

## IGA ACTIVITIES

### Message from the President

Dear IGA members, I have just returned from Berlin in Germany, where I attended the Berlin Energy Transition Dialogue meetings together with Juliet Newson, our former President. The Berlin Energy Transition Dialogue clearly has established itself as a gathering of key international decision makers in foreign energy and energy policy, industry, science and civil society as well as foremost energy experts from all over the world. While general in nature, the discussions on energy development, innovative political instruments, new investment opportunities in the ongoing transformation of the global energy sector were very interesting.

To represent our industry at events like this is very important, as we need to portrait the opportunities presented through the utilisation of geothermal energy in this global energy transformation. Two discussion rounds on Future Prospects and the Energy Transition in Latin America were of particular interest. Lead by the Executive Director of the REN21 Alliance, that IGA is part of, these rounds included Ministers from a number of geothermal countries in the region, including Argentina, Iran, Greece, Croatia, Colombia, Costa Rica, and El Salvador. The sad part is that none of them actual highlighted the role geothermal is playing or could play in their countries. So, one can see that we really need to increase the efforts on promoting geothermal energy and have countries like Costa Rica and El Salvador highlight the role geothermal energy plays in their thrive on renewable energy development. During the events, I also met the Executive Director of the German Geothermal Association and we discussed the increasing importance of geothermal heating in the European context.

In January, I attended the IRENA General Assembly and a meeting by the Global Geothermal Alliance. This was an important meeting to attend and provided a great opportunity to connect not only with representatives from geothermal countries around the world, but also meet representatives from other renewable energy organisations around the world. To represent geothermal energy on this stage is likely the most important one for us. Seeing the involvement of countries such as New Zealand, France and Iceland in

## CONTENTS

### IGA ACTIVITIES

Message from the President...	1
24 <sup>th</sup> Annual Congress of the AGM...	2
IGA Academy Course on Reservoir Engineering...	3
Maria Richards, New President of the GRC...	4
GEMex Project Is Moving Forward...	5
Upcoming Events...	6

### AFRICA

Kenya: Importance of Geothermal & Olkaria V...	6
Union of the Comoros: Karthala Project...	7

### AMERICAS

Bolivia: Loan for Sol de Mañana Project...	8
Chile: Cerro Pabellón Starts to Operate...	9
Costa Rica: Las Pailas & 99% Renewable...	9
Guatemala: El Ceibillo Project...	10
Honduras: Platanares Project...	10
Nicaragua: Legal Aspects on Geothermal...	11
United States: San Emidio, Lithium, New Projects...	11

### ASIA / PACIFIC RIM

China: Sinopec and the 13 <sup>th</sup> Five-Year Plan...	16
Indonesia: Exploration, Sarulla, Regulation...	17
Japan: Generation, Course, Takigami Plant...	20
Philippines: Acidity in Biliran Wells...	21
Saudi Arabia: Good Geothermal Potential...	22
South Korea: First Power Plant...	23

### EUROPE

European Innovation Award to enOware GmbH...	23
Belgium: 2 <sup>nd</sup> Phase of Balmaat Project Completed...	24
France: New Geothermal Heating Network...	24
Germany: 32% of Electricity from Renewables...	25
Greece: New Interest in Geothermal...	25
Hungary: News from the Győr Region...	26
Iceland: Well IDDP-2 Successfully Completed...	27
Italy: Campi Flegrei, Spirulina Algae...	28
Slovakia: Tomatoes Produced with Geothermal...	29
Switzerland: Public Consultations...	29
Turkey: Proposals for Incentives & Alasehir Plant...	31

### OCEANIA

Australia: New Geothermal Association...	32
New Zealand: The Wairakei Bioreactor...	32

### OTHER

Technology: New Cements & Drilling Techniques...	33
Climate Change: GHG, Fossils & Carbon Tax...	37

the Global Geothermal Alliance and the political things that one can achieve is great, but also shows that we need to become a stronger voice in the renewable energy context.

Having started my term as President only in November 2016, I can count on a great group of fellow board members that are actively supporting our activities. Our focus is lying on a number of initiatives that we hope will help strengthen and position IGA for the future. At the upcoming Board Meeting in Bochum in May, we will be holding a two-day session on formulizing a strategy for the association, its role and activities. It is crucial that we evaluate our activities and role towards our membership on an ongoing basis. We are also very glad to announce having been able to fill the position of IGA Executive Director at the IGA Secretariat in Bochum. The position transfers to Marit Brommer, who started in her new role at the beginning of April. She is a geoscience professional (PhD - Reservoir Geology / MSc - Earth Sciences TU Delft) with Dutch nationality and more than 10 years' experience in R&D, asset teams and operational units, at among others at Shell Global Solutions in the Netherlands and in the Energy Industry in the UK and the Netherlands. Marit Brommer follows Marietta Sanders, who left us at the end of 2016.

Until recently, Dr. Marit Brommer has been the R&D Deployment Lead of Shell Global Solutions in the Netherlands and before that time she served as a Senior Geologist and Senior Consultant for the Oil&Gas and the Energy Industry in the UK and the Netherlands.

In the end of April, I will represent IGA at the Geothermal Conference for Latin America and the Caribbean (GeoLAC) in Mexico City. It will be interesting to not only present an update on Latin American geothermal development, but also learn about new developments. With the 48 MW Cerro Pabellon geothermal plant by Enel Green Power in Chile recently started, and a large loan announced for the development of a geothermal project in Bolivia, one can only hope that this will kickstart further development in South America and the rest of Latin America.

With this and also great news on the development front in Indonesia, I am very optimistic for the geothermal sector and likely more so than in previous years.

Best wishes,

**Alexander Richter,**  
President of IGA



## 24<sup>th</sup> Annual Congress of the Mexican Geothermal Association (AGM)

**Luis C.A. Gutiérrez-Negrín, Editor**

The Mexican Geothermal Association (AGM: Asociación Geotérmica Mexicana) held its 24<sup>th</sup> Annual Congress and General Assembly on 30-31 March 2017 in Morelia, capital of the state of Michoacán in central Mexico. The AGM is the Mexican association affiliated with the IGA and is presently composed of about 200 individual members, including about 35 students.

The day before the congress, the AGM organized a pre-congress workshop on 29 March, composed of two, four hour sessions. The first, titled, 'Introduction to Geothermal Reservoir Engineering', was offered by Marco Antonio Torres-Rodríguez, a chemical engineer who specialized in reservoir engineering from the geothermal division of the Comisión Federal de Electricidad (CFE). The other session was titled, 'Exploration Geophysical Techniques in Geothermal Zones' by Cecilia Lorenzo-Pulido, a geophysicist in charge of these matters in the CFE geothermal division. Thirty six participants attended the workshop, mostly Earth Sciences PhD and Master students –plus some researchers and professionals working in geothermal development.

The opening ceremony of the congress was held on the morning of March 30<sup>th</sup>. The presidium was composed of Magaly Flores-Armenta, head of the geothermal division of the new CFE's subsidiary CFE-Generación VI, Michelle Ramírez-Bueno, head of the geothermal area of the Secretariat of Energy, Georgina Izquierdo-Montalvo, head of the geothermal division of the INEEL (the new National Institute for Electricity and Clean Energy that replaced the former IIE) and outgoing President of the AGM, José Manuel Romo Jones, head of the Mexican center for innovation in geothermal energy (CeMIE-Geo), and Abraham III Molina-Martínez, outgoing Vice President of the AGM.

The congress started with two invited presentations, one by Wilfred A. Elders ('A geothermal well in southwest Iceland has successfully penetrated a supercritical regime - an update on the Iceland Deep Drilling Project') and the second by Aída López-Hernández ('Project GEMex: Mexico-Europe Bilateral Consortium for Development of Super-Hot Geothermal Systems and Enhanced Geothermal Systems'). After this, 40 papers were presented orally for 20 minutes during the two days of the congress –including five minutes for Q&A.

The papers covered geothermal exploration (geology, geohydrology, geophysics, geochemistry), the potential of enhanced geothermal systems in Mexico, Cerro



*Participants in the 24<sup>th</sup> Annual Congress of the Mexican Geothermal Association (AGM).*

Prieto and Los Azufres geothermal fields, geothermal modeling, geothermal heat pumps, and geothermal turbines. Another 10 papers were presented as posters during the evening of March 31<sup>st</sup>, dealing with similar subjects including geothermal regulation, education and geotechnical matters.

At the same time as the technical sessions, a commercial exhibition was mounted in a space adjacent to the congress. Ten companies and institutions involved in geothermal in Mexico exhibited their products and services in 12 booths during both days of the sessions. The exhibitors and sponsors were: Air Drilling Equipment Services, CeMIE-Geo, CFE, Exergy, Geolec Instrumentos Científicos, INEEL, Instrumentos y Equipos Falcón, Mitsubishi Hitachi Power Systems de México, Nalco Water, Spectramex, PBI Herramientas y Servicios, and Universidad Nacional Autónoma de México.

On the evening of March 30<sup>th</sup>, the annual Pathé Award was presented by the AGM to a person who has long worked in the Mexican geothermal sector and/or who has made a substantial contribution to the development of the AGM. Georgina Izquierdo-Montalvo, the outgoing AGM President, delivered the award to Luis C.A. Gutiérrez-Negrín. He is a geologist with 38 years working in geothermal in Mexico, a former President of the AGM, a former member of the IGA BoD and currently director of the consulting company Geocónsul and member of the CeMIE-Geo's Directive Group.

Both days of the congress were attended by about 180 people. These include students from CICESE and universities such as UNAM, UMSNH, UANL, UAM and IPN, researchers from the same institutions and INEEL, and CeMIE-Geo, plus professionals involved

in geothermal from the CFE, the Mexican Geological Survey (SGM), Grupo Dragón, GEA, Geocónsul, ENAL, Nalco, Exergy, and the Energy Secretary. The amount of participants and of papers presented, makes this the most successful congress in the 25 years of AGM's history.

On the evening of 31<sup>st</sup> March, after the conclusion of the congress, the AGM held its 24<sup>th</sup> General Annual Assembly, restricted to members. Besides the official report from the President and Treasurer, the Assembly elected the new Board for the 2017-2019 term. The new Board is composed of Abraham III Molina-Martínez (CFE) as President, Emigdio Casimiro-Espinoza (CFE) as Vice President, Heber D. Diez-Leon (CFE) as Secretary, J. Ignacio Martínez-Estrella (INEEL) as Pro-Secretary, Mirna Tello-López (CFE) as Treasurer, and Lilibeth Morales-Alcalá (CFE) as Pro-Treasurer. We wish the best for Abraham and the new members of the Board.

## **IGA Academy: Geothermal Reservoir Engineering Short Course**

The IGA Academy offers a variety of technical and academic geothermal courses all over the world. A majority of the courses are held on site in Bochum, Germany, where the IGA has its Head Office at the great facilities of the International Geothermal Centre. The IGA Academy offer several general courses, but also can offer tailored courses based on specific needs and requirements. The next course, 'Geothermal Reservoir Engineering', will be presented by the prestigious expert Sadiq J. Zarrouk, with the following features.

Date	15-19 May 2015 (08:30-16:30 hours)
Language	English
Place	International Geothermal Centre (GZB) Bochum, Germany
Participants	20 (maximum)
Course cost (inclusive certificate)	Regular fee: US\$ 1,300 IGA members -15%: US\$ 1,105 Students (including PhD Students) - 30%: US\$ 910
Contact	Karolina Andersson ( <a href="mailto:iga@hs-bochum.de">iga@hs-bochum.de</a> )

The 5-day course is centered on lectures and exercises concerning Geothermal Reservoir Engineering, including the latest developments. The curriculum is an effort to build students' confidence in understanding geothermal reservoir assessment, development and utilization. The exercises will provide a basis for cementing the concepts and problem solving techniques introduced in the morning lectures.

The syllabus covers the following subjects:

- Worldwide geothermal development and types of geothermal systems;
- Geothermal power systems (steam field and power station equipment);
- Thermodynamics and properties of water and steam tables;
- Fundamentals of geothermal reservoir engineering;
- Heat and mass underground, stored heat calculations;
- Geothermal drilling & measurements while drilling;
- Completion tests & down-hole measurements;
- Geothermal flow measurement;
- Scaling and corrosion in geothermal development;
- Stimulation of geothermal wells; and
- Geothermal reinjection.

Students will receive the following teaching materials in hard copy format:

- Course material booklet containing: more than 500 pptx colored slides and problem sets;
- Steam tables;
- Supporting recent published research (soft copies).

Digital copies of exercise data and macros will be provided to the students on a USB stick for some of the well test data. The course attendees are required to bring calculators from day one and laptop computers from day three of the course.

Deadline for registration and payment: **18<sup>th</sup> April 2017**

More info:

[https://www.geothermal-energy.org/iga\\_academy/courses.html](https://www.geothermal-energy.org/iga_academy/courses.html)

## Maria Richards, New President of the GRC

The Geothermal Resources Council (GRC) has welcomed Maria Richards as its 26<sup>th</sup> President, succeeding Paul Brophy. The GRC is an affiliated association to the IGA.



Maria Richards is the Southern Methodist University (SMU) Geothermal Laboratory Coordinator in the Roy M. Huffington Department of Earth Sciences in Dallas, Texas. Her research is on geothermal resources and energy development. Maria's previous projects include updating the Geothermal Map of North America, developing temperature maps for Google.org, and on-site geothermal exploration in the Peruvian Amazon and the Northern Mariana Islands.

As producing geothermal energy from oil and gas fields is one of her research goals, she works directly with technology companies and the oil and gas industry to find overlapping opportunities. As an extension of this effort, she coordinates the SMU Geothermal Lab Conference, Power Plays: Geothermal Energy in Oil and Gas Fields. Another area of interest is using boreholes to quantify the extent and rate of climate change occurring by measuring the equilibrium temperature down the length of a well to see the direct impact of the surface air temperature on the earth.

Maria and her colleagues recently completed a high-resolution, shallow Enhanced Geothermal System potential analysis for the Cascades region of the U.S. Pacific Northwest for the National Renewable Energy Laboratory. Other past projects include the SMU Node of the National Geothermal Data System funded by the Department of Energy, the Eastern Texas Geothermal Assessment, the Dixie Valley Synthesis, and the resource assessment for the influential MIT Report on the Future of Geothermal Energy.

Maria previously served on the Geothermal Resources Council Board of Directors and was chair of the Outreach Committee in 2011-12. She is also a Named Director of the 2015-16 Board for the Texas Renewable Energy Industries Association (TREIA). Maria holds a Master of Science degree in Physical Geography from the University of Tennessee, Knoxville and a BS in Environmental Geography from Michigan State University.

Source:

[https://geothermal.org/PDFs/News\\_Releases/2017/January\\_25-GRC\\_Welcomes\\_New\\_President.pdf](https://geothermal.org/PDFs/News_Releases/2017/January_25-GRC_Welcomes_New_President.pdf)

## GEMex Project: The International Cooperation between Mexico and Europe Is Moving Forward

**Katrin Kieling & David Bruhn, GFZ**

From 23 - 24 March 2017 over 70 scientist from Mexico and ten European countries met for the first GEMex progress meeting in Utrecht, the Netherlands. Scientist reported the first project activities, planned geological, geochemical and geophysical surveys and discussed further activities.

GEMex ([www.gemex-h2020.eu](http://www.gemex-h2020.eu)) is a cooperation between nine Mexican and 24 European organizations with the objective to advance research on the exploration and the development of unconventional geothermal reservoirs. Under the coordination of the German Research Centre for Geosciences (GFZ) on the European site and the Michoacán University (UMSNH) on the Mexican site, the project has the ambition to bring together the extended Mexican know-how of discovering, developing, and exploiting geothermal energy systems with a variety of European expertise from similar geothermal energy systems (Italy, Iceland etc.). The focus lies on developing EGS technology, and finding new approaches to make use of super-hot geothermal systems. The approach should lead to concepts for extended future deployment of geothermal energy in Europe and Mexico.

During the meeting in Utrecht, Ernst Huenges (GFZ) presented results from a first workshop on 'Corrosion, Erosion and Scaling', held in the Los Humeros, Mexico, geothermal field in early March 2017. During this workshop, challenges due to the acidic fluids in the

superhot (>380°C) wells in the Los Humeros reservoir were identified and material testing was planned by the Iceland Geosurvey (ISOR) in the wells of the Comisión Federal de Electricidad (CFE) in this field.

Domenico Liotta (University of Bari, Italy) reported from the first field trip to Mexico, which was dedicated to structural geology in the exhumed geothermal systems close to the sites under investigation in the GEMex project. During the field trip, scientist also collected over 160 kg of rock samples, which were distributed during the project meeting and are now used for petrophysical analyses and mechanical testing.

