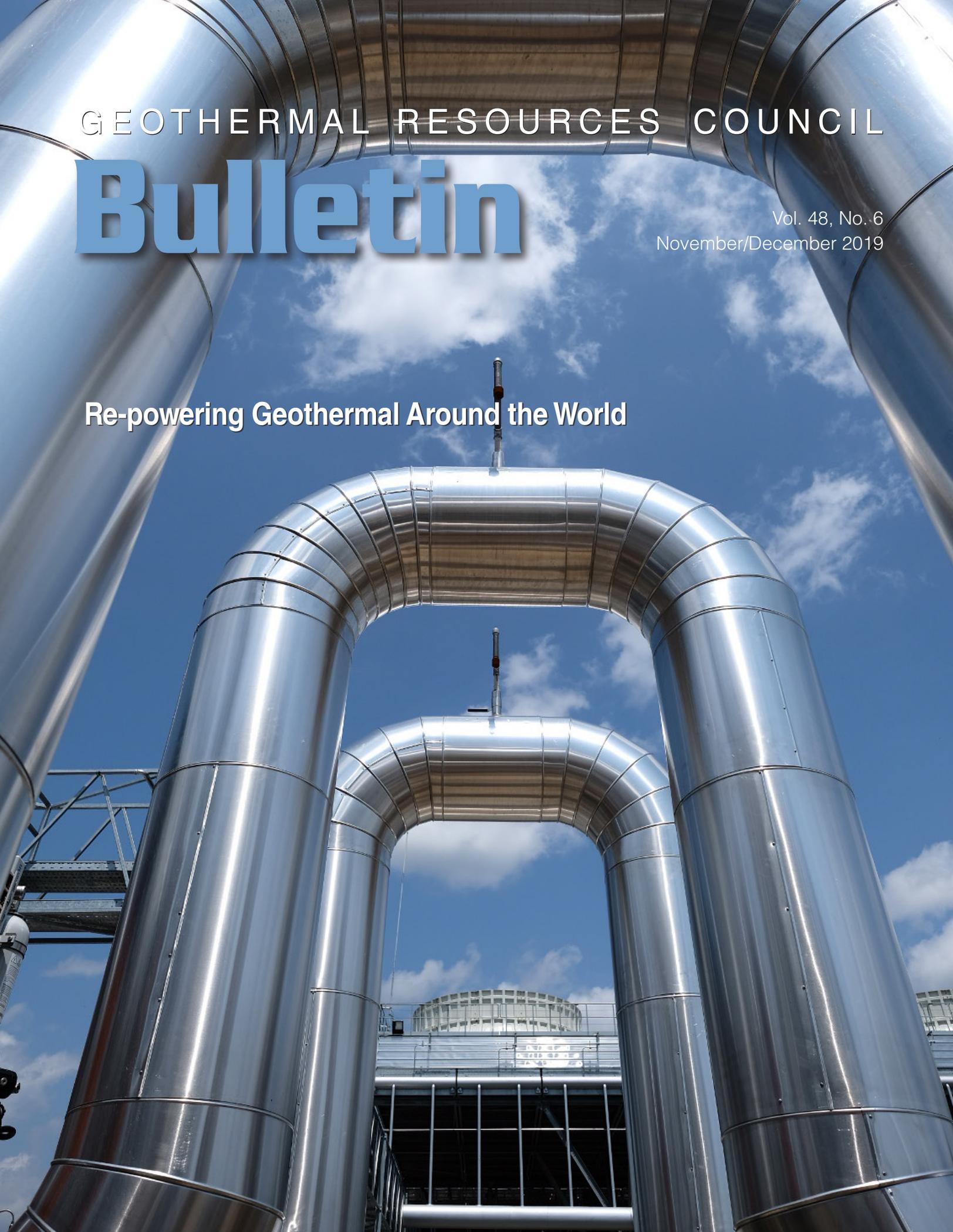


GEOTHERMAL RESOURCES COUNCIL

Bulletin

Vol. 48, No. 6
November/December 2019

Re-powering Geothermal Around the World





Geothermal Resource Group

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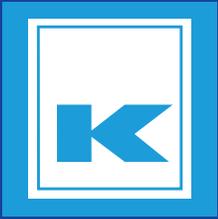
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Bulletin

Vol. 48, No.6
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The Geothermal Resources Council (GRC) *Bulletin* (ISSN No. 01607782) is published as a service to its members and the public, with six issues per annual volume. The GRC is an international, non-profit educational association whose purpose is to encourage research and environmentally sound exploration, development, and utilization of geothermal-energy resources worldwide through cooperation with governmental agencies, academic institutions, and the private sector. The GRC *Bulletin* provides a forum for information transfer to the public and among professionals in many fields related to geothermal resources, including geology, exploration, development, electric-power production, and direct-use technologies. The views and opinions expressed by authors in this publication do not necessarily reflect those of the GRC or its members. For changes of address or membership information, please contact us.

- 6** [President's Message](#)
by Andy Sabin
- 8** [Executive Director's Message](#)
by William Pettitt
- 10** [Communication from the GRC](#)
by Ian Crawford
- 14** [Inside Geothermal: North America, Central & South America, Australasia, Asia, Africa, Europe, Education, Science & Technology, Climate Change](#)
by Ian Crawford
- 34** [The Repowering of Lightning Dock Plant in New Mexico](#)
by Joseph Bonafin and Halley K. Dickey
- 41** [Publications, Websites, Videos & Maps](#)
by Ian Crawford
- 43** [In Memoriam - George Albert Frye & Gerald "Jerry" Niimi](#)
- 44** [Calendar of Events](#)

Advertisers

CalEnergy	13
Cyrq Energy	42
Dewhurst Group	7
EGESIM	13
Geologica	13
Geothermal Resource Group	Inside Front
Kenai Drilling	42
Mineralica	13
Ormat	37
Probe	3
Thermochem, Inc.	4
Webco	4



COVER: "Velika Ciglena 175 MW Turboden ORC plant - RGS geometries" by **Joseph Bonafin**, Turboden SpA, Brescia, Italy. A perspective of the nice geometries of the two phase steam pipelines from the largest European geothermal binary plant, Velika Ciglena (Bjelovar, Croatia). GRC PHOTO CONTEST 2019.



President's Message

by Andrew Sabin

Getting Organized: GRC State Chapters

For every minute spent organizing, an hour is earned. – Benjamin Franklin

A group of geologists, engineers, entrepreneurs and others have been working together for many years to bring geothermal development to the state of Colorado. This self-described Working Group assembles, discusses and strategizes with the goal of ushering in one or more geothermal development goals for the state. A common geothermal issue that they wrestle with is a perceived lack of awareness by many Coloradans, especially decision-makers, of the many forms of geothermal and how they add value, not to mention in some cases clean power, to the state's grid.

Colorado produces no utility-grade geothermal power despite its multiple, well-investigated regions of hot springs, hot water wells and elevated heat flow. Additionally, newly elected Governor Jared Polis outlined a process for achieving 100% renewable power in his "Roadmap to 100% Renewable Energy and Bold Climate Action." Not unlike California and other states with ambitious renewable portfolio standards and/or carbon emission limits, it's very difficult to imagine coming close to these goals without a substantial growth in geothermal.

In 2018 a similar group in Imperial County, California, started meeting regularly at local venues to discuss geothermal issues that concern them. They invite guest speakers to each meeting and they often have a sponsor or two willing to donate snacks and beverages. Unlike Colorado, the Salton Sea trough in Imperial County, which extends south to the Gulf of California in Mexico, has many developed geothermal fields in, what is the largest if not the hottest, geothermal, power-producing basin on earth. The geographic proximity of those working directly in these fields in combination with the organizational skills and persistence of this Chapter's leaders, Jon Trujillo and Mary Mann results in well-

attended, not to mention informative meetings. With some assistance from the Geothermal Resources Council (GRC), this group has been formally recognized as the Southern California State Chapter of the GRC.

The contrasts in geology, geography and the current states of the geothermal industries of Colorado and California couldn't be greater. The similarities between the states, however, are that both have a cadre of well-informed and passionate citizens who want to do what is right for their region and for the geothermal industry. Knowledge is power. The more knowledge and awareness that can be brought to the local populace, the more effective working groups can be in influencing voters and decision-makers in supporting any number of measures that help geothermal grow. Like with the SoCal State Chapter, GRC will help this Colorado group establish a GRC State Chapter. While this new GRC State Chapter imprimatur won't bring fame, fortune or instant geothermal development to Colorado, it will bring a closer alignment of these and other soon to be established state chapters under a common banner. As more people understand the potential and true economic value of geothermal, barriers to geothermal development will decrease.

State chapters or sections of GRC is not a new phenomenon. Unfortunately, the creation and growth of most chapters decades ago faded as the drivers of those groups retired or moved on from the industry. The ongoing resurrection and growth of old and new state chapters under the GRC umbrella should bring added momentum to the industry. And as these groups grow and become loosely aligned across geographic boundaries, they will also begin to speak with a more singular and unified voice. It's been said before that no one can hear ten different voices; but an entire coliseum can hear one voice. Let's get organized and speak with one voice. ■

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CARL SAGAN, PALE BLUE DOT, 1994



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Executive Director's Message

by Will Pettitt, PhD

Collaboration is Key

The goal of the GRC is to raise the recognition and acceptance of geothermal energy across the spectrum of society, in government, industry, academia and the general public, in the U.S.A. and around the world. Part of the GRC's strategy is to enhance our collaboration: both for our organization and our industry. That collaboration comes in many forms.

As an industry, we need to collaborate with other renewable and clean energies, such as wind, solar, biomass, and hydro, to successfully introduce the energy transition that society demands. That transition will need a mix of renewable and clean energies in our power system as well as a huge leap in energy efficiency and heat management in our homes and industries. An "all-of-the-above" clean energy strategy. Society will need energy that is always on, no matter what the time and whatever the weather, to support electrification and decarbonization. Geothermal energy



The GRC is well-placed to collaborate within the global community.

means electrical power, district heating and heat pumps in buildings, and is therefore well positioned to facilitate this transition.

Our industry also needs to collaborate with subsurface engineering industries. The oil & gas community has two big incentives: firstly, society will pressure them to move towards carbon neutrality, which means they need to invest in renewable energies and be visibly seen to do so; secondly, there are clear technical overlaps between oil & gas borehole operations and geothermal's technologies that means their workforce and talents naturally fit with ours. Both these incentives mean that the oil & gas community, in research and industry, will start investing more and more time and money into geothermal.

We should also not overlook the mining and mineral industries as there are opportunities here: many mines are physically located in areas of the world that also have geothermal resources that could provide them power; and, research into flooded abandoned mines may provide development of low enthalpy geothermal systems. There is also co-production of hydrogen for fuel cells and lithium recovery for battery manufacturing that add value to geothermal resource development.

Our organization also needs to collaborate. We are actively developing relationships with other non-governmental organizations that have similar goals to us, across the US and internationally. In November, I had the

opportunity to give a briefing in Washington DC to congressional staff and the public on geothermal energy and its role in the energy transition in collaboration with the Environmental and Energy Study Institute (EESI) and the Clean Energy and Technology Staff Association (CETSA). Further information on the briefing can be found online.¹ We are working on many similar opportunities to deliver our messaging and build long-term relationships that can help accomplish our goals. In January, we will be presenting at energy seminars on both the East and West coasts so look out for more information.

