 2016, according to the World Meteorological Organization (WMO). Last year’s increase was 50% higher than the average of the past 10 years.

Carbon dioxide concentrations have reached record levels

CO₂ parts per million (annual mean figures)



Researchers say a combination of human activities and the El Niño weather phenomenon drove CO₂ to a level not seen in 800,000 years. Scientists say this risks making global temperature targets largely unattainable.

The 2017 greenhouse gas bulletin produced by the WMO is based on measurements taken in 51 countries. Research stations dotted around the globe measure concentrations of warming gases including carbon dioxide, methane and nitrous oxide. The figures published by the WMO are what’s left in the atmosphere after significant amounts are absorbed by the Earth’s ‘sinks’, which include the oceans and the biosphere.

2016 saw average concentrations of CO₂ hit 403.3 parts per million, up from 400 ppm in 2015. “It is the largest increase we have ever seen in the 30 years we have had this network,” said Dr. Oksana Tarasova, chief of WMO’s global atmosphere watch program. “The largest increase was in the previous El Niño, in 1997-1998, and it was 2.7 ppm; and now it is 3.3 ppm. It is also 50% higher than the average of the last 10 years.”

El Niño impacts the amount of carbon in the atmosphere by causing droughts that limit the uptake of CO₂ by plants and trees. Emissions from human sources have slowed down in the last couple of years according to research, but according to Dr Tarasova, it is the cumulative total in the atmosphere that really matters as CO₂ stays aloft and active for centuries.

Over the past 70 years, says the report, the increase in CO₂ in the atmosphere is nearly 100 times larger than it was at the end of the last ice age. Rapidly increasing atmospheric levels of CO₂ and other gases have the potential, according to the study, to “initiate

unpredictable changes in the climate system... leading to severe ecological and economic disruptions”.

According to experts, the last time the Earth experienced a comparable concentration of CO₂ was three to five million years ago, in the Middle Pliocene Epoch. The climate then was 2-3°C warmer, and sea levels were 10-20m higher due to the melting of Greenland and the West Antarctic ice sheets.

Source: <http://www.bbc.com/news/science-environment-41778089>

Climate Change: World's Heavy Dependence on Fossil Fuels Projected to Continue

Global energy consumption will increase 28% between 2015 and 2040, with fossil fuels still providing the bulk, 77%, of the energy consumption by 2040, according to a new report by the U.S. Department of Energy's Energy Information Administration (EIA).

The increased energy use will be matched by a 16% increase in energy-related carbon dioxide (CO₂) emissions over that same time period, with annual emissions rising from 33.9 billion metric tons in 2015 to 39.3 billion metric tons in 2040, according to EIA's report, "International Energy Outlook 2017." That energy usage, increasing from 575 quadrillion British thermal units (Btus) (607 exajoules) per year in 2015 to 663 quadrillion Btus (700 exajoules) in 2040, assumes an annual 1.7% gross domestic product growth in the Organization for Economic Co-operation and Development (OECD) countries—including the United States and many European nations—and a 3.8% growth in non-OECD countries.

The new report, which provides long-term modeled projections of energy production and consumption, states that energy consumption could be up to 40 quadrillion Btus (42 exajoules) higher or 29 quadrillion Btus (31 exajoules) lower annually, depending on what rates of economic growth actually occur and other factors.

The growth rate of energy-related CO₂ emissions is expected to ease, with an average 0.6% increase per year between 2015 and 2040, according to the report. That's a sizeable drop from a 1.3% annual growth rate from 1990 to 2015. EIA attributes that anticipated slowdown to increases in energy efficiency and a gradual shift from coal to natural gas and renewable energy sources.

The report also forecasts a 2.8% annual increase in renewable energy, including hydropower. "By 2040, generation from renewable energy sources surpasses generation from coal on a worldwide basis," the report states.

EIA's projections find renewables to be the most rapidly growing energy source for electricity generation. Still, the agency may be underestimating the contributions from renewables, according to some economists, including Rachel Cleetus, lead economist and climate policy manager for the Union of Concerned Scientists.

The report also forecasts a continued decrease in carbon intensity, the amount of energy used per unit of economic growth. EIA attributes that decrease to China's decline in coal use and to global growth in the use of non-CO₂-emitting sources of energy.

The industrial sector continues to account for the largest share of energy consumption through 2040, with a 0.7% annual increase in energy use between 2015 and 2040. However, other sectors grow faster, with energy use for the transportation and building sectors increasing 1% and 1.1% annually, respectively.

The report projects that natural gas will be the world's fastest growing fossil fuel, increasing by 1.4% annually, whereas petroleum and other liquids will increase 0.7% and coal will see just a 0.1% increase, with declined usage in China and OECD regions offset by growth in India and other non-OECD countries.