Finally, the GEMex progress meeting was dedicated to the planning of several surveys on the sites in Mexico:



*Some participants in the meeting in Utrecht: David Bruhn (left) and Domenico Liotta (right) in the first row. (Photo by Eugenio Trumpy.)*

Over 70 seismic stations are available for a passive seismic experiment, the data of which will be used to better constrain the reservoir architecture and fracture distribution at the two test sites. Other geophysical measurements such as gravimetric and magnetotelluric surveys are planned. Soil gas emissions, from CO<sub>2</sub>, H<sub>2</sub>S and CH<sub>4</sub> to radon (<sup>222</sup>Rn) and thoron (<sup>220</sup>Rn) will be recorded while capturing soil temperature at the same time to derive a better correlation with active faults in the subsurface. Active faults in the Los Humeros complex will be mapped and monitored and further rock samples will be acquired for paleomagnetism and isotopic studies. All of these surveys will start in the course of 2017 and will be supported by complementary investigations during the 36-months lifetime of the project.

Synergies between the Mexican and the European experience proved once again very helpful during the

meeting. The cooperation is advancing and becoming a close partnership. The next GEMex meeting will take place from 2 - 3 October in Iceland.

## AFRICA

### Kenya: Dry Periods and Low Hydroelectric Outputs - The Importance of Geothermal

**Marcelo J. Lippmann, Information Committee**

Two recent notes (1, 2) on the Internet reinforce the importance of geothermal on Kenya's economy.

The first one says: "The recent dry period in Kenya results in lower hydro-power generation and required use of thermal power stations, pushing electricity price up... Geothermal energy remains an important tool for Kenya's future energy mix and lower electricity prices. [It is] seen as a key tool to improve the country's energy mix and decrease electricity prices for the general public and the businesses in the country."

The second note also comments on the effects of the drought on the cost of Kenya's electricity by adding: "Power generating firm Kengen had announced that they had scaled down on hydro-power at the Masinga dam. This in essence saw thermal power being utilized which has raised the fuel cost charge passed on to consumers by 2.25 cents. The cost of power in the country has remained rather high at US\$0.11 per kilowatt hour, not making Kenya an attractive destination for manufacturers. The government says it will be scaling up geothermal power to improve the energy mix that is to blame for the high power costs."

An earlier note (3) from 2015 entitled "Electricity cost decreases by 30% in Kenya due to geothermal" estimates that those savings amount to US\$24 million per month.

#### Some background information

According to (4), Kenya has 2,150 MW (other sources report 2,370 MWe) of generation capacity to serve a population of more than 43 million. The government aims to increase generation capacity by 23,000 MW by 2030.

Omenda and Simuyo (5) mention that as of 2015, the country's installed generating capacity based on geothermal was 573 MWe and that the total potential is about 10,000 MWe.

Kenya is (or was) a country highly dependent on hydroelectric project to satisfy its electricity needs, but it is not the only one (e.g. Costa Rica and Panama). One

## UPCOMING EVENTS

### [GEOLAC 2017 – Geothermal Congress for Latin America and the Caribbean](#)

25-26 April 2017, Mexico City

### [IGC Turkey 2017](#)

22-24 May 2017, Izmir, Turkey

### [IGA Academy Course: Mine water as a geothermal reservoir and/ or energy storage](#)

25 June 2017, Rauha, Laappenranta, Finland

### [Fiji Geothermal Conference](#)

7-11 August 2017, Savusavu, Vanua Levu, Fiji

### [International Renewable Energy Conference](#)

11-13 September 2017, Mexico City

### [German Geothermal Congress \(DGK 2017\)](#)

12-14 September 2017, Munich, Germany

### [41<sup>st</sup> GRC Annual Meeting & Expo](#)

1-4 October 2017, Salt Lake City, Utah, U.S.

**Note:** Please check the [IGA website](#) for more events.

should stress that worldwide not only geothermal, but also solar, wind, and biomass, help reduce how much fossil fuel is needed to generate sufficient power when drought occurs. That dependency should greatly decrease as the installed capacity of geothermal and other renewable resources increases in the future.

#### References

<http://www.thinkgeoenergy.com/dry-period-and-low-hydro-output-highlights-importance-of-geothermal-in-kenya/> (1)

<https://www.standardmedia.co.ke/ktnnews/video/watch/2000122372/-kenya-power-has-reiterated-that-there-are-no-plans-to-ration-power-that-kenya-has-enough-reserves> (2)

<https://cleantechnica.com/2015/03/02/electricity-cost-decreases-30-kenya-due-geothermal/> (3)

<https://www.usaid.gov/powerafrica/kenya> (4)

<https://www.geothermal-energy.org/pdf/IGAstandard/WGC/2015/01019.pdf> (5)

## Kenya: Status of the Project Olkaria V

Mitsubishi Hitachi Power Systems Ltd. (MHPS) has secured a contract to deliver two sets of geothermal power-generation equipment for the Olkaria V Geothermal Power Plant in Kenya. MHPS, along with Mitsubishi Corporation and H. Young & Company (East Africa), has received a full-turnkey contract from Kenya Electricity Generating Company (KenGen) to install the equipment at the plant located in the Nakuru district of central Kenya.

The order includes two 70 MW class steam turbines, condensers, generators and other key auxiliaries. As part of the contract, MHPS will also be responsible for the design aspects of the geothermal facilities.



*Steam turbine for geothermal power plant (Photo: courtesy of MHPS, Ltd.).*

Slated to be commissioned in 2019, the new geothermal plant is located about 100km northwest from the Kenyan capital, Nairobi. It stands at an elevation of about 2,000m in the Great Rift Valley. The current power plant facilities in the Olkaria geothermal field will be expanded by this new project.

KenGen has been supported in the project by an ODA (Official Development Assistance) loan arrangement by the Japanese government, represented by the Japan International Cooperation Agency (JICA) (*see* IGA News 106, p. 14).

MHPS would also provide technical advisors to help H.Young in installing and commissioning the power generation facilities.

Previously, the Japanese manufacturer of thermal power systems had supplied six sets of power generating equipment for the Olkaria I and II geothermal power facilities, with a 150 MW total output.

Source: [http://geothermal.energy-business-review.com/news/mhps-to-deliver-geothermal-power-](http://geothermal.energy-business-review.com/news/mhps-to-deliver-geothermal-power-equipment-to-olkaria-v-project-in-kenya-280217-5751124)

[equipment-to-olkaria-v-project-in-kenya-280217-5751124](http://geothermal.energy-business-review.com/news/mhps-to-deliver-geothermal-power-equipment-to-olkaria-v-project-in-kenya-280217-5751124)

In other news, the Managing Director of the state-owned Kenya Electricity Generating Company (KenGen), Albert Mugo, confirmed that procurement of the contractor for the Olkaria V project was concluded last month. “We have already secured funding and we expect construction to be completed by mid-2019,” Mugo said. The geothermal power plant consists of two plants, each producing 79 MW.

KenGen has also received funding from the European Investment Bank and the German Development Bank to construct another 70 MW geothermal power plant that should be connected to the national grid in 2019.

The power producer plans to add 743 MW of electricity by the year 2022, out of which 653 MW will be geothermal power and 90 MW will be wind power.

Source: [http://news.xinhuanet.com/english/2017-03/06/c\\_136107196.htm](http://news.xinhuanet.com/english/2017-03/06/c_136107196.htm)

## **Union of the Comoros: First Results of the Karthala Project**

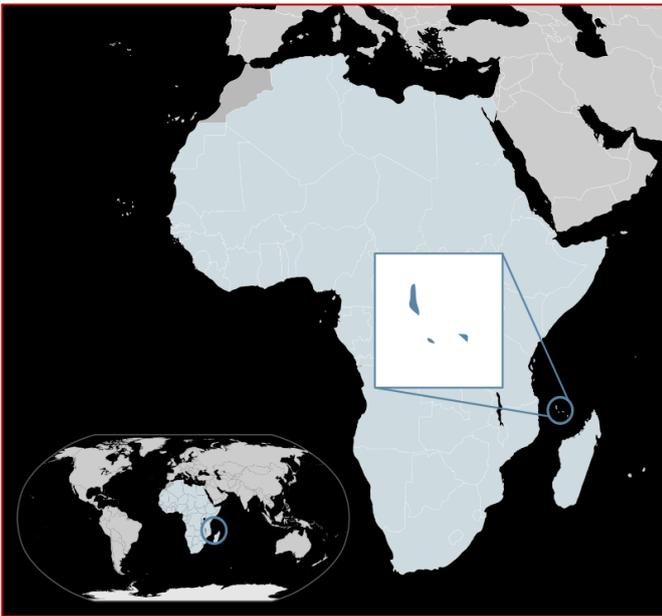
A recent study has concluded that the Karthala Geothermal Project on the Comoros Islands, off the coast of Africa, offers favorable conditions to develop high-temperature geothermal energy for power generation. Studies imply a potential of 40-45 MW of electrical generation capacity, as reported by ThinkGeoEnergy.

Not only did the study confirm the commercial opportunities of the untapped thermal resource, it highlighted the significant impact it would have on driving economic growth and development. This project was announced at the IRENA General Assembly and a meeting of the Global Geothermal Alliance.

According to ThinkGeoEnergy, the project has been financially supported by the African Union under the Geothermal Risk Mitigation Facility (GRMF) with US\$8.2 million, and the Global Environment Facility (GEF) with US\$6.6 million. The Government of New Zealand confirmed support for the project of US\$4 million. Together, these partners have been able to provide US\$18 million to start the drilling phase of the project.

The project still seeks US\$27 million. “The Comorian Government is therefore implementing a strategy to mobilize technical and financial resources to ensure the establishment of a strong partnership around the project to guarantee the implementation of the second phase of this initiative,” ThinkGeoEnergy reported.

In September 2014, the Government of the Union of the Comoros, the Government of New Zealand, and the UN Development Program (UNDP) decided to join forces and support the project.



*Location of the Union of the Comoros (Graph by Alvaro 1984 18 - Own work, Public Domain.)*

“With the positive results of the studies conducted last year, a full business plan has been completed and environmental studies and preliminary work on the scoping and design of site access and services are underway... The Karthala Geothermal Project in Grande Comore is now moving into an exploration drilling program,” ThinkGeoEnergy said. It is expected the well will confirm the resource and sites for the plant’s production and installation drilling.

Source: <https://www.esi-africa.com/news/karthala-geothermal-project-looks-promising/>

## AMERICAS

### **Bolivia: Loan Agreement to Construct the 100 MW Sol de Mañana Geothermal Project**

On March 24, the Japan International Cooperation Agency (JICA) signed a loan agreement with the Government of the Pluri-National State of Bolivia in La Paz to provide a Japanese ODA (Official Development Assistance) loan of up to 61,485 billion yen (US\$553.2 million) for the Laguna Colorada Geothermal Power Plant Construction Project (Second Stage).

The project will meet the growing power demand, contribute to diversification of the energy matrix and mitigate the impact of climate change through the

construction of a 100-megawatt geothermal power plant, transmission lines and incidental facilities in Sol de Mañana, which is located in the Department of Potosí in southwest Bolivia. The loan funds will be allocated to civil work such as well drilling, the construction of the geothermal power plant and incidental facilities and consulting services as second stage of the project following the Laguna Colorada Geothermal Power Plant Construction Project (Phase 1 of First Stage), for which a Japanese ODA loan was provided in July 2014.

Mineral resources are actively being developed in the southwest area of Potosí Department, which is one of the foremost areas in the world, for zinc, lead and silver production. Mineral resource development requires a considerable amount of electricity, which is supplied to the region by long-distance transmission lines since the power generating facilities connected to the national grid network are concentrated in the central region of the country.

Due to the poor combustion efficiency at the high altitude and the high fuel transportation costs, constructing a thermal power station is inappropriate for the region, and there are no locations suitable for a hydroelectric power plant, so the region has no large-scale power plants. Those limitations notwithstanding, the potential for geothermal development has been confirmed in the Sol de Mañana geothermal field, and it is expected that such development would greatly contribute to the stable power supply, which is a long-standing development issue in the region which has no main power supply.



*Geothermal wellhead in Laguna Colorada.*

The geothermal power plant to be constructed in this project will be the first plant in Bolivia, therefore JICA has been providing technical assistance since 2010 for the purpose of promoting understanding and capacity building for the geothermal power plant and ensuring

the smooth implementation of the project through the dispatch of experts. JICA will continue technical cooperation, such as organizational capacity building, toward successful completion of the project.

The project is planned to be completed in November 2023. The issuing of letters of invitation for consulting services (including basic design) is scheduled in July 2017, and the tender announcement of initial procurement package for international competitive bidding on well drilling will be released in April 2017.

Source:

[https://www.jica.go.jp/english/news/press/2016/170327\\_02.html](https://www.jica.go.jp/english/news/press/2016/170327_02.html)

## Chile: The First Geothermal Plant Starts to Operate

The first geothermal power plant in South America started to operate on 31<sup>st</sup> March. It is the Cerro Pabellón geothermal plant, located at the Ollagüe community, Antofagasta Region, Chile, and was constructed by Enel Green Power Chile Ltda. (EGPC), and ENAP (Empresa Nacional del Petróleo) that is the state-owned utility for hydrocarbons in Chile.

Cerro Pabellón has an installed capacity of 48 MW, composed of two 24-MW each binary-cycle units manufactured by Ormat, and is the first geothermal plant operating with high-enthalpy resources at ~4500 meters above the sea level, in the Atacama Desert. The plant is owned and operated by Geotérmica del Norte, SA, which is a joint venture between EGPC (81.7% of the shares) and ENAP (18.3%). The plant had been in pre-operational tests since late January 2017, supplying electric energy into the Norte Grande interconnected electric system (SING: Sistema Interconectado del del Norte Grande), located in northern Chile.

Once the plant be at its full capacity, it will produce

around 340 GWh annually, avoiding the emission of 166,000 tons of CO<sub>2</sub>. Cerro Pabellón incorporates the most advanced geothermal technology for working at extreme climate conditions and high altitude.

Sources:

<http://www.elmostrador.cl/noticias/pais/2017/03/31/primera-planta-geotermica-de-sudamerica-enel-y-enap-inyectan-energia-al-sistema-con-cerro-pabellon/>,  
<https://www.enel.it/en/media/press/d201703-enel-and-enap-connect-to-the-grid-first-geothermal-plant-in-south-america-cerro-pabellon.html>

In other related news, it was unveiled that the Inter-American Investment Corporation (IIC) has signed a US\$30 million corporate loan facility with Enel Green Power Chile to finance further development of the Cerro Pabellón geothermal power plant in Chile. The loan will be funded by the Clean Technology Fund Loan (CTF), administered by the IIC. The project includes a third power plant of similar capacity, to reach a combined capacity of 75 MW, an 80-kilometer transmission line and other associated facilities.

Source: <http://newenergyevents.com/chile-30m-loan-for-exploratory-phase-at-cerro-pabellon-geothermal-project/>

## Costa Rica: Advances in Las Pailas II Project, 99% Renewable Electricity

**Las Pailas II** - The flagship project of the Instituto Costarricense de Electricidad (ICE), Las Pailas II in the Province of Guanacaste, has entered into its second half of construction. The project includes a 55 MW steam turbine by Mitsubishi Hitachi Power Systems (MHPS), and construction began in January of the five-cell cooling tower. According to the construction coordinator of Las Pailas II, Didier Ugalde, in previous projects the cooling towers have been built with concrete and wood, never with fiber glass. This new material reduces the investment in the project, it brings down the costs of operation and it benefits the environment, explained Ugalde.

INITEC Energía, S.A., a Spanish engineering firm, is in charge of engineering, procurement and construction (EPC) management on the project, under the general supervision of ICE. In addition, MHPS has engineers at the site for technical support in installation and commissioning. A generator, manufactured by Mitsubishi Electric



Corp., will also be supplied for the project. The machine room will take up less space than the ones already operating in the country, a world trend in the design of geothermal projects. In this area, they will use a light concrete panel system to improve the sound isolation of the equipment.

The construction of Las Pailas II began in 2013. When it begins operating in 2019, it will be the seventh of its kind in Costa Rica. During 2015 and 2016, the country has produced more than 98 percent of its electricity from renewable sources, including geothermal energy.

Source:

<http://www.renewableenergyworld.com/articles/2016/11/costa-rican-utility-secures-turbine-for-las-pailas-ii-geothermal-plant.html>

**99% of Renewable Energy in the First Quarter** - Costa Rica continues its trend of achieving near total renewable energy production with a first quarter record of 99.06 percent, said the National Energy Control Center (CENCE).

Geothermal generation is rebounding from damages suffered at the Miravalles III plant in northern Costa Rica from Hurricane Otto late last November.



Of the total 2,744.41 GWh produced in the first quarter of 2017, 69.3 percent was from hydro, 16.2 percent from wind, 11.2 percent from geothermal, 2.2 percent from biomass, 0.16 percent from solar; and bunker and diesel, the one non-renewable source of electricity, was used for 0.94 percent of the country's needs from January 1 – March 31. Geothermal energy provided 13% of Electricity during the last year (see IGA News 106, pp. 17

Source: <http://news.co.cr/costa-rica-runs-99-renewables-first-quarter-2017/58840/>

## Guatemala: El Ceibillo Project To Be Offered in a 40 MW RFP for Geothermal Power

The geothermal developer and operator, U.S. Geothermal, has announced plans to participate in a 40 MW Request for Proposals (RFP) for geothermal in Guatemala with its El Ceibillo geothermal project in Guatemala. In early January, the Guatemalan Government, through the National Electrical Energy Commission (Comisión Nacional de Energía Eléctrica-CNEE), announced it is preparing to issue an RFP later this year for 420 MW, of which 40 MW is to be reserved specifically for geothermal energy. When the RFP is issued, the El Ceibillo project will be bid into the process.