A North America Cluster will feature at the World Geothermal Congress (WGC) 2020 Exhibition in Iceland. The cluster of booths has been assembled collaboratively by participants from North America. It will help showcase the North American geothermal community and industry at the conference and is an opportunity to better engage with partners around the world. It facilitates the building of relationships for exporting North American products and services, as well as encouraging discussions of latest technologies and innovations.



The World Geothermal Congress (WGC) 2020 will take place from 27 April - 1 May, 2020, in Reykjavik, Iceland (Courtesy Harpa Concert Hall and Conference Centre).

The cluster consists of five participants and there is available space for additional North American organizations to join in. Current participants include: Phoenix Geophysics (Ontario, Canada); Geologica (Nevada, U.S.A.); Geothermal Resource Group (California, U.S.A.); GeothermEx (California, U.S.A.); and, U.S. Department of Energy (Washington DC, U.S.A.). Please contact me for further information or to express interest.² Collaborating organizations can be based in Canada, Mexico or U.S.A. and can include corporations, National Labs, universities, and government agencies, amongst others. At the WGC, we have an opportunity to present a North American vision for geothermal energy by demonstrating the diversity and excellence of our geothermal work force and research capabilities. I hope you will consider joining us or visiting with the cluster at the conference.

The geothermal community needs to collaborate to achieve our goals of expanding our industry and being an active participant in the transition to renewable and clean energy. And we have huge opportunities to do so! As we enter the New Year, I encourage us all to

be thinking on ideas for how we can work with others inside and outside our industry to help develop and communicate our value and benefits.

Wishing all a productive and prosperous New Year! ■

¹ <https://www.eesi.org/briefings/view/111519cetsa>

² wpettitt@mygeoenergy.org

Communication from the GRC

by Ian Crawford
Director of Communications

GRC Annual Meeting & Expo Call for Papers



The Geothermal Resources Council (GRC) has issued a call for papers for the world's biggest annual geothermal energy conference taking place **October 18-21, 2020**, at the **Peppermill Resort Spa, Reno, Nevada, USA**.

The GRC 2020 Annual Meeting planning committee will consider papers for its Technical and Poster Sessions covering a range of topics, both domestic and international:

Business Development / Finance/ Market Analysis; Country Updates (example: East African Rift / Philippines); Direct Use / Heat Pumps; Drilling; Emerging Technologies; Enhanced Geothermal Systems (EGS); Exploration / Resource Assessment; Field Operations / Production Technologies; Geochemistry; Geology; Geophysics; Geothermal Education and Community Engagement; Geothermal Energy Associated with Oil and Gas Operations; Geothermal Project Case Studies; Power Operations / Flexible Generation / Maintenance; Regional Updates (example: Salton Sea / Basin & Range / Cascades); Regulatory / Environmental Compliance / Policy Issues; Reservoir Engineering/ Reservoir Management/ Modeling; Sedimentary Basins, and Utilities and Transmission.

In addition, there is an opportunity to submit papers in special themed topics:

Advanced Materials for Drilling, Completion and Monitoring; District Heating and Direct Use: Feasibility

to Implementation; EGS Collab: Experimentation, Modeling and Interpretation; FORGE Activities, Progress and Plans; Geochemistry for Early Geothermal Exploration; Geomechanics in Geothermal; Geothermal Energy in Canada: Moving Forward; Geothermal Heat Pumps: Latest Technologies and Market Developments; High Temperature Reservoir Monitoring Systems; Machine Learning in Geothermal Development; Mineral Extraction; Power Plant Improvement Strategies; Reservoir Closed Loop and Energy Transfer Systems;

Super Hot/Supercritical Geothermal Systems, and 2018 Kilauea Volcano Eruption and Geothermal Reservoir.

International participation is key to the success of the technical programs, and geothermal researchers and experts from the USA and around the world are encouraged to submit their work for consideration to be presented at the GRC Annual Meeting.

Anyone who wants to present at the GRC Annual Meeting must submit a paper. The deadline for submission is Wednesday May 27th, 2020

Additional information about paper requirements and submission forms can be obtained by contacting the GRC at (530) 758-2360 or at <https://reno2020.mygeoenergynow.org/>

For more information about the GRC Annual Meeting & Expo in Reno, Nevada, USA, visit <https://reno2020.mygeoenergynow.org/> or call (530) 758-2360.

For information on how to sponsor this event, contact Anh Lay; GRC at (530) 758-2360 X100 or alay@geothermal.org.

Book Your Hotel Room

All the events and accommodation for the GRC Annual Meeting & Expo are in one location, the **luxurious Peppermill Resort Spa & Casino**, the only resort in the United States whose heating source is totally provided from geothermal energy produced on the immediate property.

The GRC has contracted with the Peppermill for a **discounted block of rooms** for a limited time. There is a choice of rooms with a king, queen or double beds.

- We strongly recommend making your hotel reservations on-line through a dedicated webpage at <https://book.passkey.com/event/50007543/owner/7268/home>. The preferred rate is automatically applied.

OR

- If you make your reservations over the phone make sure you mention you are part of the **Geothermal Resources Council group** to get the special rate.

The average nightly rate starts at just **USD 89 a night** plus taxes and fees for a room in the newly remodeled Peppermill North and West Wings. For a room in the award winning luxurious Peppermill Tower offering panoramic views of the majestic Sierra Nevada mountains, the rate is **USD 109 a night**. At the top of the line, a Tuscany Tower Suite starts at **USD 149**.

Please make your reservation **before September 23, 2020** in order to receive our special rate. [Book your room now.....](#)

Why Stay at the Conference Hotel?

GRC strongly encourages you to stay at the Peppermill Resort Spa & Casino to gain the benefits of networking with colleagues, being close to the event venues, and relaxing in a nice hotel property.

We make every effort to negotiate the best possible rates. When you stay at the conference hotels, you help GRC meet our contractual obligations, avoid paying financial damages for this meeting, secure suitable venues and preferred dates-and-rates for future conferences.



A king bed room in the Peppermill North & West Wing.

GRC Transactions

Technical papers from the **2019 Transactions Volume 43** are now available through the *Geothermal Library* website. The **100 papers** that were presented at the GRC Annual Meeting in Palm Springs, California are available **for members only**, at www.geothermal-library.org. Papers from previous years are also available for all.