Source: <https://eos.org/articles/worlds-heavy-dependence-on-fossil-fuels-projected-to-continue>

Climate Change: Geothermal Meeting at the COP23

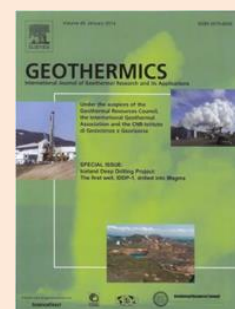
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<http://www.elsevier.com/locate/geothermics>



On 16 November 2017, in the framework of the Conference of the Parties 23 (COP23), held in Bonn, Germany, the IRENA (International Renewable Energy Agency) and the Global Geothermal Alliance (GGA) convened a high-level roundtable on ‘Geothermal in the Global Energy Transformation: What way forward?’ This COP23 side-event was held at the IRENA Pavilion, and focused on the following subjects:

- The role of geothermal energy in the achievement of medium- and long-term de-carbonization goals;
- Key challenges and possible solutions to unlock geothermal investments;
- The contribution of international cooperation under the umbrella of the Global Geothermal
- Alliance to accelerate the deployment of geothermal energy across the globe.

Alexander Richter, president of the IGA, gave a clear statement on the opportunities to mitigate climate change by changing the fossil-fuel based district heating system by geothermal.

The GGA initiative, launched during COP21 in December 2015, serves as a global platform for improved dialogue, cooperation and coordinated action among policy makers, industry, and other stakeholders. The Alliance, composed of over 70 member countries and partner institutions from across the globe, aims to improve the environment for geothermal energy development so to achieve a five-fold growth in the global installed capacity for geothermal power generation and a two-fold growth for geothermal heating by 2030. The GGA is designed to provide customized support to regions and countries with geothermal potential, facilitate the exchange of insights and experience among key stakeholders, and provide technical assistance, advice, and capacity building.

Source: <http://www.irena.org/-/media/Files/IRENA/Agency/Topics/Climate-Change/COP-23-IRENA-GGA-High-Level-Roundtable-Concept-Note-16-November-2017.pdf>

Climate Change: Massive Fires in U.S. Southern California

By December 2017, massive wildfires were raging across Southern California, threatening thousands of homes and cultural landmarks like the Getty Museum in Los Angeles. It's been an unusually bad year for the state—amid an unusually bad year for the West at large. Fires in California have destroyed more than 6,000 structures and incinerated hundreds of thousands of acres. Montana and British Columbia both also had some of their worst wildfire seasons ever.

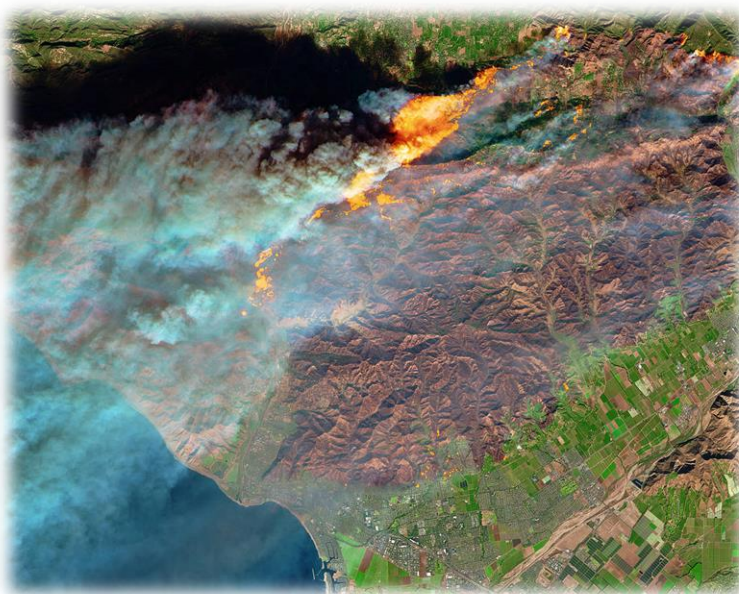
Of course, most years are bad wildfire years now. Seven of California's 10 largest modern wildfires have occurred in the last 14 years. (The state began keeping reliable records in 1932.) Given the scale of the blazes, and their increasing regularity, it makes sense to ask: Does global warming have anything to do with this?

The answer isn't as clear-cut as it was this summer, when drought- and heat-stoked fires raged across the Rockies and Pacific Northwest. Instead, a mix of forces are driving the fires in Southern California, and only some of them have a clear connection to global warming.

Here are some of the biggest factors that are shaping the wildfires in California—and how global warming is or isn't changing them:

The Santa Ana winds

Blame for the wildfires in Ventura and Los Angeles counties lies first and foremost with the Santa Ana winds, famously hot and desiccating gusts that blow from the desert to the coast. The Santa Ana winds also set the stage for the massive wildfires in Napa and Sonoma earlier 2017.