With the commercial, shallow resource now proven, in 2017 a deep well to test the producing structure down dip from well EC-5 is planned to a projected depth of 1,970 to 2,300 feet (600-800 meters). Well EC-5, completed to a depth of 1,450 feet (442 meters), intersected a high permeability zone at 1,299 feet (396 meters) with a temperature of 388°F (198°C). Chemical analyses of fluid samples taken from well EC-5 at the end of a flow test indicate a potential, deep reservoir temperature of 450 to 523°F (232 to 273°C). A deeper intersection in the reservoir could increase the reservoir capacity and production temperature, and change the

design of the power plant. Well EC-1, drilled in 2013 to a depth of 5,650 feet (1,722 meters), had a measured bottom-hole temperature of 526°F (274°C) but did not intersect permeability. The comparative geology between wells EC-5 and EC-1 suggests a fault or other structure feeding the reservoir may be located in the area between the two wells.

U.S. Geothermal is planning to install a 25 MW plant for the El Ceibillo site.

Source:

<http://www.thinkgeoenergy.com/u-s-geothermal-to-participate-in-40-mw-rfp-for-geothermal-projects-in-guatemala/>, <http://www.marketwired.com/press-release/us-geothermal-inc-provides-update-on-development-and-expansion-projects-nyse-mkt-htm-2193619.htm>

## Honduras: Platanares Project to Start Operations this Year

Construction of the Platanares geothermal power plant in Honduras is at an advanced stage, according to the advisor to the Honduran Council of Private Enterprise (COHEP), Salomón Ordóñez. The first geothermal power plant to operate in Honduras, it will have an installed capacity of 35 MW and is expected to start operating this year.

The US\$200 million geothermal project – inclusive of Honduran and foreign capital – is located in the municipality of La Unión, department of Copán, in western Honduras. In February last year, Ormat Technologies, Inc. issued a press release in which it announced that its indirect subsidiary, wholly owned, confirmed the start of construction of the geothermal project, and that in 2013, Ormat signed a contract to build, operate, and transfer the Platanares geothermal project with Electricidad de Cortés (Elcosa), a privately-owned Honduran energy company. In December 2015, Ormat concluded the drilling activity, and the evidence supporting the project's decision.

The energy generated by Platanares will be marketed under the 30-year energy purchase agreements signed with the National Electricity Company of Honduras (ENEE) (*see also* IGA News No. 105, pp. 12-13).

The Platanares geothermal project is regulated under the 'Law for the Promotion of the Generation of Electric Power by Renewable Resources', enacted in 2007. According to the law, it can benefit from a tax exemption during the first 10 years of operation.

The company expects to reach commercial operation by the end of 2017 and generate annual revenues of about US\$33 million.

Source: <http://newenergyevents.com/honduras-geothermal-plant-in-advanced-stages-of-construction/>

## Nicaragua: Legal Aspects on Geothermal Development

*Following are some interesting data on the Nicaraguan geothermal regulation, written by Attorney Fidel Sánchez.*

In Nicaragua, geothermal power provides attractive tax incentives based on Act 443, "Law on the Exploration and Exploitation of Geothermal Resources" and any amendments thereto, published on November 17, 2014. Some of these tax incentives for the development of geothermal power in Nicaragua include the following:

- Exoneration of customs duties and VAT on machinery, equipment, and materials for works construction;
- Exoneration of the payment of income tax for a 10-year period following the commencement of the project's commercial operations;
- Exoneration of payment of municipal income tax (IMI) for a 5-year period following commencement

of the project's operations.

A key aspect to be noted is that ENEL (Empresa Nicaragüense de Electricidad), a state-owned company for power development, should own at least a 10% equity interest in the specific geothermal exploitation project and must have a seat at the Board of Directors with right to speak and vote in the company that was granted the exploitation concession. On the other hand, the remaining 90% equity interest must be owned by the specific domestic or foreign investor for up to a 30-year exploitation concession period following the execution of the exploitation agreement.

The geothermal exploitation concession may be extended by the Ministry of Energy and Mines (MEM) for a similar period to that initially granted –up to 30 years–, provided that the concessionaire has applied for an extension after five years following the commencement of the exploitation and/or at least three years before the expiration thereof, and to the extent there is technical evidence on the possibility to increase its generation capacity.

The fact that geothermal power flows 24 hours a day in a consistent and uninterrupted way is an attractive factor which favors its high profitability, along with the steady investment environment in Nicaragua over the last five years, which represents a positive global landscape for the commencement of geothermal energy development projects in the country.

Source: <http://www.blplegal.com/nicaragua-legal-updates-on-geothermal-power/>

## United States: San Emidio, Lithium, Federal Budget, Unconventional and New Projects

**More Capacity in San Emidio** - US Geothermal Inc. announced that the estimate of the geothermal reservoir capacity associated with its San Emidio II project has increased from the earlier estimate of 10 MW net to an



*San Emidio plant (Photo by Us Geothermal Inc.)*

estimated generation capacity of up to 47 MW net. This increase is in addition to the current 10 MW being produced by the existing San Emidio I plant.

“Now, we would use those three power plants we own”, said Douglas Glaspey, President and Chief Operating Officer of US Geothermal, in early March. “With a temperature of over 320°F (160°C), this new resource is a perfect fit for these three power plants and most of the equipment is already stored on site at San Emidio. We received permits to deepen three more wells in the new resource area and are ready to proceed with drilling as soon as weather allows...”

In early 2016, five 1,000 foot (~300 m) temperature gradient wells were drilled in the Southwest Zone and later in the year, two of those wells were deepened. Both wells intersected a high permeability, high temperature geothermal reservoir. Data from flow tests that took place in late 2016 on the two deepened wells were incorporated into a Probabilistic Power Density model developed by Geothermal Science Inc., an independent geothermal reservoir engineering company. Based on the flow rate and temperature produced by the two wells, and by measurement of pressure response across the well field, the model estimates that the area encompassed by the five wells drilled in 2016 (0.18 square miles or 0.47 km<sup>2</sup>) has a 90% probability of 18.8 MW net of generation capacity as the Minimum. A larger area (1.4 square miles or 3.6 km<sup>2</sup>), defined by additional temperature gradient wells and geophysics, has a 50% probability of 47 MW net of generation capacity and was rated as the Most Likely outcome.

The three remaining 1,000-foot-deep temperature gradient wells all have high temperature gradients and bottom-hole temperatures indicating that an active geothermal resource exists below them. Permits to deepen these three remaining wells down into the production reservoir were received from the Bureau of Land Management (BLM) and the State of Nevada in late December. Subject to weather conditions, drilling to deepen those wells is planned for the first quarter of 2017.

Sources: <http://www.marketwired.com/press-release/us-geothermal-announces-substantial-increase-in-the-san-emidio-ii-reservoir-capacity-nyse-mkt-htm-2187722.htm>,  
<http://seekingalpha.com/article/4054302-us-geothermals-htm-ceo-dennis-gilles-q4-2016-results-earnings-call-transcript>

**Joint Venture to Extract Minerals from Geothermal Brines** - In early January a new company, Geolithic Corp., was formed with the purpose of extracting lithium and other minerals from geothermal brine. Geolithic is a joint venture between 6<sup>th</sup> Wave Innovations Corp., a nanotechnology company that

develops proprietary molecularly imprinted polymers for minerals extraction in mining applications, and TriLateral Energy, LLC that is an independent energy developer with extensive geothermal operations and construction experience.

6<sup>th</sup> Wave has already begun laboratory testing of the proprietary lithium extraction technology, which could significantly reduce the cost of producing lithium and other minerals compared to traditional mining and other mineral extraction techniques. Such minerals are naturally present in the brine utilized by many existing geothermal power plants in the U.S. and worldwide.

Geolithic Corp. plans to construct a pilot project extraction plant at one or more U.S. geothermal energy facilities, to seamlessly integrate into the facility's existing brine handling processes the extraction of lithium and other minerals prior to reinjection of the brine into the geothermal reservoir.



*6<sup>th</sup> Wave Lab in Salt Lake City, UT (Photo 6<sup>th</sup> Wave).*

Under the Joint Venture agreement, 6<sup>th</sup> Wave will retain all rights to its proprietary molecularly imprinted polymer nanotechnology but will provide an exclusive license to Geolithic Corp. for geothermal minerals extraction.

Dr. Jonathan Gluckman, CEO of 6<sup>th</sup> Wave, said, “We are pleased at the opportunity to work closely with TriLateral Energy, which has decades of geothermal power plant construction and operations experience and extensive contacts in the industry. I am confident this joint venture will establish proof of concept with a pilot lithium extraction plant in the United States.”

Don O'Shei, CEO of TriLateral Energy, stated, “I was an early investor in 6<sup>th</sup> Wave and believe that the application of this groundbreaking extraction technology to geothermal brine has the potential to significantly lower lithium and other mineral production costs. TriLateral will manage the commercial aspects of the joint venture and 6<sup>th</sup> Wave will manage the technical aspects as we move forward to combine our skill sets to

construct the first pilot plant at an existing geothermal facility.”

Source: <http://www.prnewswire.com/news-releases/6th-wave-innovations-corp-and-trilateral-energy-form-geolithic-corp-a-geothermal-minerals-extraction-nanotechnology-joint-venture-300396530.html>

**Renewables Probably Won't Be Deeply Affected by the New Federal Budget** - On March, the Trump administration released a preliminary 2018 budget proposal outlining changes to discretionary spending that, if implemented, would likely cut spending on renewable energy.

Among a list of 15 government entities that would see cuts under the proposed budget, two that could affect renewable energy programs are the Environmental Protection Agency (EPA) and the Department of Energy (DOE). Trump has proposed a 31% cut in spending for the EPA and a 6% cut for the Energy Department.

The budget proposal also seeks to cut funding for the DOE's Office of Energy Efficiency and Renewable Energy (which includes the Geothermal Technologies Office - GTO) and the Advanced Research Projects Agency-Energy (ARPA-E) and "...takes a big axe to the EPA's budget," said Raj Prabhu, CEO of Mercom Capital Group, a clean energy research firm.

Even with the budget proposal, experts do not believe the momentum of renewable energy installations will slow down.

"I hope the final budget is based on reality, jobs, and a strategic energy plan and doesn't just make cuts because some members of the Republican Party don't believe in climate change science or support newer, clean-energy technologies," Prabhu said. "What Congress does understand is jobs and the renewable sector is creating plenty of them in both red and blue states."

"By and large Congress ignores what a President is asking for and enacts a budget that most closely resembles the funding levels it allocated the year before," Prabhu said. "Congress disregarded President Obama's request for significant increases in spending on renewables and energy efficiency programs, even when Democrats controlled the legislative branch, and they are likely to do the same this year."

Source: <http://www.armnet.com.au/article/616147/here-what-trump-budget-means-renewable-energy>

**Geothermal in Texas?** - A Houston-based company, Raven Petroleum, plans to build the largest new oil refinery in the United States in 40 years, and they say that they're going 'green'.

Raven Petroleum's managing director, Christopher Moore, announced February that they will partner with Austin-based Thermal Energy Partners to build a 55,000 barrel-per-day crude oil refinery with an onsite geothermal plant on 832 acres (~337 hectares) in Duval County, just east of Laredo, Texas. The refinery will process sweet crude oil from Texas's Eagle Ford Shale and export diesel, jet fuel, naphtha, gasoline, and liquefied petroleum products to Mexico via railway.

"This is going to be a near-net-zero emission, and we will not be burning any dry gas for our energy," Moore told The San Antonio Express-News during a press conference. "We will be pulling that completely from the geothermal."



*A clean refinery. Image by Raven Petroleum.*

The geothermal plant will be capable of generating up to 20 MW of power using the heat from wells dug 12,000 feet (~3650 m) deep to power turbines, according to James Jackson, Chief Business Development Officer at Thermal Energy Partners.

"Many people don't even realize that geothermal is possible in Texas," Jackson said. But according to the native Texan, the state has vast untapped potential: He estimates Texas holds up to 10% of the total geothermal energy latent in the United States.

"The idea is to make the cleanest, greenest refinery possible, and the intent is to replicate this model," said Jackson, who has already been approached not just by other oil companies, but by other industries interested in using geothermal energy to power their operations.

However, while the new refinery has generated buzz on the pros and cons sectors of the spectrum, the project is still in its infancy. Raven Petroleum has yet to apply for the necessary permits through the Texas Commission for Environmental Quality (TCEQ), but is expected to do so by the second quarter of this year. Until then, the

full scope of the refinery's 'greenness' remains uncertain.

Source: <http://fusion.net/story/392049/major-oil-refinery-claims-it-will-be-green-with-geothermal/>, send by Marcelo J. Lippmann.

**Started Project To Use Hot Springs at Less than 90°C** - Modoc County, located in northeastern California, is beginning a project to generate constant electrical power from the geothermal water using a new, entirely green engine technology developed by Receivable Acquisition & Management Corporation d/b/a Cornerstone Sustainable Energy (CSE), headquartered in New York City. The Modoc County Board of Supervisors has contacted CSE to supply its PwrCor™ engine as part of a demonstration project that will convert ultra-low-grade heat into electricity. The project was started in early January and is sited at the Surprise Valley Hot Springs resort. The heat will be obtained from a geothermal well or hot spring.

Surprise Valley is designated by the U.S. Geological Survey as a 'Known Geothermal Resource Area' (KGRA). Substantial research to develop this geothermal potential has taken place since the 1950s. A major step in developing the resource occurred recently when CSE entered into an agreement with Warner Mountain Energy Corporation (WME) to begin the first-phase development of a geothermal energy plant to be located at the Surprise Valley Hot Springs east of Cedarville. This phase of development includes a feasibility analysis, conceptual design, and budgeting to install CSE's PwrCor™ engine with required site infrastructure to generate electrical power. The electricity generated would be entirely renewable.

WME controls about 1,000 acres (~0.405 hectares) at

delivering about 850 gallons per minute (53.6 liters per second) at 205°F (96°C). CSE will tap the hot spring water to supply heat to its PwrCor™ engine. "One of the major costs in developing geothermal power is the drilling. We are bypassing this step by only using the surface flow of hot water," explains Peter Fazio, Chief Operating Officer for CSE of New York.

CSE's technology is projected to produce 250 kW of electric power with 150 gallons per minute (9.5 lps) of water at 180°F (~82°C). At that level of output, the Surprise Valley Hot Springs site represents a potential estimated at 1.5 MW of constant, uninterrupted electric power. "The hot spring water is basically boiling at the surface and will be placed in a 'closed loop' heat exchange system which means it will never touch the working fluid. This way it guarantees no possibility for contamination to the environment or any surrounding water sources," said Curt Rose, partner with the WME. Once online, the PwrCor™ engine will operate at input temperatures and flows that are considerably less than those required by competing technologies.

"The engine is quiet and does not use turbines to generate power. Traditional geothermal plants use ammonia, pentane or other noxious gases for their heat exchange. Their equipment is usually expensive to repair. CSE's engine uses a non-toxic liquid in its heat exchanger and replacement parts are relatively inexpensive," said Fazio. The engine, weighing approximately 30,000 pounds (~13,600 kg) is 25 feet long (7.6 m), 8 feet wide (2.4 m) and 9.5 feet (2.9 m) tall and will be housed in one of the existing buildings at the hot springs.

Branded by CSE as PwrCor™, the technology operates on thermal hydraulic principles, in contrast to the thermal pneumatic principles employed by steam (Rankine cycle) engines and their cousins, the organic Rankine cycle (ORC) technologies. The PwrCor™ technology uses the physical expansion of fluids under heat to drive a piston. The company claims that this technology has very low or no fuel costs, no internal fuel combustion, produces no pollution and operates silently.

CSE will assume the financial burden of developing the entire project. WME will provide the location, engine oversight, and general sweat labor. WME will also monitor the project to see if the grid can support more engines. If so, more engines will be placed beside the original engine inside the building.



*Hot springs in Surprise Valley, California (photo from a CSE's press release).*

the Surprise Valley Hot Springs. The site has several artesian hot springs free flowing to the surface,

It will take 90 to 120 days to manufacture and deliver the pretested engine to the hot springs. Because this is the first of its kind, it is estimated that getting the engine up and running will take another 30 days. “This is a prototype for our company and could change energy production worldwide,” said Fazio. CSE has patents on their engine and exclusive rights in the Western Hemisphere. Research contributions to the WME project site have been provided by the U.S. Geological Survey (USGS), the National Space and Aeronautics Administration (NASA), Natural Resource Conservation Service (NRCS), the State of California’s California Energy Commission (CEC), UC Davis, Stanford University and others. Grant funding to university programs has come from sources such as the National Science Foundation (NSF) and Petroleum Research Fund.

CSE will be paid directly by Modoc County from funding that was arranged via a grant from the California Energy Commission, with the CSE responsible for certain project expenses. The mission of the California Energy Commission includes supporting the use of alternative energy sources, which the PwrCor™ technology will accomplish.