The GRC Library can be accessed at:
www.geothermal-library.org

Our database contains over 40,000 records on all aspects of geothermal energy, including exploration, reservoir engineering, power plant design and operation, direct use, geothermal heat pumps, regulatory issues, energy policy, energy markets, news briefs, and more.

~~~~~

## Joint GRC-SPE Workshop - Registration Now Open!

### High-Temperature Well Cementing

*"Exploring Geothermal and Oil and Gas Synergies"*

**March 30 - April 1, 2020**

**Wyndham San Diego Bayside, San Diego, California, USA**

The **Geothermal Resources Council (GRC)** together with the **Society of Petroleum Engineers (SPE)** are organizing a workshop on high-temperature cementing, integrity for the life of production and injection wells in these HT applications.

The GRC and the SPE have decided that a joint workshop would enable both industries to share their experiences, technologies, technical procedures and best practices on this important aspect of well completion. The workshop will highlight cement formulae and slurry blends, placement methods, remedial procedures and result evaluations. Case studies will be discussed and analyzed.

## Communication from the GRC

All drilling personnel, both geothermal and oil & gas drilling and production engineers, well-site supervisors, cementing engineers and interested personnel are welcome to attend and participate.

The draft agenda, hotel reservations, and registration, can be found on our new dedicated website at <https://cement.mygeoenergynow.org/>

**Save USD 100 by registering before March 1, 2020.**

- GRC or SPE Member: USD 990
- Non Member: USD 1,090

In addition, by booking and staying at the Wyndham San Diego Bay Hotel under the [GRC room block](#), the GRC will refund your workshop registration by USD 50 per night for up to 3 nights booked/paid. [Make your reservation.....](#) ■

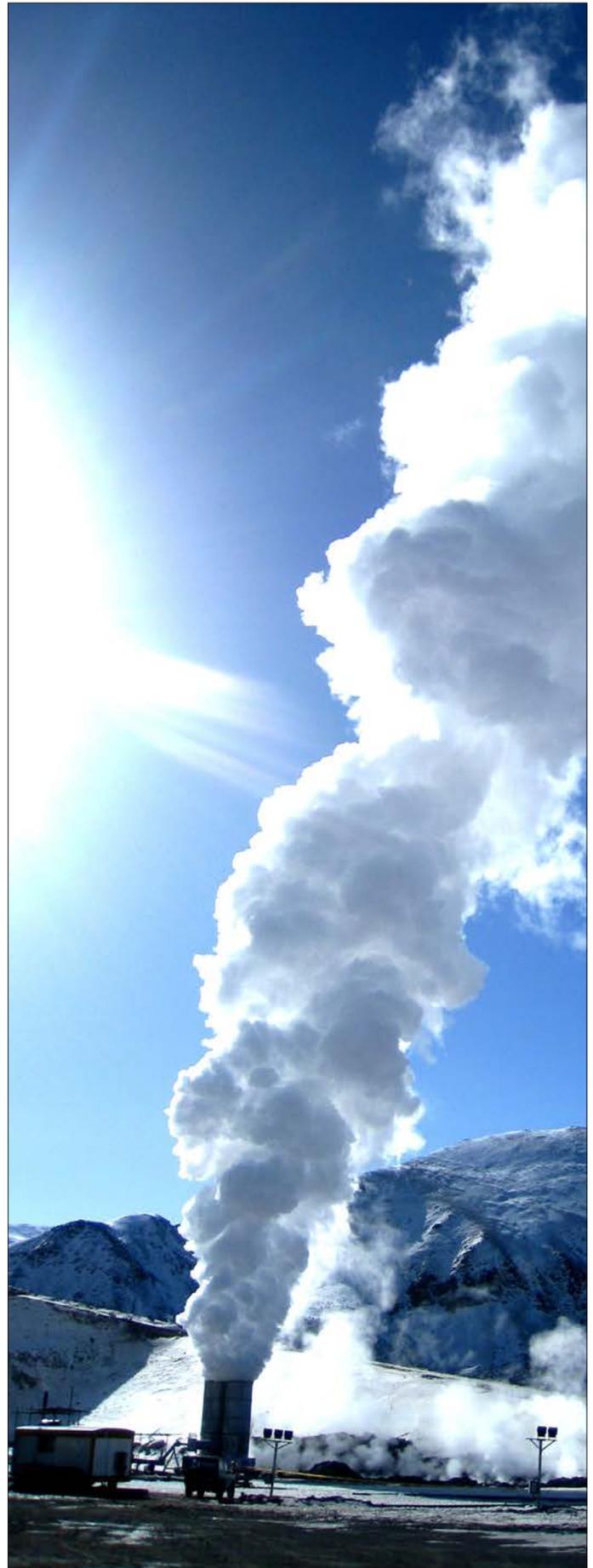


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Have Your Say!

If you would like to comment on any column or article in the *GRC Bulletin* or have an opinion on a topical subject that will interest our readers, please email the editor, **Ian Crawford** at icrawford@geothermal.org or mail to Geothermal Resources Council

P.O. Box 1350, Davis, CA 95617-1350.



The Blue Sky in Sabalan Geothermal Field, by Elahe Zarei.

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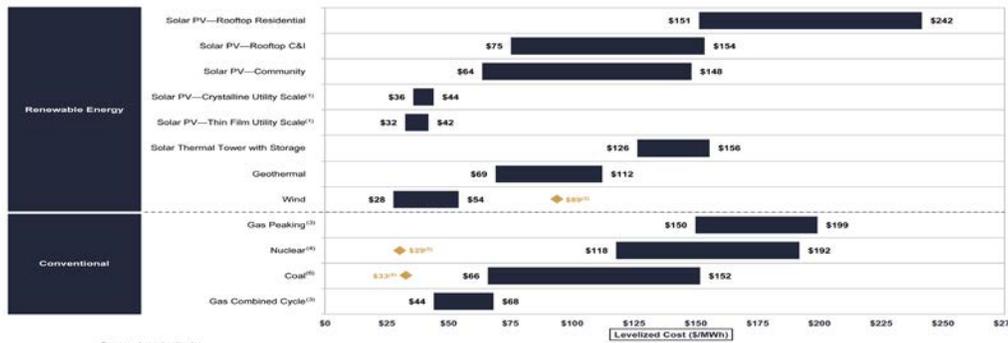
Inside Geothermal

Geothermal is Cost-Competitive with Conventional Generation

Lazard’s latest annual **Levelized Cost of Energy Analysis (LCOE 13.0)** shows that as the cost of renewable energy continues to decline, certain technologies (e.g., onshore wind, utility-scale solar and to a certain extent, geothermal), which became cost-competitive with conventional generation several years ago on a new-build basis, continue to maintain competitiveness with the marginal cost of existing conventional generation technologies. *Global Geothermal News.....*

Levelized Cost of Energy Comparison—Unsubsidized Analysis

Selected renewable energy generation technologies are cost-competitive with conventional generation technologies under certain circumstances



International Geothermal Association Announces Board Election Results



The elections to the Board of Directors of the **International Geothermal Association (IGA)** for the **2020-2023 period** have concluded and **25 members have been elected**, including members of the Geothermal Resources Council (GRC):

- Ayling, Bridget
- Bignall, Greg
- Bjarnason, Bjarni
- Blair, Andy
- Brotheridge, Jane
- Darma, Surya
- Falcone, Gioia
- Hajto, Marek
- Hillbrand, Gudrun
- Izquierdo-Montalvo, Georgina
- Kaya, Eylem
- Manzella, Adele
- Matthiasdottir, Kristin Vala

- Meier, Peter
 - Olivar, Maria Victoria M.
 - Omenda, Peter
 - Prieto, Angela
 - Sabin, Andy
 - Schmidlee, Virginie
 - Siratovich, Paul
 - Suryantini, Ninik
 - Szita, Gabor
 - Utami, Pri
 - Yasukawa, Kasumi
 - Zemedkun, Meseret
- Global Geothermal News*

Global Geothermal Capacity Anticipated to Grow to 18 GW by 2024 - IEA

Global electricity capacity from renewable energy is set to expand by as much as 50% in the next five years, bolstered by government support and falling costs. But more would be needed to slow

Geothermal installed capacity, growth over 2019-24 main and accelerated case



down warming of the globe, the **International Energy Agency (IEA)** have said in a new report.

Those gains represent an increase of about 1,200 GW from 2018 to 2024, equal to the total installed capacity in the U.S., according to the IEA report. **Countries are**

adding more clean power as a key part of efforts to de-carbonize energy supply, but it’s still not fast enough.

Geothermal capacity is anticipated to grow 28%, reaching 18 GW by 2024, with Asia responsible for one-third of global expansion, mainly through projects currently under construction in **Indonesia** and the **Philippines**, followed by **Kenya**, whose cumulative geothermal capacity is set to overtake Iceland’s during the forecast period. **Pre-development-stage risks** continue to be an important challenge, impeding the rapid development of untapped geothermal potential.

Global Geothermal News.....

Green Climate Fund Boosts Funding Efforts



GREEN CLIMATE FUND

The shared urgency of addressing climate change took an historic step forward with 27 countries pledging to

replenish the **Green Climate Fund (GCF)** by **USD 9.776 billion** for the next four years. The resources will help developing countries reduce greenhouse gas emissions and adapt to the negative effects of global warming, such as rising sea levels, record temperatures, prolonged drought, and more frequent and severe weather events. The **United Kingdom, France, Germany, Japan and Sweden** are the top contributors.

To achieve maximum impact, the Green Climate Fund's public investment boosts the climate action capacities of developing countries and helps unlock private sector markets of low-emission, climate-resilient innovation. **Every USD 1 billion invested in the Fund spurs nearly USD 3 billion in additional financing**, including from recipient countries. *Global Geothermal News.....*

NORTH AMERICA

New Legislation Would Accelerate Geothermal Energy Development in the United States

U.S. Senators **Lisa Murkowski**, Republican-Alaska, and **Joe Manchin**, Democrat-West Virginia, have introduced bipartisan legislation to accelerate geothermal energy development in the United States.

The **Advanced Geothermal Innovation Leadership Act of 2019 (the "AGILE" Act)** includes provisions for research and development of both existing and enhanced geothermal systems, resource assessment updates, grant program authorization, and improved permitting.

"Geothermal is a highly reliable, zero-emission resource able to provide both heat and power almost anywhere," Murkowski said. "Our committee's June hearing highlighted the opportunity geothermal holds to contribute to America's energy future, with expanded innovation and deployment. Our new bill addresses both technical and non-technical barriers that have kept us from realizing geothermal's full potential."

Global Geothermal News..... On November 19, the **AGILE legislation advanced out of the U.S. Senate Committee on Energy and Natural Resources.**

S.2657
Section-by-Section

Section 1: Short Title.
The Advanced Geothermal Innovation Leadership Act

Section 2: Update to Geothermal Resource Assessment.
Identifying New Geothermal Opportunities – Directs the U.S. Geological Survey (USGS) to update its geothermal resource assessment with more modern techniques and with a focus on areas suitable for new technologies such as critical minerals coproduction and long-duration energy storage. Specifically directs USGS to assess overall potential in Alaska, Hawaii, and Puerto Rico.



The **GRC Policy Committee** wrote a letter of support for this important new legislation:

Global Geothermal News.....



October 22, 2019

The Honorable Lisa Murkowski
Chairman,
U.S. Senate Committee on Energy and
Natural Resources
304 Dirksen Senate Building
Washington, DC 20510

The Honorable Joe Manchin
Ranking Member,
U.S. Senate Committee on Energy and
Natural Resources
304 Dirksen Senate Building
Washington, DC 20510

Dear Chairman Murkowski and Ranking Member Manchin:

On behalf of the geothermal industry we would like to thank you for introducing the "Advanced Geothermal Innovation Leadership Act of 2019", otherwise known as the "AGILE Act".

As the professional association for the geothermal industry and community, the Geothermal Resources Council (GRC), strongly supports the AGILE Act and applauds your leadership in bringing forth the various parts of the act:

- Updating Geothermal Resource Assessments;
- Authorizing a Secondary Use Subprogram focused on direct use, minerals recovery (lithium), desalination, industrial applications, and grid management;
- Authorizing two \$10M prizes in a competition for the demonstration of coproduction of critical minerals;
- Authorizing two publicly operated FORGE sites (Frontier Observatories for Research in Geothermal Energy);
- Authorizing four EGS projects (Enhanced Geothermal Systems) with one east of the Mississippi River;
- Authorizing \$150M to the DOE geothermal program;
- Reauthorization of High-Cost Region Geothermal Energy Grant Program;
- Authorizing the Geothermal Energy Permit Coordination Program which will provide permitting expertise.

2 | Page

The GRC kindly urges the Senate to take up this bill as soon as possible and for the House to follow suit expeditiously. Quick action on this issue is critical to the long-term future of geothermal energy and how we make a significant impact to:

- 1) building jobs and economic benefits in local communities across the nation;
- 2) helping to fight climate change through electrification and decarbonizing our economy; and,
- 3) being a reliable source of energy that gives clean renewable power and heat that's always on.

The AGILE Act impacts the whole geothermal energy spectrum across low temperature and high temperature resources. It aims to develop technical innovations through EGS and FORGE research, as well as increase value of geothermal operations through coproduction with other critical minerals.

These actions will help build a future where geothermal power and heat can be rolled out across the nation as a critical source of renewable energy for U.S. households and businesses as we transition to a clean energy future. Geothermal energy is affordable and reliable, and will play a substantive role in maintaining a functioning electricity grid – due to its position as a flexible, clean, 24/7 resource that can complement other intermittent renewable resources.

The GRC is a non-profit professional association for the geothermal industry and community in the USA and abroad. We were founded in 1972 and are headquartered in Davis, California. We have over 1,300 members from around the world and are working to advance our industry by supporting the development of geothermal energy resources through communication of robust research, knowledge and guidance.

We thank you for your consideration. We are available to answer questions and discuss further at your convenience.

Respectfully,

Paul Thomsen
GRC Policy Committee Chair