Fire in Ventura County, California, seen from the Multi Spectral Imager (MSI) on the European Space Agency's Sentinel-2 satellite on December 5, 2017 (Photo taken from <https://www.nasa.gov/image-feature/fire-in-ventura-county-california>).

Fires depend on two variables—an ignition source and fuel to burn—and the Santa Ana winds increase the availability of both. But there are few signs—at least so far—that the Santa Ana winds are becoming more prevalent or that they're systematically moving later in the year. A 2006 study from researchers at the University of California, Berkeley, and the Lawrence

Berkeley National Laboratory suggested that by the end of the century, Santa Ana winds may become more common. They may also form later in the year, including in December.

La Niña

There's currently a weak La Niña in the tropical Pacific, which means that global temperatures are cooler than they would be otherwise.

The same phenomenon is also keeping storms from making landfall in Southern California. Normally, California's wet season would have started by November, but the rains haven't appeared. Some of this is characteristic of La Niña ... as the southern tier of the United States sees less precipitation during La Niña winters.

It's still unclear how climate change will affect the Pacific's yearly dance between El Niño, La Niña, and a neutral state. A 2015 study in *Nature Climate Change* found that the Pacific Ocean may careen between extreme states—from an intense El Niño to a monster La Niña—by the end of the century, but more research on the question still needs to be done.

A very cold U.S. East Coast

Even as the West Coast remains warm and dry, the Eastern Seaboard is settling into some of its first cold weather of the season. This pattern—a warm West, a frigid East—is known as the North American winter dipole.

It's caused when the jet stream—which both ferries storms into the continent and generally divides warm air from cold air—gets especially twisted across North America. It rises far into the Canadian Northwest, keeping most of the western United States warm and dry; then it cascades down across the middle of the country, bringing cold air well into the U.S. Southeast.

This phenomenon prolonged California's drought during the first part of this decade, keeping any kind of storm system offshore. It also brought the infamous “polar vortex” down into the continental United States.

Daniel Swain, a climate scientist at the University of California, Los Angeles, argues that the ridge forms in part because the West is warming up much faster than the East. If this is the case, then scientists might expect to see the phenomenon fade in decades to come, as the East Coast catches up to the West.

But a paper published last November in *Nature Communications* takes another view. It finds that the disappearance of sea ice over the Arctic Ocean could change the circulation of the Pacific Ocean, encouraging the jet stream to veer north. In other words, climate change will make something like the North American winter dipole keep reappearing.

Source:

https://www.theatlantic.com/science/archive/2017/12/what-climate-change-did-and-didnt-have-to-do-with-the-socal-fires/547712/?utm_source=nl-atlantic-weekly-120817&silverid=MzEwMTkxMTUxMzg3S0

Financing: Lazard Analysis of Levelized Costs of Energy

Lazard is a one of the world's preeminent financial advisory and asset management firms, providing advice on mergers and acquisitions, strategic matters, restructuring and capital structure, capital raising and corporate finance, as well as asset management services to corporations, partnerships, institutions, governments and individuals. Their more recent analysis (Levelized Cost of Energy Analysis, LCOE 11.0) assumes 60% debt at 8% interest rate and 40% equity at 12% cost for all (conventional and alternative) energy generation technologies, and excludes integration (e.g., grid and conventional generation investment to overcome system intermittency) costs for intermittent technologies.

The main LCOE for several technologies are presented in the following table:

Technology	LCOE (US\$/MWh)
Solar PV-Utility scale ⁽¹⁾	
- Crystalline	46 to 53
- Thin film	43 to 48
Solar thermal with storage ⁽²⁾	98 to 181
Fuel Cell (distributed)	106 to 167
Microturbine (distributed)	59 to 89
Geothermal	77 to 117
Biomass direct	55 to 114
Wind	30 to 60
Gas Peaking	156 to 210
IGCC ⁽³⁾	96 to 231
Nuclear ⁽⁴⁾	112 to 183
Coal ⁽⁵⁾	60 to 143
Gas combined cycle	42 to 78

Notes: (1) Low value represents single-axis tracking system. High value represents fixed-tilt design. Assumes 30 MW system in a high insolation jurisdiction (e.g., Southwest U.S.). Does not account for differences in heat coefficients within technologies, balance-of-system costs or other potential factors which may differ across select solar technologies or more specific geographies.

(2) Low and high value represent a concentrating solar tower with 10-hour storage capability. Low value represents an illustrative concentrating solar tower built in South Australia.

(3) Does not include cost of transportation and storage. Low and high values depict an illustrative recent IGCC facility located in the U.S.