The project will be managed by Warner Mountain Energy Corporation. Dr. Roy Mink, Chief Executive of Warner Mountain and former manager of the U.S. Department of Energy geothermal program, explained, “The demonstration project will illustrate how low temperature geothermal heat resources, heretofore not considered economically feasible for power generation by the geothermal industry, can be tapped using this breakthrough technology.”

Sources:

[http://www.marketwatch.com/\(S\(rnrsydaynixa5x55oiibxm45\)\)/story/cse-selected-for-clean-energy-project-2017-01-04](http://www.marketwatch.com/(S(rnrsydaynixa5x55oiibxm45))/story/cse-selected-for-clean-energy-project-2017-01-04), <http://cseindustries.com/?p=1150>

**Award for Geothermal Data Logging at Very High Temperatures** - Ozark Integrated Circuits (Ozark IC), won a US\$155,000 Small Business Innovation Research award from the U.S. Department of Energy (DOE) to provide an enhanced solution for geothermal well data collection. Ozark IC is a fabless semiconductor company, based in Fayetteville, Arkansas, that develops integrated circuits designed to operate in extreme environmental conditions.

Usually, the deeper a geothermal well, the hotter the temperature. “Reliable data logging is needed to determine what is happening inside the well and to ensure the stability of the well. Typical electronic systems cannot operate at temperatures above 225°C without expensive thermal insulation systems – and even then, can only operate for a few hours,” said Dr. Matt Francis, CEO of Ozark IC.

For several years, the company has been developing special electronics that will work on the 500°C Venus surface. “With this award, Ozark IC will now use its expertise and technologies to develop high-temperature data logging electronics for geothermal wells that can operate at 300-500°C for hours to years with little or no thermal insulation,” said Dr. Ian Getreu, director of business development and strategic partnerships for the company.

**Ozark** **INTEGRATED**  
**CIRCUITS INC**

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Ozark IC has many years of experience in developing Silicon Carbide ultra-high temperature electronics and is a leader in this field. It has received five contracts from NASA to develop electronics suitable for the 500°C Venus surface as well as from the U.S. Air Force for the packaging of these electronics in aerospace applications (jet engines).

This DOE award is a significant step in Ozark IC’s strategy to commercialize its NASA-funded technology. “The oil and geothermal exploration market is an obvious first application of this expertise and technology since the environment inside deep wells is very similar to the Venus surface environment,” said Francis.

Ozark IC has received expressions of interest in the use of its technology from companies in the oil and geothermal exploration market. Ozark IC has also extended its license to NASA’s SiC IC technology to evaluate as part of this project – recently demonstrated by NASA operating for a record 22 days in Venus surface conditions.

Source: <http://asbtdc.org/ozark-ic-wins-dept-of-energy-sbir-award-for-geothermal-data-logging/>

**Demonstration Project to Use sCO<sub>2</sub> for Geothermal Power Generation** - GreenFire Energy Inc. announced in March that it has been selected for a grant award from the California Energy Commission (CEC) to build the world’s first demonstration of closed-loop geothermal power generation using supercritical carbon dioxide (sCO<sub>2</sub>) instead of water. GreenFire Energy Inc.’s geothermal power generation process could enable thousands of megawatts of new carbon-free power plants in California and other markets. The proposed US\$1.48 million grant from the Energy Commission’s Geothermal Grant and Loan Program will be considered for approval by the Energy Commission at its Business Meeting in June.

California has an aggressive goal of generating 50% of electricity retail sales with eligible renewable energy resources by 2030. Geothermal energy is an essential part of California's energy mix, as well as an important part of the state's clean energy efforts. The purpose of the Geothermal Grant and Loan Program is to promote development and maintenance of California's vast

existing geothermal projects to boost power output using the existing infrastructure," said Joseph Scherer, chief executive officer, GreenFire Energy Inc.

There is another similar project using sCO<sub>2</sub> that was recently received an award from the DOE. It is a six-year project to design, build, and operate a 10 MW supercritical carbon dioxide pilot plant test facility in San Antonio, Texas (*see* IGA News 106, pp. 32-33).

Source: <http://www.greenfireenergy.com/greenfire-energy-inc-awarded-major-grant.html>

## ASIA/PACIFIC RIM

### China: Sinopec and the 13<sup>th</sup> Five-Year Plan

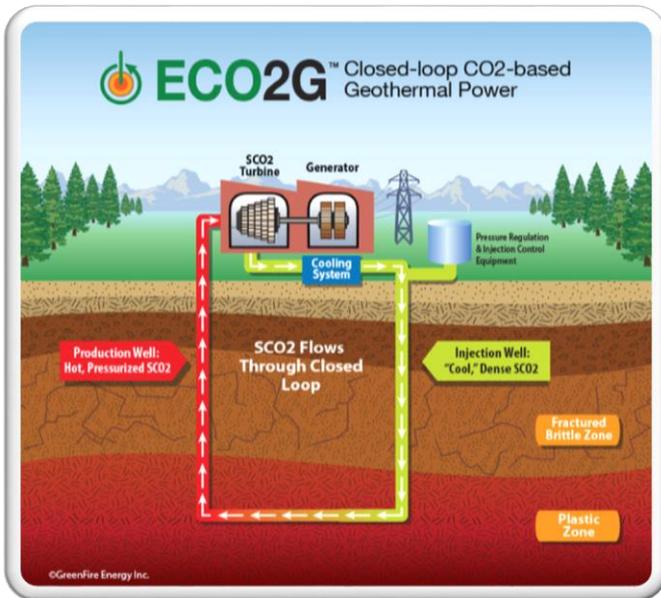
**Oil Giant Taps China's Vast Geothermal Reserves -** Chinese state-run energy giant, Sinopec, has drilled hundreds of wells across the country without finding a single drop of oil. But that was precisely the point: instead of black gold, the almost mile deep holes are providing clean heat for local homes.

While two-thirds of China's electricity is generated by coal, almost all of the homes in northern Hebei province's Xiong district—home to 400,000 people—are heated by wells as deep as 1,500 meters. Chen Menghui, director of Sinopec's geothermal branch in Hebei, said, "These underground wells are pumped with water, which comes out at a temperature of around 70°C before flowing into the heating system."

Though experts say there is immense potential in China's subterranean heat reserves, they remain largely unexploited, accounting for less than 0.5% of the Asian giant's energy consumption. Sinopec's geothermal projects in China heat more than 40% of the total number of homes heated by geothermal energy in the country, making them a potential model for how to tap this resource.

Before launching itself into the geothermal industry, Sinopec found an unusual partner in the Icelandic company, Arctic Green Energy. Sinopec needed technical support and Iceland is regarded as the leader in extracting energy from the ground. In a joint venture beginning in 2009, they invested 400 million yuan (US\$58 million) into the Xiong project, where they drilled almost 70 wells.

"Iceland, on the mid-Atlantic ridge, has exceptional resources, with temperatures exceeding 250°C—hot enough to supply power plants," said Wang Yanxin, a geological research officer at Sinopec. "In China, with the exception of Sichuan and Tibet, there are hardly any temperatures exceeding 150°C, which forces us to concentrate on heating systems," he added.



*Schematic of the process. Source: GreenFire Energy Inc.*

geothermal energy resources.

GreenFire Energy Inc.'s innovative ECO2G™ technology harnesses recent advances in deep and directional drilling technologies from the oil and gas industry to access high-temperature geothermal resources that cannot be exploited with existing geothermal technology. The demonstration project involves inserting a co-axial, closed-loop tube into an existing geothermal well that lacks sufficient permeability to generate power. Supercritical carbon dioxide will then be circulated to transfer heat to the surface and generate power from a small turbo expander.

The ECO2G™ technology developed by GreenFire is presented as a solution to harvest the earth's 'thermal battery', which is by far the largest source of continuous renewable energy. ECO2G™ accesses the extremely large, hot and deep geothermal resources that have been previously unreachable, and its modular scalable architecture fully exploits deep geothermal resources to provide grid-scale power generation. The company has been awarded two grants by the U.S. Department of Energy (DOE), and this demonstration project "...will show that ECO2G projects can be co-located with

Sinopec has geothermal facilities in 16 Chinese provinces, allowing it to heat some 40 million square meters of homes and factories –and avoiding an estimated three million tons of CO<sub>2</sub> emissions. One potential benefit of the project could be a significant reduction in local air pollution, a problem that has plagued much of northern China.

According to Sinopec, Xiong has become China's first 'smokeless town' by eliminating the coal-fired heating systems common throughout other parts of the country. Although the area is still regularly covered with a thick layer of pollution coming from surrounding industrial districts, Sinopec aims to develop 20 such 'smokeless cities' nationwide by 2020.

The company's ambitions align with the ruling Communist Party's plan to significantly reduce air pollution in Chinese cities, in part by increasing the use of clean energy to replace carbon-based fuels. That goal includes a ten-fold increase in geothermal resources: growing electrical output to 530 MW by 2020 and tripling the floor-space of buildings heated by geothermal energy (*see* note below).

Lin Boqiang, the director of the energy research center at Xiamen University, is skeptical of the project. "It's clean, but compared to solar or wind, the cost of geothermal is incredibly high," he told, questioning whether the project could survive without state support.

At Sinopec, Duan Qiaohong, who is responsible for the Communist Party committee involved with the Sino-Icelandic joint venture, discussed the problem in veiled terms. "It is evidently a crucial question whether there is demand in the market, that's ultimately what decides in the end," he told. The sector produces only "meager profits" and in the absence –for the time being– of national support, it still depends on subsidies from local authorities, he said.

But "Other big public groups have followed in Sinopec's footsteps and increased competition could encourage the development of cheaper geothermal technologies," Duan said. "Either way," he added, "the future looks bright: the geothermal industry corresponds perfectly with current clean energy priorities."

Source: <http://www.rappler.com/science-nature/environment/162600-china-sinopec-geothermal-energy>

**Plan to Reach 530 MWe by 2020** - China has recently issued the 13<sup>th</sup> Five-Year Plan for geothermal energy, the first such plan in the country, in a bid to boost clean-energy development and improve the environment. From 2016 to 2020, China will add to geothermal power's installed capacity by 500 MW, and the geothermal heating area by 1.1 billion square meters.

Thus by 2020 the country is aiming for a geothermal power installed capacity of 530 MW and a geothermal heating area of 1.6 billion square meters, according to the country's energy planner.



*A worker from Sinopec Company shows how the heat pump is operated to journalists in Zangangzhen, Heibei province (Photo by Fred Dufour/AFP, taken from the source).*

Source: [http://www.chinadaily.com.cn/bizchina/2017-02/15/content\\_28201883.htm](http://www.chinadaily.com.cn/bizchina/2017-02/15/content_28201883.htm)

## **Indonesia: Exploration, Sarulla & Muara Laboh Projects, Geothermal Pricing, Regulation 10/2017, and WB Grants**

**More Investment in Exploration & Drilling** - State-owned energy giant Pertamina has allocated US\$54 billion in investment for upstream industry between 2016 and 2025, aiming for a 185 percent increase in oil, gas and geothermal production.

In 2025, Pertamina aims to produce oil, gas and geothermal energy of around 1.91 million barrels of oil equivalent per day (boepd), a significant jump from 0.67 million boepd in November 2016.

"Hence, we want to be more aggressive in strengthening the upstream industry by trying to exploit more domestic and overseas oil and gas blocks," Pertamina spokesperson Wianda Pusponogoro said in January.

Source: <http://www.thejakartapost.com/news/2017/01/17/per>

[tamina-allocates-us54-billion-to-strengthen-upstream-industry.html](#)

### First Unit of the Sarulla Project Starts Operation -

Toshiba Corporation and Ormat Technologies Inc. announced on March 21 that the first unit of the Sarulla geothermal power plant, one of the world's largest power plants, located in Indonesia's North Sumatra, has commenced commercial operation.

The approximately 110 MW power plant, which combines flash and binary technologies to provide a high efficiency power plant and 100% reinjection of the exploited geothermal fluid, is operated by Sarulla Operations Ltd. (SOL). As participants in the project, Toshiba supplied the geothermal steam turbines and generators (STGs) for the flash systems, while Ormat provided the conceptual design of the Geothermal Combined Cycle Unit (GCCU) power plant and supplied its Ormat Energy Converter (OEC), which serve as the condensing units for the steam turbines and utilize the separated brine for maximum resource exploitation and maximum power output.



*Aerial view of Sarulla. Photo by Kyushu Electric Company.*

Toshiba and Ormat will continue to collaborate strategically on global promotion of highly-efficient geothermal combined cycle flash and binary systems, and both companies continue to seek to utilize and promote renewable energy globally. Isaac Angel, Ormat's CEO, said, "The Sarulla supply contract is the largest single contract that Ormat has signed to date... We continue to share our expertise as work continues on the second and third units of the Sarulla project that are expected to come on line by 2017 and 2018, respectively."

SOL is owned by Itouchu Corporation (25%), Kyushu Electric Power Co. Inc. of Japan (25%), PT Medco

Power Indonesia (18.9975%), INPEX Corp. (18.2525%), and Ormat International Inc. (12.75%). Total capacity of the Sarulla project will be 320.8 MW in three units, and the EPC contractor is Hyundai Engineering and Construction Co., Ltd.

Source: <http://www.ormat.com/news/latest-items/one-world-s-largest-geothermal-power-plants-commences-commercial-operation>

### Construction of Muara Laboh Geothermal Station Commences -

The Japan Bank for International Cooperation (JBIC) and the country's three megabanks will provide financial support for the Indonesian geothermal power plant planned by Sumitomo Corp., as Japan pushes infrastructure exports as a key growth strategy.

JBIC, together with Mizuho Bank, Bank of Tokyo-Mitsubishi UFJ and Sumitomo Mitsui Banking Corp., will offer a syndicated loan with the Asian Development Bank. The sum will total around US\$440 million, of which JBIC will cover roughly US\$200 million. Nippon Export and Investment Insurance will insure loans provided by the megabanks.

Sumitomo broke ground on the 80 MW Muara Laboh geothermal power plant in South Solok in West Sumatra, on 24<sup>th</sup> March, and plans to begin commercial operations in 2019. Fuji Electric will supply the plant's main parts such as steam turbines and power generators. Sumitomo will handle surveying of the project area, as well as operations and maintenance after construction is completed. It is the first time that Sumitomo, a trading house, will run a geothermal power plant. Indonesia's Supreme Energy and France's ENGIE will also participate in the project.

Supreme Energy holds the Muara Laboh concessions and the geothermal license, and formed the company Supreme Energy Muara Laboh (SEML) that signed the Power Purchase Agreements (PPA) with Perusahaan Listrik Negara (PLN). SEML has developed the exploration program since 2010 and it has completed the Micro Earth Quake (MEQ) and Airborne topographic surveys, civil engineering studies, and land acquisitions which were required for the exploration. Between 2012 and 2013 SEML drilled six exploration wells, and in 2014 made the well monitoring, data evaluation and reserve calculations. SEML obtained certification of the amount of steam backup of an independent agency, confirming that there is sufficient steam to build a power plant with a capacity of 80 MW. Finally SEML completed the EPC tender process.

French energy company ENGIE said it was making its debut in geothermal energy with a commitment to help build a power plant in Indonesia. ENGIE said it has the drilling and other subterranean experience necessary to help build a facility that at 80 MW, will have the capacity

to power 120,000 average homes. The company said construction will take about 30 months. ENGIE CEO Isabelle Kocher said her company has the technology needed to help Indonesia "...provide their population with efficient low-carbon power generation sources."

The project's cost is estimated at 70 billion yen (US\$610 million), of which Sumitomo will invest around 35 percent. According to that, the unitary cost of the project will be around US\$7.6 million per megawatt installed, which seems to look high even for a green field project.



For its part, the Asian Development Bank (ADB) announced it has signed a US\$109 million financing package for the same Muara Laboh geothermal power project. This project is one of the first to get funding from ADB's recently created Leading Asia's Private Infrastructure Fund (LEAP), which is capitalized by US\$1.5 billion in equity from Japan International Cooperation Agency (JICA). The support, which was approved in December 2016, includes a US\$70 million loan from ADB's own capital and a US\$19 million participation from the Clean Technology Fund (CTF).

Sources: <http://asia.nikkei.com/Business/Deals/Japan-banks-to-back-Indonesian-geothermal-power-project>, <http://www.supreme-energy.com/company/se-muara-laboh/>, <https://renewablesnow.com/news/adb-backs-80-mw-indonesian-geothermal-project-555850/>, <http://www.upi.com/Former-OPEC-member-Indonesia-makes-geothermal-move/7471485512163/>, <http://www.sumitomocorp.co.jp/english/news/detail/id=29868>

**INAGA Considers that Electricity Price Rule May Hamper Geothermal Exploration** - The Indonesian Geothermal Association (INAGA) is disappointed with

the Energy Ministry's regulation No. 12/2017 on the use of new renewable energy for electricity. INAGA fears that the rule will hamper efforts to discover geothermal reserves.

"The clauses are so biased, they could hamper geothermal exploration," INAGA chairman Abadi Purnomo said on early February. Abadi said the 11 clauses govern that a geothermal SPA (Sales and Purchase Arrangement) can only be signed once the developer has proven reserves, which requires exploration that costs US\$8 million-US\$10 million per well. "Who would want to pay for the explorations? And businesses will not take risks of drilling wells if there is no guarantee someone will buy the electricity," he said.