pthomsen@ormat.com

Will Pettitt, PhD
GRC Executive Director
wpettitt@mygeoenergy.org

Geothermal Resources Council Supports Renewable Electricity Tax Credit Equalization Act

Joining forces with other renewable energy associations the GRC signed on to a letter supporting a **2-year retroactive extension (for 2018-2019) of the expired renewable energy tax credits:**

"As the **House Ways and Means and Senate Finance Committees** continue their work to address tax extenders, as well as long-term tax policy legislation, the **National Hydropower Association (NHA), American Biogas Council, Biomass Power Association, Energy Recovery Council, and Geothermal Resources Council (GRC)**, come together to strongly support House Resolution (H.R.) **4186**, a bipartisan bill co-sponsored by Representatives **Elise Stefanik** (Republican-New York) and **Scott Peters** (Democrat-California), and urge swift action to pass the measure.

H.R. 4186 provides a **2-year retroactive extension (for 2018-2019) of the expired renewable energy tax credits** for hydropower, marine energy, biomass, biogas, waste-to-energy and **geothermal resources**, along with an **extension through 2024**.

The U.S. has long used targeted tax incentives to leverage investment and innovation in the energy sector. This is true for fossil and renewable resources alike. Hundreds of thousands of jobs and billions of dollars in private investment across the industries – not to mention gigawatts of affordable, reliable, and renewable power – have been driven by tax policies.

However, for too long, our resources have been undervalued and overlooked in the clean energy tax policy debate despite the carbon-free, renewable electricity benefits (among many others) they provide. Tax policy has become de facto energy policy at the federal level and our industries have been placed at an untenable

competitive disadvantage – as demonstrated by the growth trajectories compared to wind and solar resources.

The provisions of H.R. 4186 would address this disparity. These tax credits are a critical incentive for the continued deployment of reliable, renewable, baseload power in our sectors, which we believe supports a national energy strategy that seeks to reduce carbon emissions while maintaining grid reliability and resilience.

Therefore, our groups are united in seeking the retroactive extension of the tax credits and the passage of this long-term extension. We call on Members of Congress to support these objectives as the work on extenders and a larger bill develop." *Global Geothermal News.....*



Will Pettitt, PhD, FGS, Executive Director, GRC commented on the proposed legislation:

"The geothermal industry is helping build a future where geothermal power and heat can be rolled out across the nation as a critical source of renewable energy for U.S. households and businesses as we transition to a clean energy future.

The Geothermal Resources Council (GRC) can attest to the vital importance of tax credits to the success of geothermal energy business, and strongly supports and applauds the leadership shown by the House Ways and Means Subcommittee on Select Revenue Measures, and **Chairman Mike Thompson**, in drafting the **Growing Renewable Energy and Efficiency Now (GREEN) Act**.

The GREEN Act would retroactively extend the Production Tax Credit (PTC) through 2019 for geothermal, which otherwise expired at the end of 2017, and **extends the Investment Tax Credit (ITC) at 30% for geothermal plants through the end of 2024**. These tax credits provide a predictable market signal for project

development, which in turn leverages private investment and promotes job creation and local economic benefits across the country.”

New Legislation Would Boost Geothermal Energy on Public Lands

U.S. Senators **Martha McSally** (Republican-Arizona), **Martin Heinrich** (Democrat-New Mexico), **Cory Gardner** (R-Colorado), **Michael Bennet** (D-Colorado), **Tom Udall** (D- New Mexico), **Steve Daines** (R-Montana), **Jon Tester** (D- Montana), and **James Risch** (R-Idaho) introduced bipartisan legislation to incentivize responsible renewable energy development on public lands and allow local communities to reap the economic benefits.

The **Public Land Renewable Energy Development Act (PLREDA)** of 2019 would streamline the permitting process for renewable energy development on public lands and establish a revenue sharing mechanism to ensure local communities receive a percentage of the revenue created by these projects. [Global Geothermal News.....](#)

FERC Estimates Additional 860 MW Geothermal Energy Over the Next Three Years

According to a review by the **SUN DAY Campaign** of data released by the **Federal Energy Regulatory Commission (FERC)**, the agency has once again revised its three-year forecast for changes in the U.S. electrical generating capacity mix. **Sharp declines are foreseen for fossil fuels and nuclear power** while **renewable energy** (i.e., biomass, geothermal, hydropower, solar, wind) is forecast to experience even **stronger growth** than previously projected.

FERC’s monthly “**Energy Infrastructure Update**” report (with data through August 31, 2019) indicates that geothermal energy will add **another 860 MW by August 2022**. It records **6 units with 280 MW of capacity** are currently **under construction**. **The total available installed capacity** of geothermal steam in the U.S. as of August 2019 is **3,840 MW or 0.32% of total energy capacity**. [Global Geothermal News.....](#)

Increase of 3.2% Year-on-Year for Geothermal Electricity Generation in U.S.

Some interesting statistics for geothermal energy from the latest **Electric Power Monthly** from the U.S. **Energy Information Administration (EIA)**.

In the year to date **through August 2019**, the USA generated **10,926 Gigawatt hours (GWh)** of electricity from **geothermal** resources, an **increase of 3.2%** on last year, from **2,454.9 MW of net summer capacity**.

For individual states year-to-date net generation through August 2019, year-on-year increase and net summer capacity:

- **California** - 7,865 GWh (+1.3%) from 1,744.1 MW
- **Nevada** - 2,496 GWh (+9.9%) from 556.7 MW
- **Utah** - 289 GWh (-2.4%) from 73.0 MW
- **Hawaii** - 90 GWh (+22.5%) from 43.0 MW
- **Oregon** - 98 GWh (-16.1%) from 19.5 MW
- **Idaho** - 49 GWh (-12.1%) from 10.0 MW
- **New Mexico** - 39 GWh (+381.8%) from 8.6 MW

The **average capacity factors** for utility scale generators in 2018:

- Nuclear - 92.5%
- **Geothermal** - 76.0%
- Hydroelectric - 41.9%
- Other Biomass - 61.8%
- Wind - 34.6%
- Solar Photovoltaic - 25.1%
- Solar Thermal - 23.6%
- Wood - 60.6%

[Global Geothermal News.....](#)

Grant Funding Opportunity for R&D on Geothermal Energy and Lithium Co-Production

The **California Energy Commission** has announced a **Grant Funding Opportunity (GFO)** to support geothermal energy R&D to overcome geothermal technology hurdles and enable recovery of lithium. The **GFO-19-303** under the **Electric Program Investment Charge Program (EPIC)**, has a submission **deadline of January 30, 2020**.

The purpose of this solicitation is to fund applied research and development, and technology demonstration and deployment projects that meet the following objectives:

- **Develop and demonstrate technologies, tools, and strategies to improve the productivity and flexibility of existing geothermal facilities;**
- **Develop and demonstrate technologies to recover lithium from geothermal brine;**

Funded projects will help improve production and flexibility of existing geothermal facilities and demonstrate the economic capture of lithium

from geothermal brines. The projects will increase the overall economic value of existing or future geothermal projects through integration of emerging technologies and added value from lithium recovery operations from geothermal brine, which in return will ensure higher penetration of non-intermittent renewable energy in California and provide a range of benefits, including grid stability, reliability, and resiliency. [Global Geothermal News.....](#)

Calpine Announces Funding Plan for Operations at The Geysers Geothermal Field

Geysers Power Company, LLC (GPC), an indirect wholly owned subsidiary of Calpine Corporation and the owner of **13 Geysers geothermal power plants** and related assets, has announced that it intends to offer **Senior Secured Notes, Series A**, due 2039 and **Senior Secured Notes, Series B**, due 2039 to raise an estimated aggregate principal amount of up to **USD 320 million** and **USD 400 million**, respectively.

GPC intends to use the new investment to fund working capital, ongoing capital requirements and general corporate purposes of The Geysers entities. [Global Geothermal News.....](#)

BLM Publishes Environmental Assessment for Geothermal Exploration on Western Shore of Salton Sea

The U.S. **Bureau of Land Management (BLM)** has published the *Environmental Assessment* for the drilling of up to four geothermal exploration wells within the **Truckhaven Leasing Area** and the northeast edge of the **Ocotillo Wells Special Recreation Management Area** at the **Salton Sea in Southern California**, for the purpose of identifying a viable geothermal resource. The location of the lease is on the western shore of the Salton Sea - most geothermal development up to now has been on the eastern shore.

The *Environmental Assessment* for the Ormat-owned **Orni 5 LLC project** is available through the **BLM ePlanning website**, or by visiting the **El Centro BLM Field Office**, 1661 S. 4th Street, El Centro CA 92243.

For more information, contact **Carrie Sahagun**, BLM Assistant Field Manager, at 760-337-4437 or via email at csahagun@blm.gov. [Global Geothermal News.....](#)

New Community Choice Aggregator is Opportunity for Geothermal Energy

The **San Diego County** Board of Supervisors has voted to approve an ordinance establishing a **community choice energy (CCE)** program.

Community choice energy programs, also known as **community choice aggregation**, allow cities and counties to buy or generate renewable energy for residents and businesses. **San Diego County is next door to one of the largest geothermal resources in the world at the Salton Sea.**

A county CCE would offer customers in the county's unincorporated areas an alternative to buying power from **San Diego Gas and Electric**. SDG&E would still provide transmission and delivery services. [Global Geothermal News.....](#)

EnergySource Minerals Announces Commercial Lithium Extraction Initiative

California-based **EnergySource Minerals** has announced a technology platform to extract battery-spec **lithium** from California's **Salton Sea geothermal brine**.

"EnergySource Minerals has successfully completed a feasibility study for the **extraction and production of lithium from geothermal brine** and is now proceeding toward a commercial lithium extraction initiative called **Project ATLiS**," said EnergySource Minerals CEO and **President Eric Spomer**. [Global Geothermal News.....](#)

California Division of Oil, Gas, and Geothermal Resources to be Renamed

California has six new laws that **Governor Gavin Newsom** says makes the state "a leader in the fight to transition away from fossil fuels."

They include some that will be of interest to the geothermal energy community:

- Require that oil and gas well operators estimate the cost of plugging and abandoning wells and decommissioning oil and gas production facilities.
- Rename the state **Division of Oil, Gas, and Geothermal Resources (DOGGR)** the **Geologic Energy Management Division** and

specify that its mission includes protecting public health and environmental quality, including cutting greenhouse gas emissions.

- Require the submission of testing data conducted on idle and abandoned wells for publication on the DOGGR's web site.

Global Geothermal News.....

Solar Augmented Geothermal Energy Project in Nevada Moves Forward

UC Won, LLC has announced it has secured a decision from the **Nevada Public Utilities Commission** confirming that UC Won's **solar augmented geothermal energy technology** could be used to serve an end-use customer in Nevada without state regulation. *Global Geothermal News.....*

UC Won, LLC also announced it acquired the well field equipment necessary to begin development of the first **RenewGeo** power plant from **Open Mountain Energy** of Salt Lake City, Utah. *Global Geothermal News.....*

GRC Board Member is New Geothermal Commissioner

Nevada **Governor Steve Sisolak** has appointed GRC Board member **Josh Nordquist**, to the state **Commission on Mineral Resources** as the **Geothermal Commissioner**. Josh is the Manager of U.S. Resource Operations for **Ormat Technologies**, a member of the Geothermal Resources Council, served as Vice-President of the Geothermal Energy Association and was a member of the Nevada New Energy Industry Task Force. *Global Geothermal News.....*

Huge Coal Burning Power Plant Shut Down in Geothermal Rich Region

The **2,250 MW** coal-fired **Navajo Generating Station** near **Page, Arizona** has burned the last of its coal, marking the end of the plant's 45-year run. The plant was the largest coal plant in the West, and its closure will affect the entire region.

in 2014, **Salt River Project**, owner of the plant, signed a 23-year agreement with **CalEnergy, LLC** to purchase up to **87 MW of geothermal energy** a year from a number of plants located in **Imperial Valley in Southern California**. *Global Geothermal News.....*

Puna Geothermal to be Re-Started by the End of the Second Quarter of 2020 - Ormat CEO

Ormat Technologies, Inc. announced financial results for the third quarter ended September 30, 2019. **Isaac Angel**, Chief Executive Officer commented, "The reconstruction efforts at Puna are on schedule and **we expect our refurbishment activities will be completed by the end of the year**, enabling us to deliver energy from the plant.

All of our insurers have now started paying the costs to rebuild the damaged power plant equipment. we expect to be able to sell the electricity produced at Puna as soon as the relevant permits required from local authorities for the operation of the substation and the transmission network upgrades being undertaken by our partners at **Hawaii Electric Light Company (HELCO)** are received. These are expected by the end of Q1 2020, and so we expect to be able to bring the power plant back to operation promptly thereafter, and to gradually increase the power plant's generating capacity as we complete well-field drilling work, with a target of **regaining full operation by the end of the second quarter of 2020.**" *Global Geothermal News.....*

At **Steamboat Hills Power Plant (Nevada)**..."We are planning to replace all of the old power plant equipment with new advanced technology equipment that will eventually **increase the capacity by approximately 16 MW** and reduce maintenance costs. Equipment being delivered to the site and construction is ongoing. **Commercial operation is expected in early 2020.**

At **Heber Complex (California)**..."We are currently in the process of repowering the **Heber 1** and **Heber 2** power plants. We are planning to replace steam turbine and old equipment with new advanced technology equipment that will **add a net capacity of 11 MW**. Following these enhancements, we expect the capacity of the complex to reach **92 MW**. Permitting, engineering and procurement are ongoing. Manufacturing of equipment is planned to commence in the fourth quarter 2019. We expect **commercial operation in early 2021.**

"In addition, we are in the process of upgrading some of the equipment, such as turbines, pipelines and cooling systems at some of our operating power plants including **Ormesa in California, San Emidio in Nevada, Zunil and Amatitlan in Guatemala** and **Neal Hot Springs in Oregon.**" *Global Geothermal News.....*

Canadian Province Clears the Way for 5 MW Alberta No. 1 Geothermal Power Project

The province of Alberta says it has cleared the way for Terrapin Geothermics to build a geothermal power plant south of Grande Prairie by granting application for regulatory approval. Terrapin has been granted permission to do testing operations to check the geothermal potential. [Global Geothermal News.....](#)

Lithium Extraction Pilot Plant Sources Geothermal Brine from Leduc Reservoir in Alberta

Calgary-based E3 Metals says it has collected the largest sample to date of lithium-enriched brine from its project in Alberta, Canada. The 20,000-litre sample was collected from the Leduc Formation and is required to support the continued testing and scale up of its proprietary direct lithium extraction process over the next 12 months.

The company has delineated an inferred resource estimate of 6.7 million tonnes of lithium carbonate equivalent from geothermal brine in the Leduc Formation, which now ranks Alberta as having one of the largest lithium resources in the world. The company has indicated in past statements that they would consider building a binary geothermal energy plant to power the lithium extraction facility. [Global Geothermal News.....](#)

Drilling of Second Well at Estevan Geothermal Power Project Begins

Drilling on the second Deep Earth Energy Production (DEEP) geothermal power production well began in November. Kirsten Marcia, president of DEEP, said, "Now that we've done flow and build up test, we are back in the field. The first thing they did was recompleting the first well into an injection well, and then they took all that fluid on the site and injected it down into the injection well. It's been monitored with gauges to see how well it responds to reinjection. As soon as that's complete, we're drilling our second well."

Marcia continued, "Things can move quite quickly at this standpoint. We need that second well in place so we can do the long-term loop and refine our engineering and construction plans. But after that, things can move very quickly. The longest lead item is ordering the Organic Rankine Cycle power generating facility, which can take 12 to 16 months. The rest is infill drilling. At this point, we believe we can have power to the grid at the end of 2021 or the beginning of 2022." [Global Geothermal News.....](#)

National Geology Survey of Canada Starts With Geothermal Energy Exploration

Earth-system Observing Network-Réseau d'Observation du Système Terrestre (EON-ROSE) aims to install geophysical observatories in a grid that would move around the country surveying the large landmass of Canada. As part of the study, researchers from the Geological Survey of Canada and Geoscience BC descended on Mount Meager this summer, which is in southern British Columbia and is Canada's most recently active big volcano. Their goal was to explore whether its volcanic warmth - which heats groundwater up to 240°C - could be tapped for geothermal energy.

In July, geologists travelled around the mountain on helicopters to install instruments similar to those envisioned for EON-ROSE. The researchers are crunching the preliminary data now, aiming to see where permeable rocks channel Mount Meager's volcanic heat towards the surface. Future studies in other parts of Canada could help geologists find new sources of geothermal energy — such as in the remote Arctic, where residents often rely on imported diesel, says Stephen Grasby, a geochemist at the Geological Survey of Canada in Calgary who led the work. [Global Geothermal News.....](#)

An article on the Mount Meager project - [A New Boost for the Geothermal Industry In British Columbia?](#) by members of the GRC Student Committee, was published in the September/October 2019 GRC Bulletin, Vol. 48, No. 5.

St Vincent Geothermal Project Achieves Good Results from Second Well

The second phase of drilling at the geothermal site at Bamboo Range on St Vincent has yielded positive results. Project Director Ellsworth Dacon said that the drilling of the second well, named Well Number Three (sic!), took about 83 days to complete and stimulation shows that this well is at 215°C and getting hotter, the right amount of energy needed for geothermal power generation.

He added however, that although the initial findings point to this, testing equipment still has to be procured to determine how much power Well Number Three can produce.

Dacon said they are hoping to **complete the drilling program by December, 2019**, repair Well Number One by February, 2020, **start testing in March 2020** then go to the market for **plant design by August/September 2020**.

"**Plant construction can start late 2020 or early 2021** and that is the plan if everything goes well," Dacon said. *Global Geothermal News.....*

Concept Design for 7 MW Dominica Geothermal Power Project Completed

The **Dominica Geothermal Development Company (DGDC)** successfully reopened the geothermal WW-P1 production well at the **Laudat geothermal** power project on **Dominica**. A series of tests on the well were conducted through October.

Global Geothermal News.....

Minister for Energy **Ian Douglas** said the concept design for the geothermal plant has been completed including the revised route for the re-injection pipeline from Laudat to Wotten Waven and Trafalgar. *Global Geothermal News.....*

AUSTRALASIA

There is a Geothermal Power Plant Down Under! - Again!

Green Thermal Energy Technologies (gTET) has announced the commissioning of the **310 kWe Winton geothermal power station** in **Queensland, Australia**. The new plant is powered by **87-100°C** water from **depths of 1-1.5 km** in the **Great Artesian Basin**.

Previously, the **80 kWe Birdsville geothermal plant** in Queensland supplied electricity for over 25 years. However, the state-owned electricity company that managed the plant made a strategic decision to decommission it in June 2018. Australia has a geothermal power plant again! *Global Geothermal News.....*

Lithium Successfully Extracted from Ohaaki Geothermal Power Station Brine

Geo40 has announced a breakthrough in extracting **near battery-grade lithium** from geothermal fluid. The commercial demonstration plant at **Contact Energy's Ohaaki geothermal power station** was originally built to extract silica which

had to be removed before the lithium in geothermal brines could be extracted. The leap forward to lithium extraction is providing new commercial potential for the firm. *Global Geothermal News.....*

Geothermal Power Plant Begins to Supply Heat for Wood Pellet Production

On November 14th **Contact Energy** began providing geothermal energy to the **Nature's Flame** wood pellet manufacturing plant based in **Taupō, North Island, New Zealand**.