(4) Does not reflect decommissioning costs or potential economic impact of federal loan guarantees or other subsidies. Low and high values depict an illustrative nuclear plant using the AP1000 design.

(5) Reflects average of Northern Appalachian Upper Ohio River Barge and Pittsburgh Seam Rail coal. High value incorporates 90% carbon capture and compression. Does not include cost of transportation and storage.

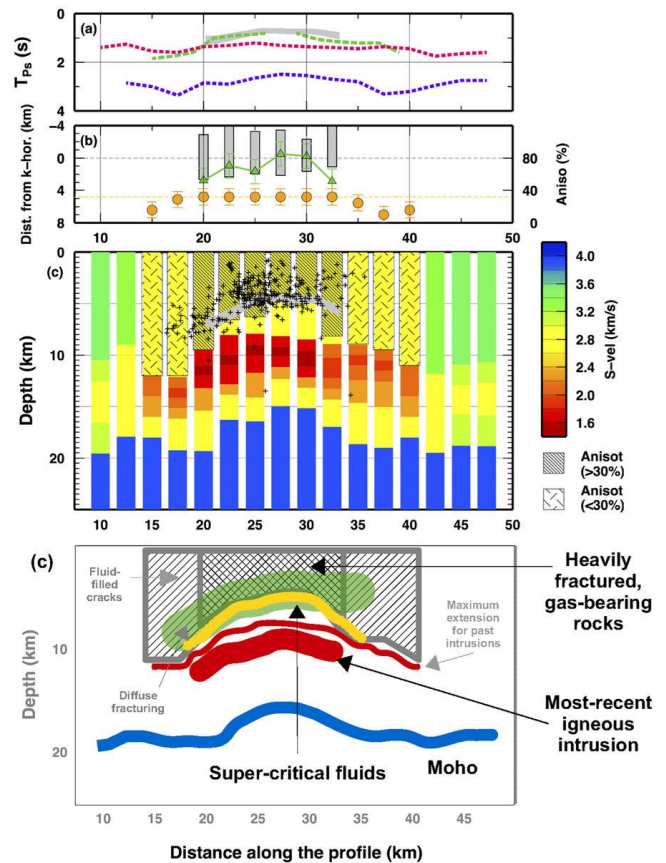
Source: <https://www.lazard.com/perspective/levelized-cost-of-energy-2017>

Science: Discovering Geothermal Supercritical Fluids by Seismic Exploration

The heat capacity of supercritical fluids (SCF), which directly impacts on energy production, is much higher than that of fluids at subcritical conditions. Reconnaissance and location of intensively permeable and productive horizons at depth is the present limit for the development of SCF geothermal plants. A group of researchers from some European centers and universities lead by Nicola Piana Agostinetti, used for the first time, tele-seismic converted waves (i.e. receiver function) for discovering those horizons in the crust.

Results from the analysis of tele-seismic data recorded from broadband stations installed across the Larderello field furnish a clear seismic evidence of SCF-bearing horizons in a geothermal area. The transition from subcritical vapor to super-critical fluid coincides with an approximately two order of magnitude decrease in fluid compressibility (or, conversely, a two order of magnitude increase in fluid bulk modulus $\propto \rho$). This variation in compressibility strongly affects P-wave seismic anisotropy related to the rocks hosting the vapor-filled fractures, and, thus, the transition to SCF can be spotted out by means of the analysis of seismic data.

The analysis of tele-seismic P-to-s converted waves (so called Receiver Function) is a long-established passive seismic tool for imaging Earth's seismic structure from the upper-mantle to the shallow-crust (e.g. sedimentary basin). Radial and Transverse RF are time-series of converted waves, extracted from the P-wave coda through the deconvolution of the Vertical component from the Radial and Transverse components. Transverse RF contains energy converted out of the radial plane, and is generally considered a proxy for anisotropy and/or dipping structures. The analysis of



(a) Comparison of the M-, n- and k- pulses with the "k-horizon". For a precise comparison, we compute the time-delay between the P wave and S converted wave (T_{ps}) of the "k-horizon" from the Two-Way-Time (TWT) data. A grey band indicates the minimum and maximum T_{ps} of the k-horizon along the profile as computed using two end-member models. (b) Depth-distribution of seismicity along the profile, reported as distance from the k-horizon. Grey bars show the ± 2 std intervals for the depth of the seismic events relative to the k-horizon. Green triangles and the green dashed line show the difference in depth between the k-horizon and the bottom of the ultra-high anisotropic volume along the profile. Anisotropic values along the profiles are shown as orange circles. An orange dashed line shows the 32% anisotropic level given by vapor-bearing microcracks¹⁹. (c) S-wave velocity model for each point along the profile AB. Colors indicate S-wave velocity. Texture indicates the area where highly anisotropic materials are present. A grey area delineated the minimum and maximum values for the k-horizon at depth. Black crosses report the depth of the seismic events occurred along the profile. (d) Schematic interpretation of our observations and modeling for the Larderello geothermal field.

the time-delay and amplitude of such converted waves

can put constraints on the depth of the velocity contrasts where the P-to-s conversions occurred.