Energy Minister Regulation No. 12/2017 governs the price of electricity generated from new renewable energy sources –including biomass, sun, wind, water, biogas, waste, and geothermal. The Ministry's Director General for Renewable Energy and Conservation, Rida Mulyana, said the sales price is based on each producing area's costs.

Rida also said that the rule provides certainties for electricity developers, guaranteeing that PLN will buy electricity from them. The rule, he said, clearly mandates PLN to buy power from clean energy sources.

The government has also allowed PLN to negotiate with developers farming energy sources in Java, Sumatera, and Bali. Abadi argues that negotiations are a source of problems hampering power purchase agreements (PPA) between PLN and developers.

However, Rida ensured that negotiations will not stall power plant constructions, as the Ministry has the power to determine the final sales price.

Source:

<https://en.tempo.co/read/news/2017/02/06/056843426/Electricity-Price-Rule-May-Hamper-Geothermal-Exploration-INAGA>

**MEMR's Regulation 10/2017** – Besides Regulation 12/2017, mentioned before, the Indonesian Ministry of Energy and Mineral Resources (MEMR) issued new regulations, numbers 10/2017 and 11/2017. The 10/2017 regulation deals with the terms and conditions of PPAs. Under existing conventional PPAs, the PLN's monthly payment to the IPPs is made up of a capacity component and a variable component. But regulation 10 states that a: (i) PLN is only required to take and pay for electricity produced by the IPP for a certain period of time; and (ii) this period of time should be agreed upon between the parties by considering the period of repayment to the IPP's lenders. This provision has, therefore, triggered concern among developers that the next model PPA issued by PLN may not provide for

capacity payments once the IPP has paid off its senior debt. It is also unclear how refinancing would be treated in this context.

Regulation 10 also requires the developer to transfer the plant to PLN at the end of the PPA period (i.e. 30 years). This is already a requirement for coal plants but has not been a requirement for geothermal or hydro plants. This loss of residual value will impact the way in which a developer would calculate the potential value of developing such a plant.

Projects with an existing PPA, a letter of intent or which have reached bid closing stage before the issuance of Regulation 10 are not required to implement the changes. Furthermore, Regulation 10 will not apply to any ongoing amendment process for an existing PPA that commenced prior to the issuance of Regulation 10. It only applies to power projects that are in a procurement process but have not yet reached bid closing.

Source:

<http://www.mondaq.com/x/573020/Renewables/Indonesia+Briefing+Latest+Changes+In+Energy+Law+Part+1>

**World Bank Grant for Geothermal** - The World Bank said in early February it will extend Indonesia a US\$55.25 million grant to facilitate geothermal energy power plant development in the country, which aims to become the world's biggest geothermal producer. The bank said in a statement that the grant will support Indonesia's Geothermal Energy Upstream Development Project and will mostly be used to fund infrastructure development and drilling exploration. "Insufficient energy holds back Indonesia's growth potential and limits the future opportunities of millions of Indonesians," said Rodrigo Chaves, the bank's country director for Indonesia.

Source:

<http://www.bangkokpost.com/news/asean/1196364/world-bank-to-give-indonesia-55m-to-develop-geothermal-energy>

## Japan: Generation from Renewables, Geothermal Training Course, Takigami Power Plant

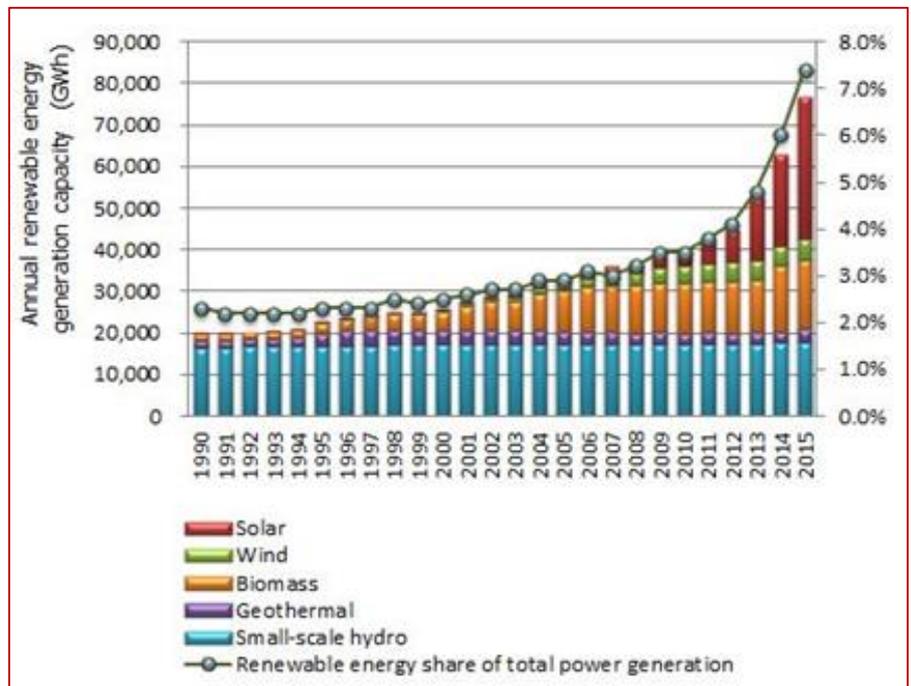
**Power Generation from Renewable Sources in FY2015** - Japan was four days late to ratify the Paris Agreement, which meant that its name was not included in the list of participating countries when the agreement

went into effect on November 4, 2016. The nation now faces some extra scrutiny from global society on how to tackle the issue of climate change.

Domestically, various problems related to the current power system became evident after the Great East Japan Earthquake in 2011. In response, the government is implementing power system reforms, including the complete deregulation of the retail electricity market. During the fiscal year 2015 (FY2015), the power generation in Japan from renewable sources was 76,205 GWh, as shown in the following table:

Technology	Estimated Annual Generation (GWh)	% of total
Solar photovoltaic (PV)	34,085	3.31%
Wind	5,381	0.52%
Geothermal	3,115	0.30%
Small-scale hydropower	17,777	1.73%
Biomass	16,395	1.59%
<b>Total</b>	<b>76,205</b>	<b>7.41%</b>

Trends in the last 25 years, are shown in the following graph:



Source:

[http://www.japanfs.org/en/news/archives/news\\_id035668.html](http://www.japanfs.org/en/news/archives/news_id035668.html)

**JICA and Kyushu University Hosted Intensive Geothermal Training Course** - The Japan International Cooperation Agency (JICA) has started an

Intensive Training for Geothermal Resource Engineers in 2016 in cooperation with Kyushu University. The training course is one of the JICA Knowledge Co-Creation Programs (Group & Region Focus) to be implemented as part of the Official Development Assistance of the Government of Japan. After a break of 15 years since 2001, the training course has been revised and restarted by accommodating requests from developing countries with geothermal resources.

In fiscal year 2016, there were 14 participants from Bolivia, Djibouti, Ecuador, Indonesia, Kenya, Nicaragua, Papua New Guinea and Tanzania. The six month training course includes lectures and project study for three months each. Participants receive lectures on geothermics, geothermal geology, geochemistry, exploration geophysics, reservoir engineering and other related topics presented by faculty member and specialist for each area. For three months after the lectures, participants undertake a project on specific topics under the guidance of professors. The participants presented a poster on their work at the International Symposium on Earth Science and Technology (CINEST) held at Shiiki Hall, Kyushu University. It was a great opportunity to show their work and to network with colleagues.

Study trips were undertaken to geothermal fields, a turbine factory and a solar power plant during the course. Participants visited the actual site and learned not only present situation of geothermal development in Japan but Japanese culture, as well.

On 16<sup>th</sup> December 2016, the course was completed with a closing ceremony in Kyushu University. The President of Kyushu University and the Director General of JICA-Kyushu International Center congratulated all the participants for their achievement.

The training course in 2017 will be held about the same schedule as of 2016 at the Ito Campus of Kyushu University.

Contacts:

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Kyushu University, Dept. of Earth Resources Engineering, Faculty of Engineering: Junko KAMITAKI: [kamitaki@mine.kyushu-u.ac.jp](mailto:kamitaki@mine.kyushu-u.ac.jp)

**Takigami Binary Power Plant Starts Operations** - Idemitsu Kosan Co., Ltd. announced that on 1<sup>st</sup> March, commercial operation began of a binary power plant at the Takigami Office of its wholly owned subsidiary Idemitsu Oita Geothermal Co., Ltd. The construction of the plant, with an installed capacity of 5 MW, started in March 2016 in the area of the Takigami Power Station of Kyushu Electric Power Company, Inc. The new Takigami plant is one of the largest binary power

plants in Japan. Idemitsu also unveiled its plans to contribute to Japan's energy security and to the realization of a sustainable society by using domestically sourced renewable energy, such as geothermal power to increase the supply of electricity.

Source: [http://v4.eir-parts.net/v4Contents/View.aspx?template=ir\\_material&sid=65877&code=5019](http://v4.eir-parts.net/v4Contents/View.aspx?template=ir_material&sid=65877&code=5019)

## Philippines: Acidity in Wells of Biliran Solved

Biliran, located in Leyte and considered one of the largest green field geothermal projects in the Philippines, has a potential of 350 MW. The initial developments of the Biliran project started in the 1980s but the 49 MW project was not completed due to the acidity of the geothermal brine. Now, according to a statement by the company Biliran Geothermal Inc. (BGI) released in late January, Filipino scientists have found a way to overcome this problem for successful development. The company said that a series of tests effectively treated the acidic nature of the fluids from the drilled wells, making the field fit for the generation of geothermal power.

“Acidic wells are very problematic. This is a challenge faced by every geothermal energy developer much like Biliran,” said Aylmer Marbello, a Biliran geothermal geologist.

“When we completed the drilling, a majority of the wells were acidic. We had to address the situation to



*Biliran Geothermal Well Pad Bn-11. Photo by Jalnz, taken from: <http://www.biliranisland.com/biliran-geothermal/history/#foobox-4/10/BiliranGeothermalPadB-11.jpg>.*

ensure the success of the project. After a number of studies, we identified the solution we now call FMS,” said Biliran geothermal geophysicist, Nilo Apuada.

FMS involves the injection of chemicals into the wells to treat the acidity, making the brine acceptable for use in the generation of geothermal power. It entails careful and rigid monitoring of the well geochemistry and correct dosage and application of chemicals. This chemical treatment was also used in the Miravalles geothermal field in Costa Rica, where the geothermal brine required treatment for acidity.

“We took every consideration and precaution to ensure the available resources arrive at favorable test results so we could move on to the next phase of the project, the construction of the geothermal power plant,” said BGI Project Director Danilo Catigtig.

The BGI development scheme is modular, with at least 5 MW per wellhead unit. “We are confident we will deliver the first 5 MW out of the 49 MW project, as detailed in the environmental compliance certificate (ECC),” said Catigtig.

Emerging Power Inc. acquired 60 percent of BGI in 2016 and proceeded with the development of the project. Emerging Power is majority owned by Nickel Asia Corp., one of the country’s biggest mining companies.

Sources:

<http://thestandard.com.ph/business/227964/biliran-geothermal-problem-addressed.html>,

<http://www.biliranisland.com/biliran-geothermal/history/>

## Saudi Arabia: Attractive Preliminary Geothermal Potential in the Kingdom

Saudi Arabia is eyeing geothermal power as part of its strategic energy plan that also includes massive uses of solar energy and wind farms, a senior official told in a conference in Abu Dhabi in mid-January. Saudi Energy Minister, Khalid Al Falih, speaking at the World Future Energy Summit in the UAE capital, said his country will generate a total of 10 gigawatts from a combination of solar, wind and geothermal power projects to be installed by 2023.

Al Falih, also the Chairman of Saudi Arabian Oil Company (Aramco), has said Riyadh is set to start soon the first round of bidding for up to US\$50 billion worth of renewable energy projects for the fresh energy projects, including geothermal energy. This is not surprising, since there are at least 10 known hot springs in Saudi Arabia. Recent studies show potential geothermal sites in Al Khouba area, in the southwestern

province of Jizan, where there are a number of structurally related hot springs.

Saudi authorities are encouraging and supporting not only research in the area but earmarking huge investments in renewables. Abu Dhabi, the home of International Renewable Energy Agency (IRENA), hosted the week-long conference, and international summit on renewables.

Al Falih highlighted Saudi Arabia’s rich geothermal resources, which are located mainly in the country’s western region and related to the general tectonic activity of the Red Sea. They are associated with a series of volcanic rocks and ridges.



*Energy Minister Khalid Al Falih, speaking at the World Future Energy Summit (Photo by the Ministry of Climate Change and Environment of the UAE).*

Analyses of available satellite images, geo-indicators and 2D electric geophysical surveys gave experts a clue about Saudi Arabia’s geothermal reserve potential for possible energy production. One study revealed the presence of many good geothermal anomalies in Jizan province, where the Al Khouba geothermal resource is considered the most important.

Researchers found good surface lithological and thermal properties (high temperatures, up to 78°C and good flow rates) and subsurface characteristics —good vertical and lateral extensions— as well as potential thermal properties in these sites. A preliminary geothermal potential of ~18 MW<sub>th</sub> is estimated for the Al Khouba hot spring, providing a reservoir area of 1.1 km<sup>2</sup>.

Geothermal resource exploration studies started in 1980 in Saudi Arabia. In the Western region near Jeddah and Makkah, there are large volcanic areas, known as ‘barrats’, which are formed by volcanic activity. The volcanic eruptions of barrats near the Medina area were recorded in the year 1256 AD.

Experts have seen at least six thermal springs in Jizan and four in the Al-Lith area and temperatures at some of these locations are around 120°C.

In Saudi's northwestern area, there are other volcanic regions, like Harrat Al Shamah, Harrat Al Raha and Harrat Uwayrid near Tabuk, and Harrat Ithnayn.

The volcanoes by the side of the expressway from Jeddah-Makkah to Madinah have basaltic lava-field chain up to 600 km long, called the Makkah-Madinah-Nafud volcanic line. Between Makkah and Madinah, the Harrat Rahat lava-field is spread over an area of 20,000 km<sup>2</sup>, where some 36 shield-volcanoes and 24 domes are found. Between Madinah and the Great Nafud are the coalesced harrats Khaybar, Ithnayn and Kura with an area of 20,560 km<sup>2</sup>.

Source:

<http://gulfnews.com/business/renewables/now-oil-rich-saudi-arabia-eyes-geothermal-energy-too-1.1963641>

## South Korea: First Power Plant to Be Installed in April

Pohang is a city on the southeastern coast of the Korean Peninsula, which has been making use of geothermal energy from a reservoir located some four kilometers below the surface at the Heunghae Basin, an area covered by Tertiary sedimentary rocks and Quaternary alluvium. The project began in 2011 thanks to efforts from South Korea's Ministry of Trade, Industry & Energy, and a total of 43.2 billion won (US\$38 million) –18.4 billion government and 24.8 billion private– has been invested so far.

The 1.2 MW project will be completed by April and is



Hot springs near Pohang (image: KobizMedia/ Korea Bizwire).

expected to provide electricity to some 1,000 households as early as the latter half of 2017, if not by next year, officials said. Upon the first successful supply of geothermal electricity, officials will raise an additional 80 billion won in investment through a power plant consortium to expand the current facility to generate 6.2 MW by 2019.

The current development of the Pohang project is part of the DESTRESS project, funded by the European Union, the Swiss Confederation and the National Research Foundation of Korea (*see* IGA News No. 106, pp. 23-24). The development of a megawatt-capacity enhanced geothermal system (EGS) on non-volcanic grounds will be the first of its kind in Asia.

Officials said regions in Pohang were found to have the optimal conditions for generating geothermal electricity, with some reaching 180°C at a depth of five kilometers.

Source: <http://koreabizwire.com/geothermal-power-plant-is-a-first-for-korea/75748>

## EUROPE

### Europe: German Company Wins the European Innovation Award 2017

enOware GmbH received the European Geothermal Innovation Award 2017 during the opening session of the GeoTHERM exhibition and Congress 2017 in Offenburg, Germany. The award was given for its miniaturized sensor designed to professionally plan, monitor and measure near-surface geothermal wells and probes.

The European Innovation Award, now in its fourth year, is an initiative of the European Geothermal Energy Council (EGEC) and Messe Offenburg. The award is given to companies that have made an outstanding contribution in the field of geothermal energy in the form of innovative products, scientific research or project initiatives.

enOware specializes in sensor systems for fluid applications, energy monitoring and Research & Development services. The wireless sensor for which they were given the award, is designed to swim through geothermal wells up to 450 m deep and measure a very precise temperature-depth profile, the absolute well depth as well as the permeability.

Commenting on the award, Ruggero

Bertani, Enel Green Power, President of EGEN and member of the jury said, “The product developed by enOware shows that there are high-tech innovations also for shallow geothermal, which can assist planners and designers developing advanced ground source systems, and can convince the customers of the reliability of geothermal heating and cooling. This kind of innovation, with its potential to facilitate GSHP system design by decreasing costs and increasing efficiency, is a good step forward for further developing the market in Europe.”