Contact's Chief Generation and Development Officer **James Kilty**, said "Contact now provides direct heat energy from our geothermal facilities to the Nature's Flame plant which dries wood fibers for wood pellet production. The wood fibers are a **carbon neutral alternative** to fuels such as coal, gas and oil. So we are helping to replace an emissions heavy energy source with an environmentally friendly alternative, all while using a renewable energy source."

"We are thrilled by the outcome of this deal with Contact. With our new energy supply system getting to operational status, we are able to increase to 100% of capacity, creating new jobs in the Taupō region. We are now receiving **18 MWth of heat** continuously, which is fuelled by a low carbon renewable source," says **John Goodwin**, Nature's Flame Operations Manager. *Global Geothermal News.....*

ASIA

Experimental Geothermal Energy Conversion Technology System Charges Smartphones at Hot Springs

Fans of "**onsen**" bathing never need worry about whether their mobile devices have run out of juice while they are relaxing in a famed southern Japan hot spring resort. That's because of an experimental thermal energy conversion technology system that has been launched at the popular **Kannawa onsen** tourist facility in **Furomoto district**.

The charger system targeting users of Smartphones and other electronic devices will be accessible to sightseers and other visitors until the end of January. The aim is to show visitors that **spa water can be used for numerous purposes, including generating electricity**.

According to city officials, the system generates a small charge utilizing the difference in temperatures between **close to 100°C** spa water springing from

the ground at the rear of the Kannawa facility for a large communal bath and the outside air, which is normally between zero and 30°C.

The system generates an output of only **2.5 watts**, which is **stored in a battery**. People can recharge their mobile devices by connecting them with any of six USB ports during its business hours. There is no charge for the service. *Global Geothermal News.....*

Earthquake Damages Mt. Apo Geothermal Power Plant

On October 31st, a **magnitude 6.5 earthquake** caused landslides in sections of the road leading to the **Mt. Apo Geothermal Plant in Barangay Ilomavis, Kidapawan City in Mindanao, Philippines**.

Colonel Rey Alvarado, commanding officer of the Army 72nd Infantry Battalion, said around 100 personnel workers were initially stranded when roads leading to the power plant were rendered impassable. However, the next day the workers trekked on foot down the mountains to reach safety.

Energy Development Corporation (EDC), who owns and operates the plant, said all of their employees are safe and accounted for. EDC Magpet facility head **Romy Kee**, said two of their power plants—the **M1 and M2**—sustained some damage and “were put on turning gear operation only.” *Global Geothermal News.....*

EDC later reported that the 54.24 MW Mt. Apo M2 power plant **successfully synchronized** to the grid on November 12th and the 54.24 MW M1 power plant **returned to service November 15th**. *Global Geothermal News.....*

Government Fast-Tracks Geothermal Energy Projects in Philippines

The Philippines **Department of Energy** has certified four new projects, including two geothermal projects, as nationally significant, granting a faster permitting process.

The department awarded certificates of energy project of national significance (EPNS) to **Philippine**

Geothermal’s Mt. Malinao geothermal project and the EDC Mahanagdong geothermal brine optimization plant. *Global Geothermal News.....*

Toshiba to Supply 10 MW Small Scale Geothermal Power Plant in Central Java

Toshiba Energy Systems & Solutions Corporation (Toshiba ESS) has announced a contract with **PT Inti Karya Persada Teknik (IKPT)**, to supply a steam turbine and generator for the **Dieng Small Scale Geothermal Power Plant in Central Java, Indonesia**.

The power plant is being developed by **PT Geo Dipa Energi (Persero)**, Indonesia's state-owned geothermal energy company. Toshiba ESS has commenced the design and engineering work for the scope of supply. The power plant is **scheduled to start commercial operation in March 2021**.

This 10 MW-class small scale geothermal power plant will be constructed on the Dieng plateau near the existing **Dieng Geothermal Power Plant Unit 1**, which has been operating since 2002. For this new power plant, Toshiba ESS will supply '**Geoportable™**', a compact power generation system with an output between **1 and 20 MW**. This system employs advanced technologies, including leading-edge corrosive gas resistance materials, which are crucial for geothermal steam turbines, and a unique design for the steam path, which leads to high performance and reliability. *Global Geothermal News.....*

Exploration for Geothermal Power Resources Begins in NW India

The **Institute of Seismological Research (ISR)** has started exploration for geothermal resources in the North-West state of **Gujarat** for what would be **India’s 1st geothermal power plant**.

Using **3D Magnetotelluric (MTM.T.)** location technology the ISR hopes to find the best spots for the locations for possible geothermal power plants. *Global Geothermal News.....*

Possible Use for Geothermal Heat for Desalination in United Arab Emirates

Dubai Electricity and Water Authority (DEWA) is requesting proposals for an early-stage feasibility study on geothermal heat energy and its use in domestic power generation, particularly for water desalination. *Global Geothermal News.....*

AFRICA

Drilling Contract Signed for 50 MW First Phase of Tulu Moyo Geothermal Project

A contract to begin drilling work for phase one of the **Tulu Moyo geothermal project** in Ethiopia has been signed between **Kenya Electricity Generating Company Limited (Kengen)** and **Tulu Moyo Geothermal Operations PLC (TMGO)**.

TMGO will design, finance, build, operate and maintain the geothermal power plant including the drilling of geothermal wells. The project has an **estimated capacity of 150 MW** and will be developed in two phases (Phase one - 50 MW, Phase two -100 MW) to produce electricity for **Ethiopian Electric Power**.

TMGO is joint venture between **Meridiam**, a French based global investor & asset managing company & **Reykjavik Geothermal Ltd.** *Global Geothermal News.....*

Kengen Issues Tender to Build 140 MW Geothermal Power Plant at Olkaria

KenGen has issued a **Request for Qualifications** of bidders for the financing, design, supply, construction, commissioning, operation and maintenance of a **140 MW Olkaria Public Private Partnership (PPP) geothermal power project** on a Build, Own, Operate, Transfer (BOOT) basis. **The tender closes on December 23rd, 2019.**

The new geothermal resource is in the northeastern sector of the Olkaria geothermal field next to the existing **Olkaria II** power station. *Global Geothermal News.....*

KenGen said the successful firm will enter into a **Joint Venture (JV)** with KenGen and create a **Special Purpose Vehicle (SPV)** to finance and develop the geothermal power plant. The firm will have a **majority 75% stake**.

"KenGen has drilled and tested all production wells required for the project and will be responsible for the operation, maintenance, and management of steam supply to the project," said KenGen. "KenGen will be a shareholder in the SPV with a shareholding of 25%. The SPV will be responsible for

the development, design, financing, construction, operation and maintenance of the project."

The power firm said it will also enter into a long-term *Power Purchase Agreement (PPA)* with **Kenya Power** as off-taker. *Global Geothermal News.....*

Unit II of Olkaria V Geothermal Power Plant In Service

Unit II of the **Olkaria V geothermal power plant** is now fully operational. Italian group **Steam**, one of the companies in the **SGC Geothermal consortium** that worked on this project with **Gesto Energy**, made the announcement.

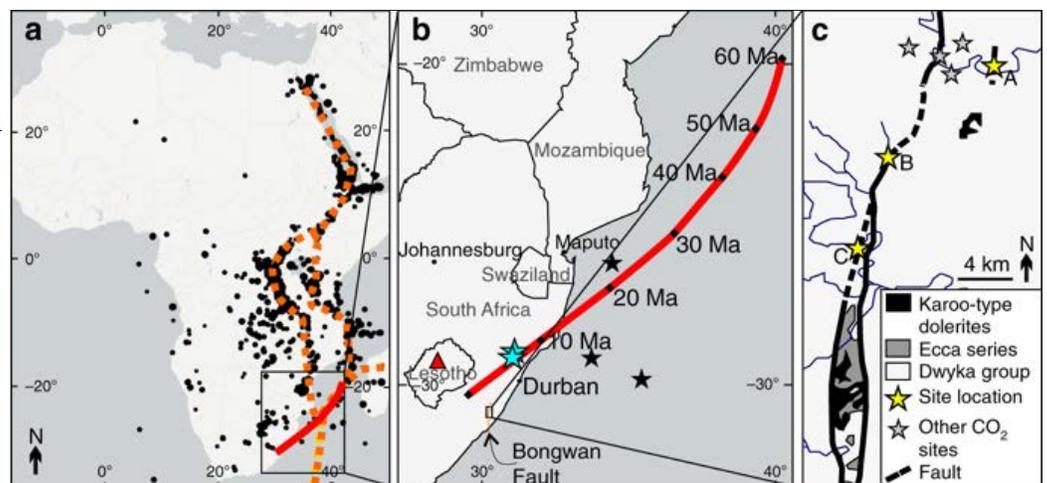
Unit I was commissioned by **KenGen** in July 2019. Together, both Unit I and II have a **total capacity of 160 MW**. *Global Geothermal News.....*

Geothermal Development Company Receives GRMF Funding for Baringo-Silali Exploration

Geothermal Development Company (GDC) has received a grant of **Sh1.9 billion** from the **Geothermal Risk Mitigation Facility (GRMF)** for drilling operations and geothermal exploration at the **Baringo-Silali** project. In August, the company **struck a successful first well** at Paka that confirmed the area as productive. *Global Geothermal News.....*

Discovery of Hotspot Could Lead to Geothermal Energy Development in South Africa

Geologists in **South Africa** have revealed that carbon dioxide-rich gases bubbling up through natural springs in the country originate from a hotspot located deep inside the earth. The hotspot pushes the crust upwards, generating the distinctive landscape, which consists mostly of tablelands more than one kilometer above sea level, the researchers say.



Location of study area and relevant geological features. (Courtesy authors)

This also explains why **rocks beneath the region are hotter than expected** – a property that could be harnessed to generate geothermal energy. *Global Geothermal News.....*

Noble gases confirm plume-related mantle degassing beneath Southern Africa, by S. M. V. Gilfillan, D. Györe, S. Flude, G. Johnson, C. E. Bond, N. Hicks, R. Lister, D. G. Jones, Y. Kremer, R. S. Haszeldine & F. M. Stuart. *Nature Communications* volume 10, Article number: 5028 (2019).

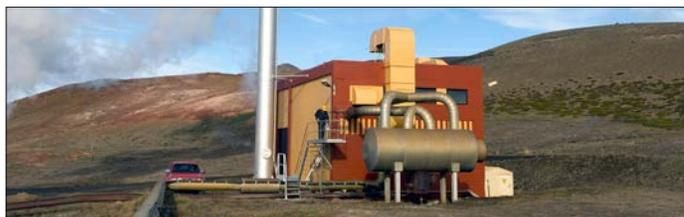
EUROPE

Plans to Re-Inject More CO₂ and H₂S from Geothermal Power Plants

ON Power, a subsidiary of Reykjavík Energy, has revealed plans to ramp up **carbon capture and storage (CCS)** operations at **Hellisheiði** and **Nesjavellir** geothermal power plants. ON Power will double the amount of CO₂ and H₂S currently reinjected into the subsurface using the **CarbFix** method at Hellisheiði, and conduct experimental reinjection at Nesjavellir, utilizing the excess carbon in collaboration with nearby industries. Currently, ON Power re-injects a daily amount of about 33 tons of CO₂ where it eventually turn into stone. *Global Geothermal News.....*

Upgrade at Bjarnarflag Geothermal Power Plant Boosts Output by 2 MW

Green Energy Geothermal (GEG), has reported the successful conclusion of its contract to supply and build a **5 MW turbine-generator** package for the **Bjarnarflag geothermal power plant** in the northeast of **Iceland**.



Bjarnarflag Geothermal Power Plant (Courtesy Landsvirkjun)

GEG was awarded the contract by Icelandic national power company **Landsvirkjun** to design, manufacture and supply a replacement back-pressure turbine and generator, which was delivered, installed and commissioned on site.

With higher efficiency of the new plant, the plant now provides **2 MW more in power generation** capacity, utilizing the same amount of steam. A new operating license has been issued, as well as a renewed power plant and geothermal resource utilization license. *Global Geothermal News.....*

Fish Farming Plant Powered by Geothermal Heat Opens in Iceland