Due to the capability of RF to map buried anisotropic materials, the SCF-bearing horizon is seen as the 4km-depth abrupt termination of a shallow, thick, ultra-high (>30%) anisotropic rock volume, in the center of the Larderello geothermal field, in Italy. The SCF-bearing horizon develops within the granites of the geothermal field, bounding at depth the vapor-filled heavily-fractured rock matrix that hosts the shallow steam-dominated geothermal reservoirs. The sharp termination at depth of the anisotropic behavior of granites, coinciding with a 2 km-thick stripe of seismicity and diffuse fracturing, points out the sudden change in compressibility of the fluid filling the fractures and is a key-evidence of deep fluids that locally traversed the supercritical conditions.

The presence of SCF and fracture permeability in nominally ductile granitic rocks open new scenarios for the understanding of magmatic systems and for geothermal exploitation.

Source: The report (Discovering geothermal supercritical fluids: a new frontier for seismic exploration) appeared in *Scientific Reports* 7, Article number: 14592 (2017) doi:10.1038/s41598-017-15118-w, and can be freely downloaded from the source.

Source: <https://www.nature.com/articles/s41598-017-15118-w>

Science: Map of Geothermal Heat Flux in Antarctic

Researchers from the British Antarctic Survey (BAS) published a 'geothermal heat flux' map of the Antarctic, which was published in last November at *Geophysical Research Letters* (Heat flux distribution of Antarctica unveiled). This map contains key data required by scientists in order to model how the White Continent is going to react to climate change.

If the bedrock's temperature is raised, it makes it easier for the ice above to move. And if global warming is already forcing change on the ice sheet, a higher flux could accelerate matters.

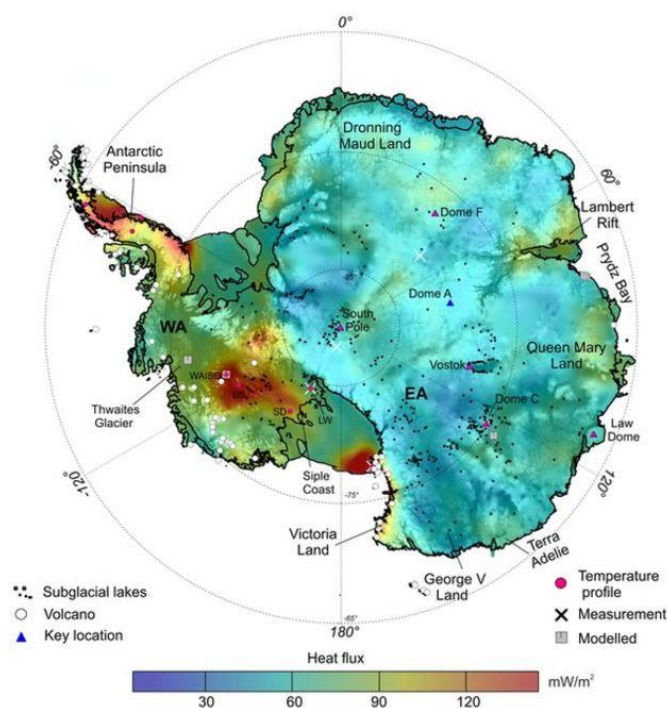
"The heat coming from the Earth's interior is important to understand the overall conditions that control the dynamics at the base of the ice sheet and hence the ice flow," explained Yasmina Martos, principal author of the paper and currently affiliated to the NASA. "If this heat flux is elevated, the ice base can melt and produce water that acts as a sliding film. One result of our study is that the heat flux is higher underneath West Antarctica, where more ice is currently melting, than underneath East Antarctica. Even a little melting at the

base helps the ice sheet to slide faster. We also identified areas of low heat flux, which will help stabilizing the ice sheet," she told.

No-one has actually drilled through the kilometers of ice in Antarctica to take the temperature of the bed. Instead, the BAS team inferred the likely warmth of rocks from their magnetism. This property can be sensed by instruments flown across the surface of the ice sheet by planes. Scientists know the temperature (580°C) at which hot minerals lose their magnetism, so if they can gauge how close to the rock-ice interface this occurring then they have a means of estimating the heat flux.

The new map is said to represent an improvement on previous efforts. It supports with far more detail the established idea that East and West Antarctica are very different provinces. The East is a giant chunk of old, cold continental crust. The West, however, underwent recent rifting in the Cretaceous (100 million years ago) that has pulled it apart.