The German company won against strong competition from the four other endorsed nominees: HakaGerodur AG (Switzerland), for the pressure-resistant borehole heat exchanger (BHE) for difficult geological conditions and applications up to 300m; Huisman Well Technology BV (The Netherlands), for the application of the Enhanced Casing Installation (ECI) system in a geothermal well; Jansen AG (Switzerland), for the JANSEN shark technology, which reduces the flow resistance in the pipe and results in less pumping power; and SWM Services GmbH (Germany), for the project to provide 100 percent renewable energy for the district heating of Munich, including a major contribution by geothermal energy.

The jury for the 2017 edition of the award was composed of Ruggero Bertani (Italy), Adele Manzella (Italy), Sandra Kircher (Messe Offenburg), Pierre Ungemach (France), and Javier Urchueguia (Spain).

Source: <http://egec.info/enoware-gmbh-awarded-the-european-geothermal-innovation-award-2017/>

## Belgium: Completed Two First Phases of Balmaat Project

The Flemish institute for technological research (Vito) has completed the first two phases of a local project aimed at extracting geothermal heat. The third phase consists of installing a power station at the Balmatt site. At the Vito site in Mol, Antwerp province, drilling went down to 3610 meters, to the 350-million-year-old limestone layer where the temperature reaches 138°C. When pumped to the surface, the water from that layer retains a temperature of 126-128°C, which allows it to be used for heating. In the second phase of testing, it was found that water could also be returned to

the limestone layer, be reheated and pumped back out, creating a closed water loop. A second well drilled to re-introduce cold water reached a depth of 3830m. The tests on the reintroduced water were completed in September 2016.

The site is now ready to install a power station on the surface where water will be pumped up from the depths, used as a source of energy and then re-injected into the limestone layer to be reheated naturally. Now the cycle will be repeated. Works on the third phase are expected to be completed by the end of the year.

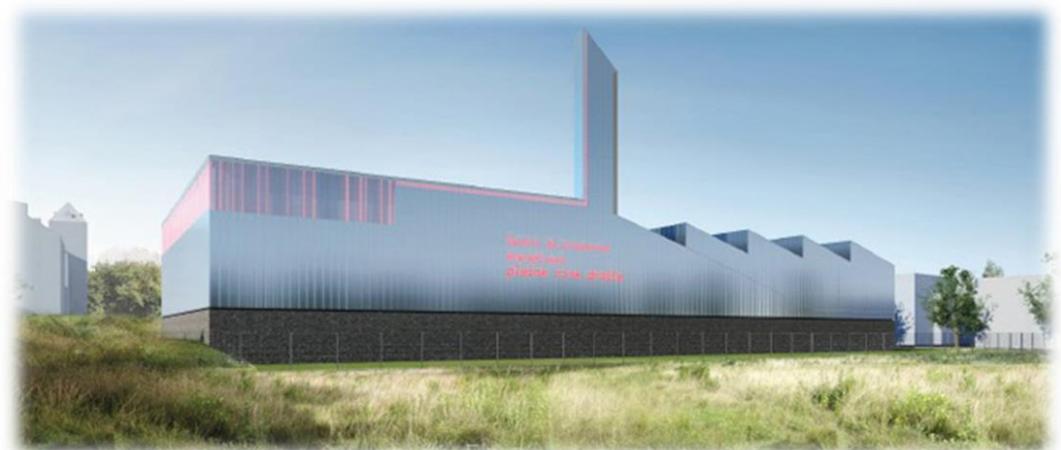
After that, other sites in the region, also with the underground limestone layer, will be investigated. According to forecasts, the layer could provide enough power from the natural heat of the earth's crust to supply 80 geothermal plants in Antwerp and Limburg provinces, providing heat for 800,000 homes.

The investment for the Balmatt project, resulting in an operating deep geothermal energy plant, would amount to €22 million. The exploratory drilling project, costing €7 million, is funded by Vito and the government of Flanders, which contributed €2 million (*see* IGA News 102, pp. 21).

Source: <http://www.flanderstoday.org/innovation/vito-gets-closer-harnessing-geothermal-energy>

## France: New Geothermal Heating Network in the Plaine Rive Droite Area of Bordeaux

Fully committed to the energy transition in its area, Bordeaux Métropole (comprising the city of Bordeaux and some of its suburbs) is taking another step forward in its Climate Plan with the creation of the Plaine Rive Droite geothermal heating network, which will serve the neighborhoods of Brazza, Niel, Benauges and Garonne-Eiffel.



*Artistic conception of the heat production plant, an iconic building to be constructed from sustainable materials. Source: Engie.*

To best meet the city's expectations, ENGIE subsidiaries ENGIE Cofely and Storengy joined forces to submit a single integrated tender for deep geothermal energy, combining ENGIE Cofely's expertise in heating networks and Storengy's expertise in subsurface exploration and development. In selecting ENGIE's tender, Bordeaux Métropole has chosen a partner that is committed to the long-term success of all aspects of this ambitious project, which marks a revival of deep geothermal energy in France. The concession has been awarded to ENGIE for a 30-year period.

Bordeaux Métropole Council has chosen geothermal as a green source of energy for its heating network. The Council has decided to explore a new geological horizon with the aim of finding a deeper and hotter resource – the first time this has happened in France, outside the Paris region, in 30 years. The natural heat of deep aquifers will meet 82 percent of the heating needs, with the rest being supplied by natural gas. Work on the heating network will begin once all the administrative permissions have been obtained. The drilling of the two geothermal boreholes, a production well and a reinjection well, will start in early 2019 and last for four months. It will be carried out by Storengy, an ENGIE subsidiary with extensive expertise in geoscience and in the design, development and operation of boreholes.

The heat production plant will make reference to the local industrial heritage. Blending naturally into the landscape, this iconic building designed by the Bordeaux firm Moon Safari will be constructed from sustainable materials.

ENGIE will build a Maison des Energies Citoyennes (House of Civic Energy), which will play host to city residents and school groups, with interactive learning programs catering for a range of needs. The House will adjoin the heating plant, making an ideal base from which to visit the energy generating equipment. It will bring together all the project stakeholders, forging lasting links between them that will work to the benefit of the energy transition.

Source: <http://www.engie.com/en/journalists/press-releases/geothermal-bordeaux/>

## Germany: 32% of Electricity Came from Renewables in 2016

In 2016 Germany used more renewable electricity than ever before, receiving 32 percent of the gross amount of electricity consumed in the country from sun, wind and other renewable sources. The Centre for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW) and the German Association of Energy and Water Industries (BDEW) arrived at this figure in an initial

estimate in late 2016. If the projections are correct, more than 191 billion kilowatt-hours (kWh) (191,000 GWh) of electricity were generated from renewables by end of the year. This marks an increase from the previous year during which the country consumed slightly more than 187,000 GWh, which is 31.5 percent of the gross amount of electricity consumed that year. The federal government's energy targets call for renewables' share in gross electricity consumption to arrive at 35 percent by 2020 and the country is clearly on track to achieve that goal.

The energy sources breakdown as follows:

Offshore wind 13,000 GWh – up 57 percent over 2015  
Onshore wind 67,000 GWh – down 6 percent from 2015

Solar PV 38,000 GWh – down 1 percent from 2015

Hydropower (including pumped storage hydro) ~22,000 GWh – up 13 percent from 2015

Biomass and waste 52,000 GWh – up 3 percent over 2015

Geothermal power 200 GWh – up 12 percent over 2015

Stefan Kapferer, Chairman of BDEW's General Executive Management Board, said while the growing share of renewables is positive, the country still needs conventional sources of power in the mix to back up the ongoing conversion of the country's energy supply. He also stated that the grid expansion is necessary.

Source:

[http://www.renewableenergyworld.com/articles/2017/01/germans-get-almost-one-third-of-electricity-from-renewables-in-2016.html?cmpid=enl\\_REW\\_SOLARENERGYNEWS\\_2017-01-10&email\\_address=l.g.negrin@gmail.com&eid=291021978&bid=1630507](http://www.renewableenergyworld.com/articles/2017/01/germans-get-almost-one-third-of-electricity-from-renewables-in-2016.html?cmpid=enl_REW_SOLARENERGYNEWS_2017-01-10&email_address=l.g.negrin@gmail.com&eid=291021978&bid=1630507)

## Greece: Geothermal Energy Could Play a Pivotal Role in the Country

The largest power generation company in Greece, PPC, has announced that geothermal energy will be a crucial element in its plans for renewable energy project deployment. Through its renewable energy subsidiary



PPC Renewables, the company is active with renewable energy sources, even though the company's renewable-energy sources (RES) current market-share is just 3 percent –as Manolis Panagiotakis, PPC's chief executive said recently.

A newly appointed board at PPC Renewables appears determined to rectify the firm's faults committed in the past and establish better prospects for the subsidiary. The fresh PPC Renewables board aims to triple the renewable energy firm's installed capacity over the next three years. A business plan is underway to establish a strategic objective that may elevate PPC Renewables as a key player, if not the market leader, in Greece's RES market.

The development of geothermal technology is expected to play a pivotal role, the PPC chief executives noted, while also pointing out the major prospects in this field for the Cyclades islands and possibly further south. Panagiotakis added that geothermal technology, combined with other technologies, could end the region's high-cost dependence on fuel, diesel and mazut for electricity generation.

He pointed out the utility's unsuccessful investment of 62 million euros on geothermal technology research in previous decades, while adding that, despite the setback, he remains optimistic on the domain's prospects for the Cyclades and possibly beyond. Major foreign corporations, including Enel, Ormat and Mitsubishi, have expressed an interest in helping develop the country's geothermal energy potential.

Source: <http://energypress.eu/geothermal-development-pivotal-in-ppc-renewables-business-plan/>

## Hungary: Two Notes from the Győr Region

**Audi Factory Uses Geothermal Heat** - *Audi Hungaria* is the largest industrial geothermal energy user in Hungary. Since its conversion to green energy, the volume of the company's geothermal energy consumption has grown to 100 thermal GWh, which so far has reduced carbon dioxide emission by 20,170 tons.



The Győr-based, Audi Hungaria Ltd., is an entity of the Audi Group, the key engine supplier of the Audi and Volkswagen Group. Two years ago, the company placed its energy supply on new foundations, and since November 2015 renewable geothermal energy has been supplied by the Heating Center of Bőny. Within the framework of the Geothermal Project of Győr, *Audi Hungaria* has entered into a long-term heat energy supply agreement for the provision of geothermal energy to the company's Győr site with PannErgy Plc's subsidiary, DD Energy Ltd. This cooperation has been forged for 17 years, and can be optionally extended for an additional period of 15 years.

“Sustainability and efficiency is a dominant element of *Audi Hungaria's* efficiency, and therefore we put great emphasis on their encouragement in day-to-day operations, as well as manufacturing processes”, said Axel Schifferer, *Audi Hungaria's* Managing Director for Finance. “Its reliance on geothermal energy ensures the company's environmentally conscious operations in the long term, because this way we can cover nearly 70 percent of our heat energy demand in a carbon-neutral manner.”

Source: <http://www.4-traders.com/PANNERGY-NYRT-6491748/news/PannErgy-Other-Information-ndash-Even-greener-future-for-Audi-Hungaria-rsquo-s-heat-23827481/>

**Győr Concession to PEGE Ltd** - The Hungarian company PannErgy Geothermal Power Plants Ltd. (PEGE Ltd), which is a PannErgy Plc subsidiary, disclosed in late February it has signed a concession agreement with the State of Hungary for a definite term of 35 years (with a non-recurrent renewal option for another term of 17 and half years) in relation to the area of Győr, toward the exploration, extraction and utilization of geothermal energy. By relying on the rights acquired with the concession agreement, PEGE Ltd and its concession company, to be founded later, will examine the concession-based geothermal endowments of the region potentially found under 2500 meters depth, and thereafter will decide on the investment opportunities. The company added that it has the long-term objective to enhance energy safety with the use of renewable geothermal energy at an even larger scale – with proper respect to environmental sustainability, thereby supporting the goals of climate policy.

Source: [http://pannergy.com/wp-content/uploads/2017/02/eo\\_pannergy\\_20170206.en\\_.pdf](http://pannergy.com/wp-content/uploads/2017/02/eo_pannergy_20170206.en_.pdf)

## Iceland: Drilling of Well IDDP-2 Successfully Completed

A significant milestone was reached in the Iceland Deep Drilling Project at the Reykjanes Peninsula in Iceland

when well IDDP-2 was completed on January 25<sup>th</sup> at 4659 meters depth. All of the initial targets were reached: to drill deep, extract drill cores, measure the temperature and search for permeability. Temperature at the bottom of the well has already been measured at 427°C, with a fluid pressure of 340 bars; drill cores were retrieved; and the rocks appear to be permeable at depth. It's clear that the bottom of the well reached fluids at supercritical conditions, so that the main drilling phase objective of the project has been achieved. The drilling operation lasted 176 days since drilling operations began on August 11, 2016.

The depths beneath the production zone of the geothermal field at Reykjanes have never before been explored. Well IDDP-2 took advantage of HS Orka's well RN-15, which was a 2500 meter deep production well. The first phase of the IDDP-2 project was to deepen well RN-15 to 3000 meters and cement a steel casing firmly into the surrounding formations. From there, the well was deepened to its final depth of 4659 m from rig floor.

Potential utilization will not be known until the end of 2018 when all research, including substantial well stimulation and flow testing, is finished. But the first indications are positive.

Drilling a well this deep and hot comes with many difficult challenges. In the beginning, there were difficulties extracting drill cores. But in the end, 27.3 meters of core samples were cut in 13 attempts. The last core was from the bottom of the well at 4650 meters from surface.

Using conventional drilling methods was not an option for many aspects of the project so new methods had to be developed to ensure its progress. The well is drilled vertically to 2750 meters and drilled directionally below that. The bottom of the well has a vertical depth of about 4500 meters and is situated 738 meters southwest of the well head. Various challenges arose as the drilling progressed and the drill got stuck a few times. Each problem was successfully solved, as were all other challenges as they occurred. However, the major unsolved problem was a complete loss of circulation below 3060 m depth, which could not be cured with lost

circulation materials or with multiple attempts to seal the loss zone with cement.

At 3180 m, the team chose to stop the cementing attempts. Below that depth no drill cuttings returned to the surface. Consequently the drill cores were the only deep rock samples recovered.

The purpose of the IDDP-2 project is research and the drilling completion is only one phase of the activities planned. The next steps will be to undertake further testing and research on the well, and, most importantly, flow tests and fluid handling experiments will be conducted within the next two years. Final results on the technology and economics of production from the well will not be clear until end of 2018.



*(Left) Core 11 at 4637.80 m depth. Two centimeter thick "felsite" dike in dolerite. The red surface at the felsite margin is due to rapidly quenched hematite mineralizing fluid. (Right) Close up of core fragments removed from the open space on the left. Top: open fracture mineralized with quartz + biotite. Bottom: "felsite" dike with basaltic inclusions. Center Right: Irregular contact between "felsite" and basalt. Rocks of this core are primarily basaltic and doleritic, hypabyssal, intrusive rocks, apparently part of a sheeted dike complex. (Photo and caption taken from the report available in the source.)*

HS Orka has led the IDDP-2 project in close collaboration with other partners. In Iceland, these are Landsvirkjun, Orkuveita Reykjavíkur and Iceland's National Energy Authority. Statoil, the Norwegian oil company, has also been an active participant. The IDDP-2 has received substantial grants from the EU H2020 (DEEPEGS) as well as other international science grants (ICDP and NSF). The drilling contractor was Jarðboranir (Iceland Drilling Company).

Source: <http://iddp.is/wp-content/uploads/2017/01/IDDP-2-Completion-websites-IDDP-DEEPEGS.pdf>

## Italy: The Campi Flegrei Caldera & New Project to Cultivate Spirulina Algae

**Campi Flegrei Caldera** - Campi Flegrei Caldera is the largest volcanic feature along the Bay of Naples, Italy. Excerpts follow from a note by Alexandra Branscombe.

Two massive eruptions caused the collapse of the Campi Flegrei Caldera: the Campanian Ignimbrite, which occurred 39,000 years ago, and the Neapolitan Yellow Tuff, which occurred 15,000 years ago. Scientists—and residents around the caldera—fear another eruption will come. Right now, the alert for the Campi Flegrei caldera has been raised from ‘base’ volcanic activity to ‘attention’ status. To get an accurate understanding of the caldera, Giuseppe de Natale et al. (2016) turned to scientific drilling: the Campi Flegrei Deep Drilling Project (CFDDP), drilled to a depth of 501 meters in western Naples, the morphological limit of Campi Flegrei caldera.

history of the volcano and how Campi Flegrei has changed over time. The deeper layers, between 250 and 501 meters, do not contain fossils, meaning that the volcano was well above sea level more than 35,000 years ago. In the shallower layers, the scientists found microfossils that indicate an ocean environment, confirming that sometime between 17,000 and 35,000 years ago, the volcano collapsed.

The rock types and ages at the drill site also reveal a curious finding: the amount of collapse attributed to the older and larger Campanian Ignimbrite eruption is smaller than the collapse that occurred after the eruption of the Neapolitan Yellow Tuff. Although there could be many reasons for the smaller collapse after the mega eruption, the authors discuss an alternative hypothesis: that the Campanian Ignimbrite did not erupt from Campi Flegrei (which was only a peripheral eruption vent), but rather from fractures to the north of the caldera. This hypothesis would explain the low-level collapse in the caldera because the magma chamber would have remained intact.