A huge new **aquaculture** breeding and hatchery centre has opened for business in the west of Iceland, on a remote fjord more than 250 miles from the capital Reykjavik.

The **GBP 25 million (ISK 4 billion) Arctic Fish** owned facility near the small fishing harbor of **Tálknafjörður**, raises salmon using **geothermal heat**. *Global Geothermal News.....*

Dr Charlotte Adams is an Energy Champion!



Dr Charlotte Adams, Assistant Professor at **Durham University** was awarded "Energy Champion" at the gala ceremony of the **20th Energy Institute (EI) Awards** in London.

The award citation notes that "Charlotte Adams' outstanding work bridges the gaps between academia, industry and society and promotes geothermal energy options in the UK. She was co-founder of **BritGeothermal** and her work on the potential to use water from abandoned mines to heat UK homes has led to a debate in Parliament led by **Helen Goodman MP**." *Global Geothermal News.....*

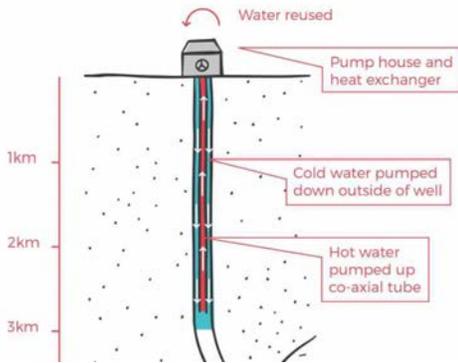
Drilling at Eden Geothermal Project to Begin Next Summer

A plan to heat the giant biomes of the **Eden Project** and, eventually, neighboring communities by tapping into the "hot rocks" beneath the Cornish attraction has moved a step closer.

The Eden Project has announced that it had **secured the funding to begin drilling** for a geothermal resource next summer. **Cornwall council** and the **European Union** have provided the bulk of the **GBP 16.8m** needed to launch the geothermal project, which will initially involve a

Eden Geothermal phase one: research project

Courtesy Eden Project



A narrow 25cm well is drilled 4.5km into the granite to investigate temperature and permeability.



25cm WELL
— ABOUT THE SIZE OF A MEDIUM PIZZA

From 3km down the well is steered to intersect with a naturally fractured zone in the granite

To demonstrate heat production an insulated pipe is inserted into the well to 3km.

Cold water is injected down the outside, with hot water travelling back up the inside. This is called a co-axial system.

well being sunk almost **three miles (4.5km)** into the granite crust beneath Eden.

The GBP 16.8m will pay for the first phase of the project – drilling a well, a research program and a heat main – to prove the extent of the resource.

This first well will initially supply a heating system for Eden's biomes, offices and greenhouses. It is intended to pave the way for the second phase – another well almost three miles deep and an electricity plant.

Completing the **second phase** will mean Eden will be generating sufficient renewable energy to become carbon positive by 2023, and it aims to be able to **provide heat and power** for the local area. [Global Geothermal News.....](#)

Southampton Geothermal Heating Company Connects to Local Sports Center

Solent University's new sports complex has been successfully connected to **Southampton Geothermal Heating Company's (SGHC)** pioneering district energy scheme after signing a **GBP 2.8 million** deal with energy and services specialist, **ENGIE**, over the next 20 years.

The SGHC is a working partnership between ENGIE and **Southampton City Council**, launching more than 30 years ago. The scheme supplies heat, chilled water and electricity to commercial and residential energy users across Southampton – currently serving a 2km radius of the energy centre.

Users already included TV studios, a hospital, shopping centre, student accommodation, residential buildings and hotels; with Solent University tasking ENGIE with the implementation of a new heating connection which would link up existing assets, as well as a new state-of-the-art sports centre. [Global Geothermal News.....](#)

Geothermal Spa Now to Open in Spring Next Year

The launch of **Cornwall's** first geothermal spa in **Penzance** has been delayed. The seafront **Jubilee Pool** reopened for the summer holidays in 2019 but without the geothermal spa after **Geothermal Energy Limited** "encountered some **unforeseen delays with the geothermal well**".

The opening was pushed back to winter this year but the Jubilee Pool team announced that it is deferring the launch of its geothermal facilities once again, **until spring 2020**.

They said the move will minimize the business risks associated with the previously proposed winter launch. "The decision to move the geothermal launch date was made as it has become apparent that the power upgrade required for the geothermal launch will not be completed this winter but also in the light of the business risks associated with a winter launch." [Global Geothermal News.....](#)

TU Delft Announces New Assistant Professor of Geothermal Energy

Maren Brehme is the new assistant professor of **Geothermal Engineering** at **TU Delft**. Maren is a hydrogeologist aiming to understand subsurface fluid flow using multidisciplinary approaches for sustainable geothermal energy use.

She has 10 years experience in geothermal research. In her PhD she studied the role of faults and fractures in geothermal reservoirs, while in her Post-Doc she studied the operation of geothermal systems.

The future work will cover two main aspects: **Where to drill the next well?** and **How to run a geothermal system sustainably?** She combines approaches from hydrogeology, structural geology and geochemistry to find answers to this questions. One of the main projects she will be involved in is the **DAP geothermal doublet** on the TU Delft Campus. [Global Geothermal News.....](#)

Dutch Geothermal District Heating Project Chooses Location Near Utrecht

In search of a suitable location to continue the **LEAN Research Project**, **Warmtebron Utrecht** has chosen a site in **Nieuwegein** near **Utrecht**. [Global Geothermal News.....](#)

Geofood Project Researches Use of Geothermal Heat for Greenhouse and Fish Farming in the Netherlands

The aim of the new **Geofood project** is to investigate whether geothermal heating can not only be used to heat greenhouses, but also to breed fish.

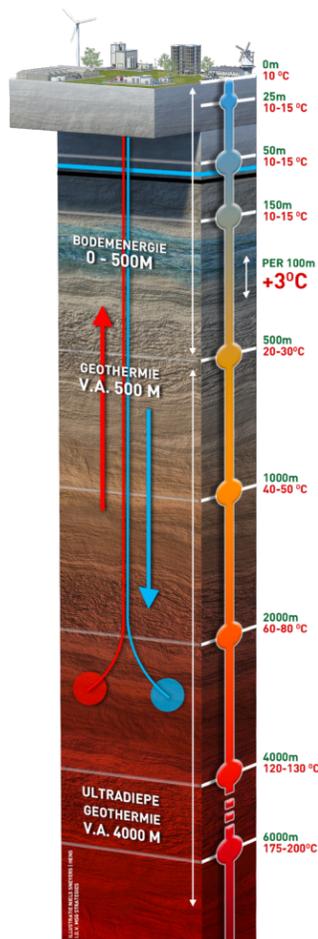
Geofood is a collaboration between the **Greenhouse Horticulture** business unit of **Wageningen University & Research (WUR)** and partners from Iceland, Slovenia and the Netherlands.

To validate this model, an advanced fish farming system was installed at WUR in **Bleiswijk** in early 2019. It is a so-called recirculating aquaculture system (RAS). The largest tanks in this system contain around 10,000 liters of water containing thousands of fish. *Global Geothermal News.....*

Dutch Government Initiates the 'Netherlands Seismic Campaign for Geothermal Energy'

To accelerate the development of geothermal energy projects, the Dutch government has initiated the 'Netherlands Seismic Campaign for Geothermal Energy' (**Seismische Campagne Aardwarmte Nederland** or **SCAN**). SCAN will complete a map of the Dutch deep subsurface as much as possible by filling in the blank spots, and by doing so help support the future determination of geothermal potential.

Other research into, for example, safety, deep geothermal exploration and other relevant topics



Courtesy SCAN.

will also be carried out to further the understanding of geothermal energy exploitation.

Finally, scientific drilling will possibly take place during the final stages of the program to help confirm and supplement the measured data to gain an even better understanding of the subsurface in these areas. *Global Geothermal News.....*

Second Geothermal District Heating Project Announced for Paris Suburb

The **Coriance group** has announced it will build a second **geothermal district heating network** in **Champigny-sur-Marne**, just outside of **Paris**. Coriance will be in charge of drilling the geothermal doublet to a **depth of 1800 meters** and building a new geothermal power plant. Coriance said it will implement an innovative solution for well drilling with an **internal composite casing** to avoid the corrosive effects of geothermal water and thus guarantee performance over time. *Global Geothermal News.....*

Good Progress for Bordeaux Geothermal District Heating Networks

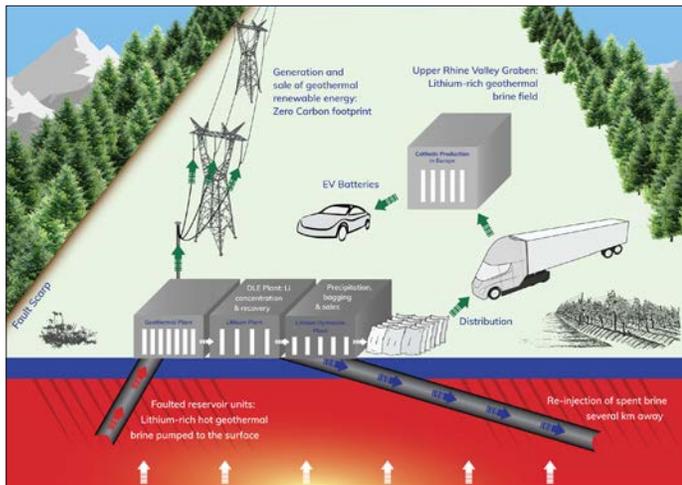
Bordeaux Métropole has started work on a new 25 km long **geothermal district heating network** in the south-western French city. Entrusted to **Storengy** and **Engie Cofely**, the project will consist of two wells: one for production and the other for reinjection, **drilled to 1,700 meters** deep to the waters of the Jurassic aquifer where, according to studies, the temperature is around **70°C** and the pumping rate could reach **300 m³/h**. *Global Geothermal News.....*

German Geothermal Power Plant to Supply Brine for Lithium Extraction Demonstration Plant

Vulcan Energy Resources Ltd has signed a **Memorandum of Understanding (MoU)** with **Pfalzwerke geofuture GmbH** to supply geothermal brine and well data from its **Insheim geothermal power plant** for Vulcan to use in its pre-feasibility lithium extraction study.

The Insheim plant in south-west Germany sources geothermal thermal waters at **165°C**, producing a maximum of **4.8 MWe power** and **10 MWth thermal energy**.

Vulcan will construct and implement a demonstration plant at Insheim. Pfalzwerke geofuture can then choose to co-operate on the construction of a commercial-scale lithium plant on



Geothermal District Heating Network from Abandoned Coal Mine in Spain Wins European Award

A district heating network in **Spain** that sources hot water from an **abandoned coal mine** has won at the **Global District Energy Climate Awards**, organized by the **Euroheat & Power** network.

Winner in the **emerging market** category, **Barredo Colliery** in **Mieres, Asturias**, in northern Spain hosts a **District Heating and Generation Plant** where heat pumps benefit from water pumped at **23°C**. The heat is supplied to two public buildings and 245 homes. *Global Geothermal News.....*

site, or give up the royalty on lithium production. *Global Geothermal News.....*

Surveying Begins for Waghäusel-Philippsburg Geothermal District Heating Project

In August 2019, **Deutsche Erdwärme GmbH** acquired the license for exploration near **Waghäusel-Philippsburg** in **south-western Germany**. Deutsche Erdwärme has commissioned **DMT GmbH & Co. KG** to conduct the necessary survey work to produce a high-resolution, three-dimensional map of the subsurface. *Global Geothermal News.....*

Drilling at Swiss Geothermal Energy Project to Begin 2021

The **Lavey deep geothermal project** for the **AGEPP SA consortium** has obtained all the necessary authorizations from the cantons of **Vaud** and **Valais** without any opposition. The construction of the **drilling platform** will **begin mid-2020**.

The drilling is planned for a period of five months starting mid-2021. **The commissioning is planned for 2022**. The project consists of drilling to a maximum **depth of 3,000 meters** to extract water at **110°C** at a **flow rate of 40 liters/second**. *Global Geothermal News.....*

Italian Geothermal Power Plant Now Also Supports District Heating Network

The **Chiusdino 1 geothermal power plant** (located in **Caggio in Tuscany**), has inaugurated the first phase of a local district heating network in the surrounding area in addition to continue providing clean, dependable renewable electricity. *Global Geothermal News.....*