"This rifting has thinned the crust and brought hot material from deep down in the Earth, from hundreds of km down to within 100 km or so, or even maybe less, of the rock surface," said co-author Tom Jordan. "It confirms what you would expect from the sparse, exposed geology in West Antarctica where we have volcanoes."



Antarctic's geothermal heat flux map (taken from the source).

One of the great advances in polar science in the past decade is the recognition that there is a really extensive hydrological network under the ice sheet. Rivers of

water feed huge subglacial lakes that fill and burst their banks periodically. Satellites see the top of the ice sheet heave and relax when this happens.

Any projections of future change in Antarctica and its contribution to sea level rise through the loss of ice have to take this basement hydrology into account, and the variations in geothermal heat flux are a critical part of the overall picture.

One research project that will see an immediate benefit from the map's data is the quest to drill the oldest ice on the continent. Europe, America, China and others are seeking a location where they can collect a core of frozen material that contains a record of past climate stretching back at least 1.5 million years. This information about historic atmospheric conditions including carbon dioxide levels can be deciphered from tiny air bubbles trapped in the ice.

"It is very exciting to see the implications this new heat map has for many communities, including new generations of ice sheet and sea level models," said Dr. Martos. "I am very glad we are contributing an important aspect at unprecedented detail. The Earth's interior has a lot to tell us in terms on how the ice behaves."

Source: <http://www.bbc.com/news/science-environment-41972297>

Science: Large Igneous Provinces (LIP) Could Be the Culprit of Mass Extinctions

Our planet Earth has extinguished large portions of its inhabitants several times since the dawn of animals. Such events are called 'mass extinctions,' incidents in which many species of animals and plants died out in a geological instant. They are so profound and have such global reach that geological time itself is sliced up into periods—Permian, Triassic, Cretaceous—that are often defined by these mass extinctions.

Debate over what caused those catastrophic events includes diseases, galactic gamma rays, dark matter, and even methane from microbes. But since the 1970s, most scientists have considered the likely root cause to be either asteroid impacts, massive volcanic eruptions, or a combination of both.

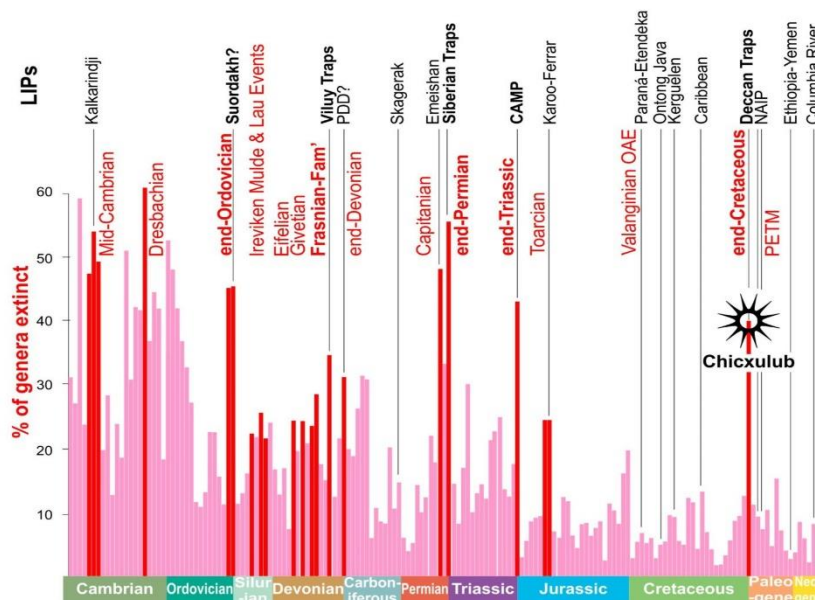
Volcanism has coincided with most, if not all, mass extinctions. This isn't the regular Vesuvius/St. Helens/Hawaii style volcanism. It's not even super-volcanoes like Yellowstone

or Tambora. This is something far bigger: a rare, epic volcanic phenomenon called a Large Igneous Province or 'LIP.'

LIPs are floods of basalt lava on an unimaginable scale: the Siberian Traps LIP, which erupted at the end-Permian extinction, covers an area the size of Europe. It's estimated that over 3 million cubic kilometers of rock were vomited onto the planet's surface. The end-Triassic Central Atlantic Magmatic Province, stretching from Canada to Brazil into Europe and West Africa, was just as large. Others are similarly gigantic.

Four of the 'Big Five' extinctions are associated with LIPs—too many to be mere coincidence—implying that large-scale volcanism is the main driver of mass extinctions. Even the extinction of the dinosaurs at the end of the Cretaceous was simultaneous with the Deccan Traps LIP in India. It's possible that the combination of the Chicxulub asteroid impact and the Deccan eruptions, rather than just the impact, pushed life over the edge. And recent evidence points to a LIP trigger for the second phase of the end-Ordovician extinction. If confirmed, that would link LIPs to all five of the Big Five extinctions.