*Fig. 1 of The Campi Flegrei Deep Drilling Project (CFDDP): New insight on caldera structure, evolution and hazard implications for the Naples area (Southern Italy), by De Natale et al., 2016, journal G3: Geochemistry, Geophysics, Geosystems.*

Drilling gives scientists a precise view into the deep structures of the caldera, its geothermal characteristics, and its magma chemistry. All these can reveal clues to how the caldera formed. The researchers took samples from different depths of the drill site and measured argon isotopes periodically so to estimate the age of various layers.

The scientists combined the isotopic ages, fossil findings, and historical sea level records to assess the

Additional results from the drill site reveal that further caldera collapse won't extend into the central city of Naples. However the authors conclude that there is a complex mechanism that drove the caldera collapse that requires further study to better predict future eruptions in this major metropolitan area of Italy.

Source: <https://eos.org/research-spotlights/deep-drilling-reveals-puzzling-history-of-campi-flegrei-caldera>

**Project to Cultivate Spirulina Algae Using Geothermal Energy** - On mid-January, Enel Green Power (EGP) and the Consortium for the Development of Geothermal Areas (CoSviG) signed in Larderello an Agreement of collaboration for experimentation on geothermal resources applied to the cultivation of algae. The objective is to build a pilot plant next to the Chiusdino geothermal plant for the production of spirulina algae using geothermal energy. Both partners will put up 100,000 euros. The agreement lasts one year and involves the construction of a greenhouse where spirulina algae will be cultivated using both geothermal heat and carbon-free CO<sub>2</sub>, a product of the geothermal energy production process and a substitute for natural emissions that is useful for fostering the cultivation of algae.

Already known in antiquity, spirulina is a natural micro-alga originally from Central America and central Africa. It is currently cultivated in special aquatic farms, especially in sub-tropical regions. This alga is one of the

so-called ‘superfoods’: highly rich in protein, it has antibiotic and antiviral properties and is one of the most potent sources of nutrients available to humans.

Alongside Enel Green Power and CoSviG, others involved in the experiment include the Department of Agricultural and Food Production and Environment at the University of Florence, which, through a start-up of the University Incubator of Sesto Fiorentino, will take care of *inocula* development and the training of plant employees, and CNR (National Council for Research) which will monitor and characterize the cultures.

The Chiusdino pilot plant will be ready by the beginning of spring, when it will begin cultivating the algae: at the end of 12 months, the results of the experiment will be assessed in terms of the economic and environmental suitability of using geothermal heat and CO<sub>2</sub> for its cultivation.

The goal, if the experiment goes well, is to foster the development of this type of activity on a larger scale in all of the Tuscan geothermal territories to benefit the environment, the health of the citizens and local employment.

Geothermal energy is able to cover more than 27 percent of Tuscany’s energy needs. It heats over 10,000 homes in the area and provides heat to 30 hectares of greenhouses, dairies and other local agricultural businesses. Now it will become an innovative frontier in nutrition and pharmaceutical science, thanks to the spirulina algae project.

Source:

<https://www.enelgreenpower.com/en/media/news/d201702-tuscan-geothermal-to-cultivate-an-aztec-superfood.html>

## Slovakia: Tomatoes Produced with Geothermal

Since 2008, inspired by the Dutch model of protected agriculture, but under different conditions, a cooperative of growers from southern Slovakia claims to have taken more than half of the market and to have expanded into new growing regions.

The GreenCoop group only uses renewable energy from geothermal sources, and its brand ‘Happy Tomato from Rye Island’ is taking market shares from big European players in Slovakia, the Czech Republic and Hungary.

GreenCoop *družstvo* president Zsolt Bindics said the cooperative was now producing crops –mostly tomatoes but some cucumbers– on 30 hectares. “We are here because we would like to extend the export to other countries, but our main focus is to grow and sell locally in our region of the Slovakia, the Czech Republic and Hungary.”

He said the average greenhouse was between 4.5-6 hectares, and all members had to have a very strong

environmentally-friendly philosophy in practice. He added the team traveled far and wide to select the best seeds, and at the moment GreenCoop was producing around 20 different tomato varieties.

Bindics said, “In southern Slovakia you have a granted 2,000 hours of sunlight but some varieties need more, some need less, and usually in summertime we have very high temperatures in greenhouses. We have some disadvantages because in our area the summers are hotter, but the main advantage is the geothermal energy. In our region, if you drill below than 1km, you will find hot water and you can heat the greenhouse.”



View of the greenhouses. Photo by GreenCoop.

Director of production Zoltán Kiss said that when the cooperative began with this project in 2008 it was not common to do ‘green things’, but now others are trying their hand at the practice as well. “I can say in our region we are the main producers and the biggest producers of tomato.”

Source:

<http://www.freshfruitportal.com/news/2017/02/21/greencoops-enviro-friendly-tomato-project-takes-off-central-europe/>

## Switzerland: Public Consultation on Energy Strategy and Hydraulic Fracturing

**Public Consultation on Energy Strategy Could Benefit Geothermal Projects** - In the context of the energy strategy for 2050, the Federal Council put the regulations on the new Energy Act and the new CO<sub>2</sub> law under public consultation. This will last until 8 May 2017. According to the Swiss Geothermal Energy Association, the most important points for geothermal energy are:

- Different Feed-in Tariffs (FiT) for hydrothermal and petrothermal projects. Hydrothermal projects (use of

naturally occurring hot water) currently receive a FiT of 0.227 to 0.4 CHF (practically equal in US\$) per kilowatt-hour depending on the plant size. Now, petrothermal projects (without natural fluids) would receive 7.5 additional cents to reach 0.302 to 0.475 CHF per kilowatt-hour, depending on the plant size (see table below). According to the calculations of the Swiss Federal Office of Energy (SFOE), the cost of electricity from petrothermal plants per kilowatt hour is 5 to 17 cents higher than for electricity from hydrothermal plants:

Capacity (MW)	FiT (CHF/kWh)	
	Hydrothermal	Petrothermal
≤5	0.400	0.475
≤10	0.360	0.435
≤20	0.280	0.355
>20	0.227	0.302

- Deep exploration can also be supported by up to 60 percent of eligible costs. The most important of these eligible costs include access roads and well pads, drilling, tests and stimulation of exploration wells.
- Geothermal energy guarantee for electricity projects. If a well is not successful, the Confederation can reimburse up to 60 percent of the eligible costs, among them: preparation, construction and dismantling of the drilling site, drilling costs including pipes, cementation and completion for all planned production and injection wells, and well logs and tests.
- Direct geothermal heat utilization. For geothermal heat projects, up to 30 million Swiss francs can be spent annually on exploration and development. The Federal Government can accept up to 60 percent of the eligible costs, among them: Preparation, construction and dismantling of the drilling site, drilling costs including pipes, cementation and completion for the planned exploration and production wells, and well stimulation and tests.
- Expert Panel and Project Support. All applications from project developers will be assessed by an expert

committee from the Swiss Federal Office of Energy (SFOE). If the project is assessed positively, the expert committee will recommend a specialist as project support for the entire project. This expert will report to the expert committee.

- If a geothermal project realized with federal support generates 'excessive profits', the federal government can reclaim funds.

If the Swiss public approves the energy strategy 2050, the revised Energy Act, the revised CO<sub>2</sub> Law and the corresponding regulations can enter into force on 1 January 2018.

Source:

<https://translate.google.com/translate?depth=1&hl=en&ie=UTF8&prev=t&rurl=translate.google.ca&sl=de&sp=nmt4&tl=en&u=http://geothermie-schweiz.ch/bis-zu-47-5-rappen-einspeiseverguetung/>

**The Federal Council Approves Hydraulic Fracturing for Geothermal**

- In other news, in early March the Swiss Federal Council issued a statement declaring it has approved the use of hydraulic fracturing under certain conditions, specifically for deep geothermal drilling. It has made clear that, due to climate policy reasons, the use of this technique is not approved in wells drilled seeking for natural gas. The council approved the report *Fracturation hydraulique en Suisse*, which concluded that there is no reason to forbid this technique and that the current federal regulation is in principle sufficient, although the municipalities (cantons) may decide the adoption of different regulations within their territories. The report also mentions the possible environmental and health impacts of hydraulic fracturing, among them: triggering of microseisms, the possible contamination of shallow aquifers by chemical additives used in the fluids for fracturing, and the releasing of some natural contaminants present in the underground, like heavy metals, radioactive minerals or methane.

The following principles must be applicable when using hydraulic fracturing:

- o Fluids for fracturing should not contain any materials hardly degradable or harmful for human health.

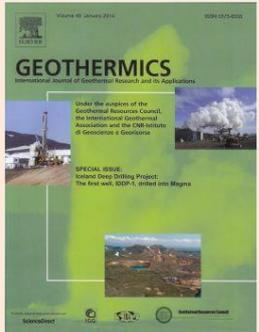


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- It is mandatory declare the amount of all the materials to be used.
- All of the fluids for fracturing must be safely stored, handled and disposed of. The same is applicable to the fluids obtained in surface after the operations.
- Norms and procedures of high-level of security must be followed during construction, exploitation and dismantling of the installations to minimize emissions to the atmosphere, soils and water.
- It must be applied an integral managements of hazards and risks along the life-cycle of all fracturing projects.
- The underground characteristics must be better understood to develop a more satisfactory risk analysis.
- The principle, “who contaminates must pay for it”, shall be applied and the responsibilities clearly defined.

Source:

<https://www.admin.ch/gov/fr/accueil/documentation/communiqués.msg-id-65882.html> (in French)

## Turkey: Proposal of Differential Incentives and New Binary Plant in Alasehir

**Proposal of Differential Incentives for Low-Temperature Resources** - In early January, the Chairman of JESDER, the Association of Geothermal Power Plant Investors, Ufuk Şentürk said: “In order to increase the capacity in geothermal, an additional incentive application is required for 105, 120, 130 and 140 degrees Celsius, as well as a \$0.105/kWh purchase guarantee for different water temperatures from 90 degrees to 140 degrees Celsius”.

Ufuk Şentürk, stated that the geothermal power generation potential in Turkey is 5,000 MW and that different incentive amounts should be applied according to the water temperature levels in the power plants in order to reach this capacity.

Şentürk explained that JESDER made a study on the capacity increase in geothermal energy and submitted the work to the Ministry of Energy and Natural Resources. He also added that an additional capacity of 350 MW can be reached in the near future.

Şentürk emphasized that geothermal energy is a very important resource in terms of sustainability and energy supply security and that, “in order to increase the capacity in geothermal, besides the purchase guarantee of 10.5 dollar cents at different water temperatures from 90 degrees to 140 degrees Celsius”, an additional incentive is required for waters at 105, 120, 130 and 140 degrees Celsius.

As the water temperature increases, the necessary equipment for the electricity generation and the technical characteristics of the turbines change, too, he said. “This means additional cost for the investor. By adding an additional fee for every temperature value, we calculated that electricity generation would be more economical for investors in high and low temperatures: 5.5 cents for 105 degrees, 2.9 cents for 120 degrees, 1.3 cents for 130 degrees and 0.3 cents for 140 degrees. At the same time, this situation may be more predictable for financing in terms of banks. If the calculated values are supplied to the geothermal investor, the target of one thousand megawatts in 2023 can be folded five times.”

If we interpreted correctly the JESDER proposal, it is aimed to make more attractive and affordable the development or low-temperature geothermal resources, since the proposed incentives would be as presented in the table:

Temperature (°C)	Incentive (US\$ cents/kWh)
90 to 105	(10.5 + 5.5) 16.0
105 to 120	(10.5 + 2.9) 13.4
120 to 130	(10.5 + 1.3) 11.8
130 to 140	(10.5 + 0.3) 10.8

Source: <http://www.thinkgeoenergy.com/investors-ask-for-further-incentives-for-geothermal-development-in-turkey/>

**New Binary Cycle Plant in the Alasehir Field** – A 13 MW binary cycle plant started to operate last March in the Alasehir geothermal power plant, operated by Zorlu Enerji. The hot source is the outlet of a flash turbine supplied by Toshiba. The turbo-generator is the most powerful equipment ever built in Cryostar’s workshops



*Cryostar turbine on site at the Alesehir geothermal power plant, Turkey (source: Zorlu Enerji).*

and was designed to be integrated into a heat-to-electricity Organic Rankine Cycle (ORC) conversion process, developed by the American company, TAS. The turbine expands R134A refrigerant fluid as a working fluid and is part of the TG800 turbine range, designed to develop up to 19 MW of power. The TG800 includes an 800 mm titanium wheel. It is a radial centripetal turbine with variable blading. This technology makes it possible to optimize the machine's output over an extended operating range, which is the best solution to maximize annual electricity production.

Source: <http://www.thinkgeoenergy.com/cryostar-successfully-commissions-turbine-at-alasehir-turkey>

## Oceania

### Australia: New Geothermal Association

In early March, Graeme Beardsmore, Technical Director of Hot Dry Rocks Pty Ltd and chair of the IGA's Committee of Reserves and Resources, announced the incorporation of the Australian Geothermal Association (AGA). He stated that, "AGA will continue the work of the Australian Geothermal Energy Group (AGEG) and the Australian Geothermal Energy Association (AGEA), both of which are now deregistered. Residual funds from AGEA have been transferred to AGA, as approved by the outgoing AGEA Executive." The inaugural Board of AGA comprises Graeme as President, Adrian Larking (Secretary) and Betina Bendall (Public Officer), with Ludovic Ricard performing the role of Treasurer.

The objectives of this new association are:

- to provide a forum for persons and bodies corporate involved or interested in geothermal energy;
- to hold, make available and provide information about all forms of geothermal energy, its benefits, risks, usage and potential;
- to maintain the Australian geothermal energy sector's links with the Australian clean energy sector and international geothermal energy sector and with other organizations representing each of those sectors, including the Clean Energy Council and ARENA, and by

affiliating with the International Geothermal Association;

- to conduct or manage support services including education and training; and
- generally to carry on, do or assist in all or any matters which the Association may deem fit for promoting or encouraging the development of, and science and technology relating to, geothermal energy.

AGA will hold an inaugural Annual General Meeting before the end of 2017, at which all board positions will be vacated and a new executive committee elected.

### New Zealand: The Wairakei Bioreactor Sets Example for United States

The Wairakei Power Station is a geothermal power station located in the North Island of New Zealand. The station is situated on the Waikato River, so it can utilize the river water to cool the geothermal fluid that is extracted in order to generate electricity. However, after usage in the cooling process, pollutants from the plant are introduced into the water. Releasing the polluted fluid back into the Waikato River is damaging to the natural river ecosystem, especially as a threat to local biodiversity.

In an effort to reverse the detrimental environmental impact of the plant, the Wairakei bioreactor was conceived, and its construction was completed in 2012. The bioreactor is made up of 378 km of underground pipes that house bacteria on their internal surface area.

These bacteria are sulfur-oxidizing, meaning they reduce the amount of the harmful hydrogen sulfide in the cooling water by consuming the pollutant. Huge amounts of water are pumped into these pipes at a rate of 13,000 liters per second, and the bacteria, which are



*View of the bioreactor facility at the Wairakei Power Station near Taupo. Photo / Jeremy Bright, NZHerald.*

native to the local river environment, are able to remove up to 80 percent of the pollutant.

A note published in early 2017, highlights that the success of the bioreactor has made it a potential model for similar technology to be produced in the United States, since the country also faces water pollution difficulties. The issue is prevalent in the highly agricultural Midwest due to runoff polluted with harmful chemicals and other nutrients from fertilizer.

With parts sometimes known as the Corn Belt, the U.S. Midwest is also home to an underground network of pipes known as tile drainage networks. Any excess water is channeled into these networks, so it can be transported to nearby streams, lakes or rivers. While these networks are useful for preventing farmers' fields from becoming waterlogged, they also have a hugely negative impact on water quality.

The networks are vehicles for bringing runoff that is polluted with nitrogen from over-fertilization to local bodies of water. Excessive levels of nitrogen fertilizer lead to algae blooms. When the algae die and bacteria decompose them, water becomes deoxygenated as bacteria use the oxygen for fuel. As a result, bodies of water become unsustainable for life; these areas are known as dead zones.

Professor Laura Christianson of the University of Illinois is currently researching solutions to reduce nitrogen pollution using the Wairakei bioreactor as a model. Her work is focused on woodchip bioreactors, which are trench structures meant to remove pollutant from water before it enters tile drain networks. Christianson's idea would research the process of denitrification, wherein bacteria found in soil convert the nitrate pollutant into nitrogen gas, which is environmentally friendly as the gas comprises approximately three-fourths of the atmosphere. Thus far, wood chips have been shown to be an effective construction material for the bioreactor; however, researchers like Christianson are looking into other possible solutions.

Overall, the Wairakei Power Plant's bioreactor has proven to be a useful model in showing how local microorganisms could provide a multi-use option for saving their local environment.

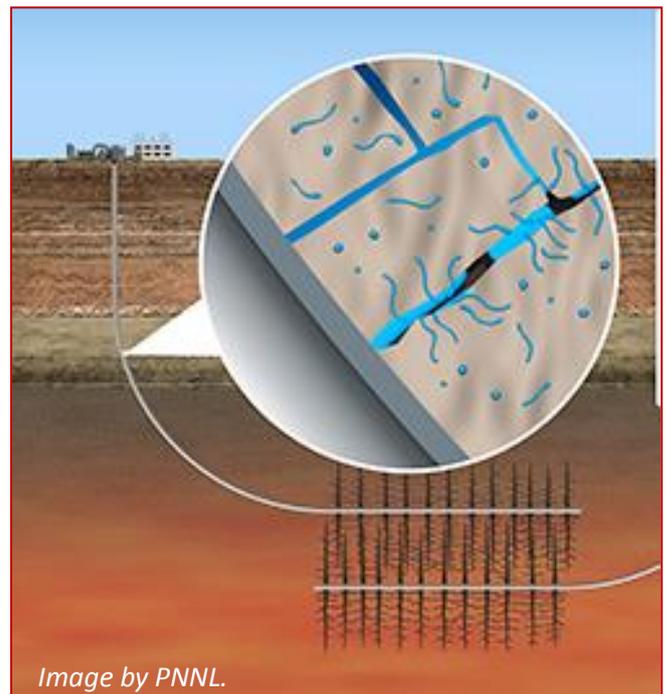
Source: <http://www.concordy.com/sci-tech/2017/01/new-zealands-first-bioreactor-sets-example-for-united-states/>

## Other

### Technology: High Strength Self-Healing Cement

Researchers at the U.S. Pacific Northwest National Laboratory (PNNL) have developed a cement that can heal itself when cracks occur. Using self-healing cement for geothermal wells would save geothermal plants millions of dollars and would reduce the amount of downtime necessary for repairs.

With an average life span of 30-40 years, the cement around geothermal production wells eventually cracks over time. Because wells with cracked cement are vulnerable to leakage, reduced strength, and corrosion, it is important to repair them in a timely fashion. However, repairs can easily top US\$1.5 million dollars; the cost of new materials, excavation, installation, and halting power production adds up fast.



When using the PNNL-developed self-healing cement to set the casings in geothermal wells, cracks and breaks in the well can heal automatically. This technology has the potential to eliminate excavation, repair, and replacement costs associated with cracked cement wells.

PNNL chemist Carlos Fernández and his team discovered that by adding the strong, flexible and powerful ingredient called polymers, they could create self-healing cement. Naturally found in the human body and plant structures, these large, chain-like molecules work to hold substances together. The team discovered that by mixing in 5 to 20 percent of man-made polymers into typical cement before it is poured and cured, the cement can repair itself when cracks occur. PNNL's research team has successfully proven this cement can repair itself in a few days, and they predict it has the potential to heal itself in just a matter of hours. Just as impressive is the cement's projected ability for continuous self-healing, meaning it can repair itself

many times over and maintain the rheological and mechanical properties necessary for geothermal wells.

Source:

<http://www.pnnl.gov/science/highlights/highlight.asp?id=4534>

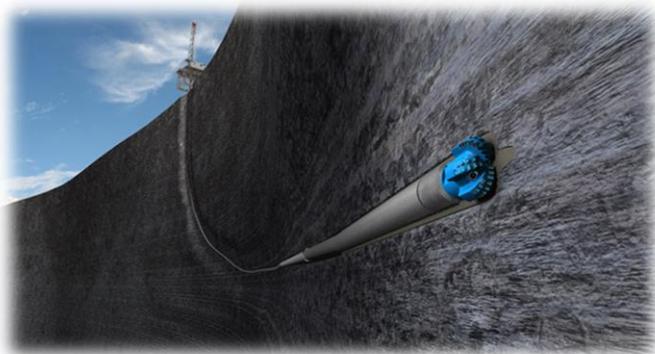
## Technology: Rockets to Drill Geothermal Wells

HyperSciences, a startup based in Spokane, Washington that uses rockets to drill for geothermal energy, is designing new, more cost-effective drilling methods. The company has raised 70% of a US\$1 million funding round to continue development of its HyperDrill and HyperBreaker tunneling machine prototypes, in addition to testing its ThermoElectric Generator (TEG) technology.

HyperSciences CEO Mark Russell has worked for NASA, Boeing and Blue Origin, and is now bringing space technology to drilling. After using projectiles to drill nearly five kilometers to access geothermal heat, HyperSciences uses TEG technology to bring the thermal power to the surface. Russell said similar technology has been used to power spacecraft such as the Voyager or the Curiosity rover on Mars.

The company has been testing its HyperBreaker and HyperDrill at Russell's family's mine in Spokane for two years and it demonstrated the system to Shell this past November. The machines shoot rocket-like projectiles into the earth to dig faster and more efficiently than current systems.

Since launching in 2015, HyperSciences has raised \$2.6 million in angel investments and received an undisclosed amount of funding under a non-equity contract with Shell GameChanger for its HyperDrill system.



Source:

<http://www.geekwire.com/2017/hypersciences-raises-690k-use-rocket-technology-geothermal-drilling/>

## Technology: Deep Well Project to Test Drilling

## Techniques in Crystalline Rocks

The U.S. Department of Energy (DOE) awarded a contract to evaluate the scientific and technical aspects of drilling deep, large-diameter boreholes in crystalline rock for the safe and effective disposal of waste. Wells of this type may eventually be used for the disposal of certain forms of nuclear waste, but the purpose of this contract is to investigate the geological and geochemical properties of deep granite and evaluate techniques for drilling large diameter (8-3/4") holes to a depth of 5000 meters in this environment. The project will be conducted near the town of Nara Visa, New Mexico. The project will be developed by a team led by Enercon Federal Services, Inc., Wastren Advantage, Fugro and DOSECC Exploration Services.

Most of this year will be spent working with local communities and government entities to communicate the purposes and methods of the testing, including: how the site will be responsibly managed during testing, how the land will be restored once the research is complete, as well as permitting the hole and developing the drilling and testing plan. Previous efforts to test this method in North and South Dakota lacked community support, but DOSECC has a strong track record of building trust with residents through transparency and communication.

The scientific drilling and data collection itself will not likely commence until the spring of 2018, once the DOE determines the most promising site where a successful community partnership exists. When the drilling portion begins, the scientific drilling team will be tasked with drilling a 5000-meter deep borehole 8-3/4" in diameter. If successful, a second borehole, 17" in diameter, would be drilled to the same depth at the same site. The data gathered will allow scientists to study the type and temperature of the rock as well as the nature and chemistry of the fluids encountered.

Marc Eckels, DOSECC Program Director for this project, explains that the data gained from this uniquely deep geological research has potential for other local and societal benefits, such as providing new drilling and testing techniques for geothermal energy applications.

Source: <http://dosecc.com/about-us/news/>

## Technology: Advanced Drilling System to Operate at Extreme Conditions

Underground extreme temperatures, extreme pressures, and crystalline rock formations are usually challenging in geothermal drilling. To overcome these challenges, Baker Hughes Incorporated, a global oilfield services

company, with investment from the U.S. Department of Energy's Geothermal Technologies Office (GTO), has developed and successfully demonstrated an advanced drilling system designed for these critical conditions.

The technology can drill directionally at extremely high temperatures (~300°C). The system uses a high-temperature lubricant in the drilling fluid, a full metal drill bit to break the formation, and a full metal drilling motor known in the drilling industry as a 'metal-to-metal motor'. In December 2016, Baker Hughes successfully directionally drilled with this innovative system in a deep geothermal well. In fact, the metal-to-metal motor operated for a continuous 270 hours – the longest time that a system like it has ever operated.

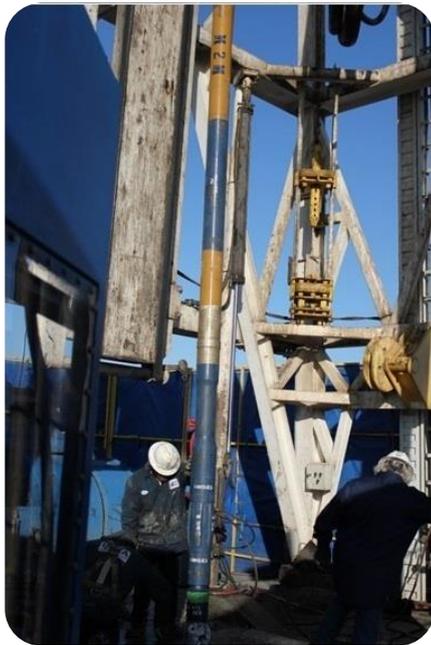
Because of its reliability in extreme subsurface conditions, the successful deployment of this drilling system could have far-reaching impacts. Not only does this technology advance the state of geothermal technologies and open more geothermal resource areas for development (including the immense Enhanced Geothermal Systems resource), other subsurface sectors such as fossil and nuclear energy are ready to embrace

this recent development.

These sectors can leverage the work funded by the geothermal energy sector for their own gains.

It was not disclosed when this drilling system will be commercially available –or if it is already.

Source: <https://energy.gov/eere/articles/new-drilling-technology-could-drive-advances-america-s-geothermal-energy-industry>



*A Baker Hughes geothermal drilling operation in progress. Photo taken from the GTO website.*

[geothermal-energy-industry](https://energy.gov/eere/articles/new-drilling-technology-could-drive-advances-america-s-geothermal-energy-industry)

## Climate Change: Short-lived Greenhouse Gases Cause Centuries of Sea-level Rise

Even if there comes a day when the world completely stops emitting greenhouse gases into the atmosphere, coastal regions and island nations will continue to experience rising sea levels for centuries afterward, according to a new study by researchers at Massachusetts Institute of Technology (MIT) and Simon Fraser University. In a paper published in early January in the *Proceedings of the National Academy of Sciences*, the researchers report that warming from short-lived compounds —greenhouse gases such as methane, chlorofluorocarbons, or hydrofluorocarbons, that linger in the atmosphere for just a year to a few decades— can cause sea levels to rise for hundreds of years after the pollutants have been cleared from the atmosphere.

Recent studies by many groups have shown that even if human-caused emissions of carbon dioxide were to stop entirely, their associated atmospheric warming and sea-level rise would continue for more than 1,000 years. These effects —essentially irreversible on human timescales— are due in part to carbon dioxide's residence time: The greenhouse gas can stay in the atmosphere for centuries after it's been emitted from smokestacks and tailpipes.

In contrast to carbon dioxide, other greenhouse gases such as methane and chlorofluorocarbons have much shorter lifetimes. However, previous studies have not specified what their long-term effects may be on sea-level rise. To answer this question, the team composed of Susan Solomon, Kirsten Zickfeld and Daniel Gilford, explored a number of climate scenarios using an Earth Systems Model of Intermediate Complexity, or EMIC, a computationally efficient climate model that simulates ocean and atmospheric circulation to project climate changes over decades, centuries, and millennia.

With the model, the team calculated both the average global temperature and sea-level rise, in response to anthropogenic emissions of carbon dioxide, methane, chlorofluorocarbons, and hydrofluorocarbons.

The researchers' estimates for carbon dioxide agreed with others' predictions and showed that, even if the world were to stop emitting carbon dioxide starting in 2050, up to 50 percent of the gas would remain in the atmosphere more than 750 years afterward. Even after carbon dioxide emissions cease, sea-level rise should continue to increase, measuring twice the level of 2050 estimates for 100 years, and four times that value for another 500 years.

In one particular climate modeling scenario, the team evaluated sea level's response to various methane emissions scenarios in which the world would continue to emit the gas at current rates —until emissions end entirely in three different years: 2050, 2100, and 2150. In all three scenarios, methane gas quickly cleared from the atmosphere, and its associated atmospheric warming

decreased at a similar rate. However, methane continued to contribute to sea-level rise for centuries afterward. What's more, they found that the longer the world waits to reduce methane emissions, the longer seas will stay elevated.

“Amazingly, a gas with a 10-year lifetime can actually cause enduring sea-level changes,” Solomon says. “So you don't just get to stop emitting and have everything go back to a preindustrial state. You are going to live with this for a very long time.”

In conclusion, the researchers point out that efforts to curb global warming should not be expected to reverse high seas quickly and longer-term impacts from sea-level rise should be seriously considered. “The primary policy conclusion of this study is that the long-lasting nature of sea-level rise heightens the importance of earlier mitigation actions.”

Source: <http://news.mit.edu/2017/short-lived-greenhouse-gases-cause-centuries-sea-level-rise-0109>

## Climate Change: The Fossil Fuel Industry Revenge has Started

*This is an excerpt of a The New York Times article published in print on February 5, 2017, on Page A1 of the New York edition with the headline: ‘G.O.P. and Trump Hurry to Slash Oil and Gas Rules, Ending Industries’ 8-Year Wait’, written by Eric Lipton.*

The document carried the title ‘A Roadmap to Repeal,’ a concise list of Obama administration environmental regulations that a Koch brothers-backed group was pressing President Trump and Congress to quickly reverse after Inauguration Day.

It was a tally of rules that energy industry executives and lobbyists had waged a futile fight against for eight years, donating millions of dollars to lawmakers who vowed to help block them, filing lawsuits to try to overturn them and hiring experts to generate reports that questioned the need for them.

But in a flurry of activity (...) Congress did what Charles G. and David H. Koch—who own a conglomerate that sells hundreds of products, including gasoline, jet fuel and coal—and other industry leaders had been asking for.

Using a rarely invoked law, the Republican-controlled Congress nullified a measure intended to curb the venting of gas wells on federal lands, and began the process of rolling back other regulations, including one enacted to limit damage that coal mines cause to streams—each items on the ‘Roadmap to Repeal.’

Not since the Reagan administration has Washington moved so quickly to roll back or nullify so many federal regulations, one of the clearest signs of an abrupt shift of power in a government now under one-party control that has flipped the script of winners and losers.

A three-way alliance has now been formed among Congress, the Trump administration and industries that struggled to reverse what they saw as an out-of-control rush to regulate by the Obama administration.



*The Koch Brothers. Photo Credit: Donkey Hotey/Flickr*

This new alignment of power is causing alarm not only among environmental groups but also other—mostly liberal—advocates who have spent much of the past eight years pushing for new rules to cover Wall Street banks, broadband providers, teacher preparation requirements, prepaid credit cards and even companies that sell high-calorie foods in vending machines.

All of these measures, and many others, now stand a chance of being reversed, watered down or blocked.

Lobbyists for the so-called extraction industry—oil, gas, coal and other mining operations—said they were as surprised as anyone else by the outcome of the November election, which gave them new clout in Washington (...). But the energy industry spends about US\$300 million a year lobbying Congress, deploying an army of three lobbyists for each member. It also contributed more than US\$160 million during the most recent election cycle to federal candidates, with 80 percent of that going to Republicans, according to a tally by the Center for Responsive Politics, a nonprofit group. And the industry now wanted congressional leaders like Mitch McConnell, who is from one of the country's top coal-producing states, to nullify the Obama administration's new rules.

Source:

<https://www.nytimes.com/2017/02/04/us/politics/republicans-oil-gas-regulations.html? r=1>

## Climate Change: Top U.S. Republicans Propose a US\$40 Carbon Tax

A group of senior Republicans and a dedicated think tank (the Climate Leadership Council), are encouraging the Trump administration to modify its tone on global warming. The group of veterans includes former Treasury Secretaries Hank Paulson and George Shultz along with George HW Bush's secretary of state James Baker.

They are proposing a carbon tax that would start at US\$40 a ton of carbon dioxide and gradually increase, signaling U.S. intent to cut emissions to business and rewarding citizens with tax dividends. In one example cited on the proposal –the Conservative Case for Carbon Dividends– a family of four could recoup as much as US\$2000 in payments in the first year of roll-out. “Carbon dividends would increase the disposable income of the majority of Americans while disproportionately helping those struggling to make ends meet,” says the report.

Why US\$40? The figure is roughly in line with U.S. Environmental Protection Agency (EPA) calculations on the damage a ton of CO<sub>2</sub> can inflict on the planet. It's much higher than carbon prices in the EU (just over US\$5) and China's pilot carbon pricing schemes (US\$2-5) but in contrast to those schemes the revenue would be redistributed to households. It would raise US\$200-300 billion a year.

The plan includes a complete repeal of Barack Obama's flagship plan to reduce emissions from the power sector on the basis it would no longer be necessary. Yet the proposal stresses that the “initial carbon tax rate should be set to exceed the emissions reductions of current regulations,” to ensure it wins bipartisan support.

Even though some supporters did not accept humans are the key driver of warming (for instance, Baker said, “I don't accept the idea that it's all man made... but I do accept that the risks are sufficiently great that we need to have an insurance policy.”), the proposals are likely to be fiercely opposed by some of Trump's supporters, like the libertarian Competitive Enterprise Institute (CEI), which describes any such tax as ‘market rigging’.

Source:

<http://www.climatechangenews.com/2017/02/08/top-us-republicans-pitch-40-carbon-tax-to-trump/>

*Do you have some drawings, sketches, or small paintings geothermal-related? So, why not include them to illustrate your contributions to the IGA News? Next time you send an article or short note, just send your drawing attached as a \*.jpg or \*.png file.*

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