For decades, the sheer size of LIPs and the wide error margins in attempts to put dates on rock formations led geologists to suspect that LIPs erupted slowly over millions of years; any associated extinctions could easily be just coincidence. But in the last four years, improved rock dating techniques have shrunk those error margins, revealing two important things: LIPs erupt in intense



The many links between LIPs and mass extinctions. Larger mass extinctions highlighted in red. (Redrawn and modified from Bond & Grasby Palaeo3 2017, with Valenginian OAE from Svensen et al., Geol Soc SP 2017 & Suordakh LIP from Gong et al., SREP 2017.) Graph taken from the source.

pulses that are geologically fast (tens of thousands of years), and they often coincide precisely with mass extinctions.

This is true for multiple LIP-extinction links. Precise matches have been confirmed for the mid-Cambrian, the end-Triassic, the Toarcian, and others. And it isn't just a date match. Volcanic nickel and mercury have been found at several extinction-aged locations, including for the Ordovician and Cretaceous events.

Source:

https://arstechnica.com/science/2017/11/when-will-the-earth-try-to-kill-us-again/?mbid=synd_digg&utm_source=digg&utm_medium=email

Technology: Heavy-oil Technology May Be a Perfect Fit for Geothermal Power

One prominent applied research group in Canada says that some of the technologies involved with heavy oil have the potential to be used around the world. Technologies involved in steam-assisted gravity drainage (SAGD) would be used primarily not to produce oil but geothermal power.



*Universal Testing Systems at C-FER's facilities.
Photo by C-FER Technologies.*

Brian Wagg, director of business development at Edmonton (Canada) based C-FER Technologies, explained how SAGD pushes large volumes of steam

into the ground via an injection well to heat viscous oil to the point at which it flows freely into a producing well.

C-FER is promoting an EGS (Enhanced Geothermal System) that would send cool water down an injector well to become heated as it moves through a non-hydrocarbon-bearing rock formation. C-FER wants the geothermal sector to begin using new SAGD technologies to make capturing rock heat more efficient and improve the output of this type of power plant. To prove whether the idea is feasible, C-FER is seeking partners for a new joint industry project it recently proposed.

The ultimate aim is to design a dual-well geothermal plant capable of generating between 1MW and 5MW. To reduce the risks associated with drilling an EGS well, the good news is that there is no shortage of established oilfield solutions. Among those developed specifically for SAGD are high-temperature electrical submersible pumps (ESPs), down hole, flow-control devices, thermal-well casing connections, coiled tubing instrumentation, and specialized cement for zonal isolation.

Two other key technologies will be required to make the perfect geothermal well: horizontal drilling and multistage hydraulic fracturing. Both are needed if geothermal operators want to vastly increase a well's output by enlarging the area where injected water can contact high-temperature rock.

Some geothermal wells have been drilled directionally, but horizontal drilling is less common. And single-stage hydraulic fracturing has been used too, but not the multistage techniques that create the 20 to 50 fracturing clusters that define modern, shale-well designs.

To bring this well concept closer to reality, C-FER's joint-industry project first needs to complete the front-end engineering work and modeling to show that SAGD technology can change the financial equation of EGS—which historically has not been that good and thus explains its limited use. The next step is to find companies willing to drill pilot wells and test how well they work with technologies originally developed for the heavy-oil sector.

Source: <https://www.spe.org/en/jpt/jpt-article-detail/?art=3225>, <https://www.cfertech.com/testing-equipment/load-frames>

Technology: New HARP System Turns Heat into Seriously Efficient Power

Organic Rankine cycle (ORC) systems have been used for decades to generate power. The generators work

much like a steam engine; however, instead of water, ORC systems use a fluid with a much lower boiling point than water. As a result, an ORC generator can use low-grade heat ($<150^{\circ}\text{C}$) to produce electricity.

Since their initial development, improvements in turbine efficiencies and heat transfer materials have been incorporated into ORC systems, improving their performance. But the technology remains largely underutilized, tapping only a fraction of the potential market due to the upfront costs of the systems and relatively high cost of the power produced.

Sponsored by the U.S. DOE's Geothermal Technologies Office, Pacific Northwest National Laboratory (PNNL) has made a transformational advance in the ORC technology and its use within the geothermal industry. The PNNL-developed system HARP (Harmonic Adsorption Recuperative Power) uses a novel approach that eliminates the need for the evaporator, high pressure pump, and condenser in ORC systems.

Conventional ORC systems work by transferring heat to a working fluid until it vaporizes at a constant pressure. The high-pressure vapor is passed through a turbine, or other engine, that produces electricity. The vapor is then condensed back to a liquid and recycled using an electric powered pump. The HARP cycle scraps all those components and substitutes a patented multi-bed heat engine architecture and a specially formulated metal organic framework (MOF) sorbent to drive the engine.

pores are packed to capacity with the working fluid. When heat is subsequently applied to the MOF, the working fluid vapor is released from the MOF pores, and tremendous pressure is generated. This process takes the place of evaporating the working fluid back to a vapor state. In the HARP system, the working fluid remains in a vapor state the entire time; the only difference is that the working fluid vapor attaches, detaches, and reattaches into the MOF pores. A set of four heat exchangers packed with the MOF work in tandem, adsorbing and desorbing the working fluid in a "harmonic" cycle that swings the pressure and temperature every one to two minutes. The multi-bed heat exchanger system thus becomes a thermal compressor that powers the HARP system.

The elimination of the ancillary components in the ORC allows the HARP system to generate 40 percent more power from the same heat source. Even better is the cost of electricity when using HARP: only \$0.05/kWh. Compare that to \$0.15-0.20/kWh of a conventional ORC system. A 10 kW unit—big enough to power about eight average U.S. households—can be paired with many different sources of low grade heat, including waste heat from diesel generators, solar arrays, produced water at oil and gas sites, or shallow depth geothermal sites. Scaling up to 1 MW or even larger systems is straightforward due to the simple design PNNL staff developed for the thermal compressor components, which is readily manufacturable at scale.

The PNNL Staff are putting the finishing touches on the first HARP system that should be generating power by 2018.

Source:

<http://energyenvironment.pnnl.gov/highlights/highlights.asp?id=2887>

Technology: Ultra High Temperature Filtration for Extraction of Lithium from Geothermal Brine

The Canadian firm MGX Minerals Inc. reported in late November 2017 that its engineering partner PurLucid Treatment Solutions Inc. has developed high temperature filtration for the purification of geothermal brines and associated extraction of metals and minerals including lithium.

Geothermal brines contain concentrated amounts of metals and dissolved salts. The presence of these impurities produces scaling that severely reduces flow and heat transfer of geothermal heat exchangers. This in turn negatively impacts the long-term operating performance and in many cases eliminates the economic viability of these systems. Geothermal brines contain



*Researcher JJ Jenks operates HARP in the laboratory.
(Photo from the source)*

In the HARP system, the working fluid vapor is adsorbed into the nanostructured pores of the MOF sorbent, resulting in near liquid phase density. This process takes the place of condensing the working fluid vapor back to a liquid state. Instead, the MOF sorbent

lithium, magnesium and other minerals and metals including gold.

Mineral	Feed	Pre Treatment	Concentrate
Lithium	67	41	1,600
Boron	110	59	4
Calcium	23,000	11,000	370
Magnesium	2,800	<10	13
Potassium	4,500	2,800	12
Sodium	57,000	43,000	68
Sulphur	96	56	7

Lithium in the brine is upgraded from 67mg/l to 1600 mg/l Li in the filtration and pre-treatment phase of the lithium extraction process. Source:

<http://www.purlucid.com/index.php/news/item/10-mgx-minerals-and-purlucid-report-advancement-of-lithium-filtration-technology>

After an initial period of research and development, MGX and engineering partner PurLucid have developed a proprietary, low energy design process that removes scale-forming ions and dissolved salts while not requiring a reduction in brine temperatures for filtration to occur. This process utilizes PurLucid's existing patented and exclusively licensed replaceable membrane skin layers (RSL) filtration system, originally developed by David Bromley Engineering, which creates highly charged pore spaces to force dissolved ions into colloidal particles, simultaneously filtered down to 0.01 microns. The RSL is designed specifically to foul and is removed and replaced in situ, resulting in 100% flux rate recovery. The ultrafiltration can then be followed by a patent-pending membrane distillation system in projects where heat is available. The matrix is composed of materials capable of operating at up to 700 degrees Celsius.

This new technology also represents an environmentally friendly alternative for geothermal brine disposition, which is largely limited to non-treated reinjection. Similar to MGX's existing wastewater treatment and rapid petro-lithium recovery units, MGX and PurLucid are conducting engineering studies to fabricate treatment systems capable of being integrated into existing geothermal infrastructure or incorporated as standalone systems for mineral and metals extraction. MGX currently owns a 34% interest in PurLucid and has the right to acquire 100% through successive future investments. MGX owns the global rights to the minerals extraction technology jointly developed.

Source:

<https://www.mgxminerals.com/investors/news/2017/293-mgx-minerals-announces-ultra-high-temperature-filtration-for-extraction-of-lithium-from-geothermal-brine.html>

IGA News

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