Promising Test Results for Possible Konin Geothermal District Heating Project

The **Geotermia Konin** company has reported satisfactory results for a geothermal district heating project for the town of **Konin** in central **Poland**. After drilling the **test well to 1,600 meters**, the water temperature was measured at **62°C** with **35 g/liter mineralization**. The results of the flow tests were also very promising - as much as **300-500 m³/h**. It is worth noting that the second of the prospective aquifers, located at a depth of **2,600 meters**, has more favorable parameters: **97.5°C** at **150 g/liter mineralization and high efficiency**. *Global Geothermal News.....*

16.5 MWe Velika Ciglena Geothermal Plant Officially Unveiled

Croatia's first geothermal power plant, the **16.5 MW Velika 1** in **Ciglena** near **Bjelovar**, has been officially unveiled. **Europe's biggest binary power plant** was built with an investment of **HRK 325 million (around EUR 43.7 million)**.

The **Velika 1 geothermal power plant** was **put into operation in December 2018**, and has been operating at full capacity since March 2019, supplying electricity to almost the entire city of **Bjelovar**. The plant's core technology was produced by Italy's **Turboden**, while domestic suppliers and contractors accounted for over 68% of the total investment, according to the **Croatian Renewable Energy Sources (OIEH) association**.

Project manager **Dragutin Domitrović** said that **Velika 1** has a **Power Purchase Agreement** with the **Croatian Energy Market Operator (HROTE)** for **10 MW of installed capacity**, which corresponds to the average consumption of **29,000 Croatian households**. *Global Geothermal News.....*

Tender Announced for Geothermal Exploration in Croatia

The Croatian Hydrocarbon Agency (**Agencija za ugljikovodike – AZU**) has announced a public tender to select the most suitable bidder for the exploration of geothermal resources in the **Virovitica 2**- exploration area. *Global Geothermal News.....*

Serbian Geothermal District Heating Network Operating Successfully

A geothermal district heating network has started operations in **Bogatic** in north-west **Serbia**. The geothermal resource from **5-700 meters deep** flowing at **25 liters per second**, with a water temperature of **75°C**, is now being used to heat a kindergarten, primary and secondary school, court, social welfare center, utility company and a police station. *Global Geothermal News.....*

Northern Serbian Geothermal Project Gets Organized

A working group to facilitate the development of geothermal power plant and district heating projects in Serbia's northern province of **Vojvodina** has been established. France's **ES-Geothermie**, will offer general contracting services for the development of deep geothermal projects. *Global Geothermal News.....*

Geothermal District Heating Network to Go Ahead in Greece

A geothermal district heating network has been given the green light in **Alexandroupolis** in **East Macedonia and Thrace, Greece** near the border with Turkey. The **10 MWth** of district heating from a **97°C resource** will be supplied along a **18 km network**. *Global Geothermal News.....*

Chinese Company to Supply 3.2 MW Geothermal Power Plant in North-West Turkey

Kaishan Compressor, a Chinese air compressor maker, has won its first Turkish contract to construct a **3.2 MW binary cycle geothermal power plant** in the northwestern city of **Canakkale**.

The Turkish unit of **Transmark Renewables**, a Dutch geothermal energy firm, has given Kaishan the USD 6 million *Design, Engineering, and Procurement (EDC)* contract. The plant is expected to be **finished next October, 2020** and Kaishan has already received a 20% advance. *Global Geothermal News.....*

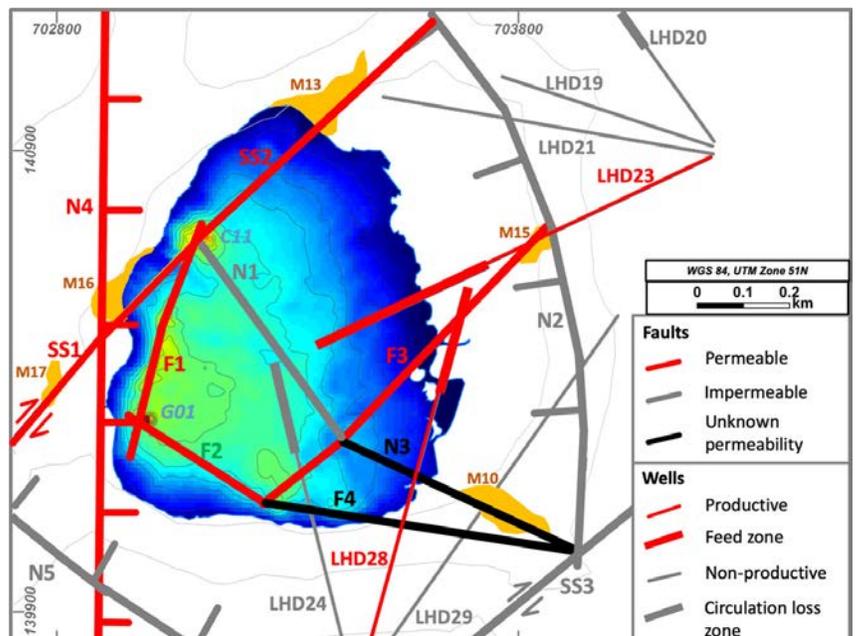
SCIENCE & TECHNOLOGY

Survey Identifies Ideal Geothermal Drilling Site in North Sulawesi, Indonesia

In a recent article in the journal *Nature* by **Maren Brehme**, the new assistant professor of Geothermal Engineering at **TU Delft** (see news on page 25) an ideal geothermal drilling site has been located in **north Sulawesi, Indonesia** by surveying a volcanic lake.

"We investigate fluid pathways beneath volcanic lakes using bathymetry and geochemical measurements to locate best-possible drilling sites. Highly permeable structures, such as faults, provide fluid channels that are the most suitable access points to the geothermal resource.

Accurate mapping of these structures therefore guides the successful targeting of wells. Lakes, rivers or ocean, can hide surface footprints of these



Fault permeability pattern in the Lake Linau area.

permeable structures, such as in our case beneath Lake Linau.

High-resolution bathymetry identifies linear and conical discontinuities, which are linked to offshore tectonic structures as confirmed by surrounding outcrops and hot springs.

Geochemical measurements document inflow of hot saline acidic water into the lake verifying bathymetry-located highly permeable structures.

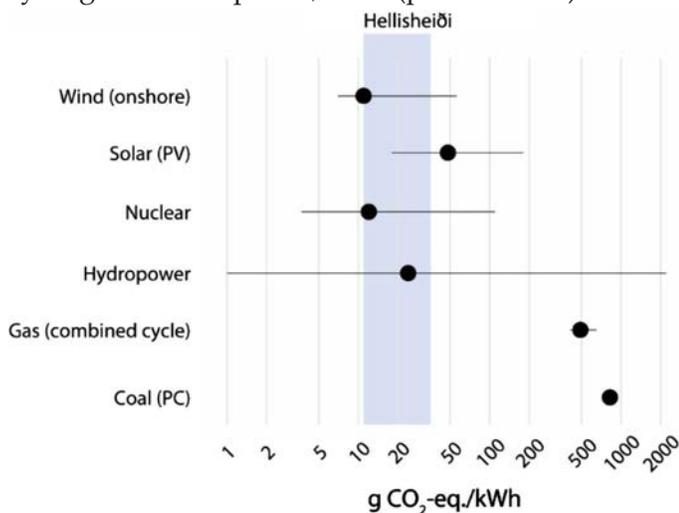
Integrating onshore well data, our bathymetry and chemical results locates an ideal drilling site into the geothermal reservoir beneath the **western shoreline of Lake Linau**. *Global Geothermal News*.....

Brehme, M., Giese, R., Suherlina, L. et al. **Geothermal sweetspots identified in a volcanic lake integrating bathymetry and fluid chemistry**. *Sci Rep* 9, 16153 (2019) doi:10.1038/s41598-019-52638-z

Study Concludes Geothermal Can Help in Decarbonization of the Power Generation Industry

This article in *Environment International* journal focuses on **Hellisheiði**, a combined heat and power double flash geothermal plant located in **Iceland**, with an **installed capacity of 303.3 MW** of electricity and **133 MW of hot water**. The study has a two-fold goal: (i) identify hot spots in the life cycle and, where possible, suggest improvements, and (ii) understand the potential of geothermal energy to decarbonize the power generation industry.

The comparison shows that the **carbon intensity** of Hellisheiði is in the **range of 15–24 g CO₂-eq./kWh**, which is similar to those of binary cycle geothermal plants, solar (photovoltaic)



Comparison of climate change impacts (g CO₂-eq./kWh) between Hellisheiði and other energy sources. The blue area identifies the minimum and maximum carbon intensity of Hellisheiði according to different configurations and allocations strategies. The carbon intensity of other energy sources is reported in terms of median values (dots) and minimum and maximum ranges (lines). (Courtesy Andrea Paulillo, et al)

and hydropower, lower than other geothermal technologies and fossil-based technologies, and higher than nuclear and onshore wind.

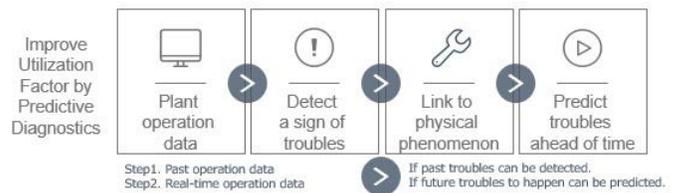
The results demonstrate that **geothermal energy**, alongside other alternative and renewable sources, **can play a substantial role** towards achievement of the **Paris Agreement** goal and the **decarbonization of the power generation industry**. Further work should investigate the relation between utilization of geothermal energy and the natural release of greenhouse gases from geothermal systems. *Global Geothermal News*.....

The environmental impacts and the carbon intensity of geothermal energy: A case study on the Hellisheiði plant, by Andrea Paulillo, et al. *Environment International* Volume 133, Part B, December 2019, 105226. <https://doi.org/10.1016/j.envint.2019.105226>

Toshiba to Test Anomaly Predictive Diagnostics at Patuha Geothermal Power Plant

Toshiba Energy Systems & Solutions Corporation (Toshiba ESS) will install an anomaly predictive diagnostics system using big data analysis in **PT Geo Dipa Energi (Persero)'s Patuha geothermal power plant** and examine the plant operation data on a real-time basis in order to review the technology's ability to predict anomalies ahead of time, while validating the effectiveness of this technology.

Through this demonstration, Toshiba ESS aims to **lower the rate of problem occurrences at geothermal power plants by 20%** and reduce unplanned outage period in power stations. Increasing utilization factor leads to an increase of power generation amount and a reduction of the generation cost. It can be expected that the project will contribute to higher adoption of geothermal energy. *Global Geothermal News*.....



Predictive diagnostics technology's outline. (Courtesy Toshiba)

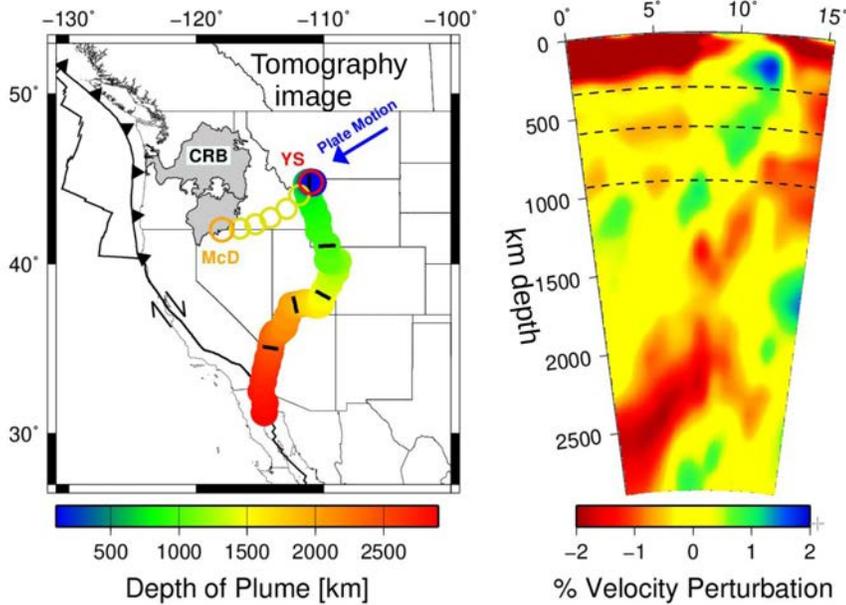
Mantle Plume Brings High Geothermal Heat to Yellowstone

Yellowstone National Park in the USA, with its geysers and hot springs, is a major attraction for tourists. However, especially in times of little news, the media often focuses on the Yellowstone supervolcano, which last erupted about 630,000 years ago. Inevitably then, the question of the underlying geological structures will be posed.

A recent study by **Bernhard Steinberger** of the German **GeoForschungsZentrum** and colleagues in the USA helps to better understand the processes in the Earth's interior based on modeling the Earth's mantle under Yellowstone.

According to the model, beneath the Yellowstone volcano lies a so-called **mantle plume**: a chimney-like structure that reaches thousands of kilometers deep to the border of the Earth's core and mantle.

The origin of the plume lies under the Baja



Left: Color coded track shows the position of the plume conduit versus depth inferred from the tomography model of Nelson and Grand (2018), using TX2016 (Lu & Grand, 2016) as the starting model. Tickmarks are every 500 km in depth. Colored circles indicate the hotspot track along the Snake River Plain, from Yellowstone (YS) to McDermitt Caldera (McD). The area covered by the Columbia River Basalts (CRB) is shown in grey. The direction of recent North America absolute plate motion is indicated by the blue arrow. Plate boundaries in the region include the Cascadia subduction zone (indicated by line with solid triangles), the Pacific-North America plate boundary with strike-slip motion (indicated by half-arrows) along the San Andreas fault, and the spreading ridge and transform faults between the Pacific and Juan de Fuca plate.

Right: Cross section through the tomography model of Nelson and Grand (2018) along the plume conduit as shown in the left panel, with angular distance along the track in degrees

California, more than a thousand kilometers southwest of the national park. Evaluations of earthquake waves had already suggested something like this, but the idea of such a "mantle plume" did not fit in with the movement of the Earth's lithospheric plates. *Global Geothermal News.....*

Yellowstone plume conduit tilt caused by large-scale mantle flow, B. Steinberger et al, *Geochemistry, Geophysics, Geosystems* (2019). DOI: 10.1029/2019GC008490

Direct Thermal Charging Cell for Converting Low-Grade Waste Heat to Usable Electricity

Dr. Tony Shien-Ping Feng of the **Department of Mechanical Engineering** at the **University of Hong Kong (HKU)** and his team has invented a **Direct Thermal Charging Cell (DTCC)** which can effectively convert heat to electricity, creating a huge potential to reduce greenhouse effects by capturing exhaust heat and cutting down primary energy wastage.

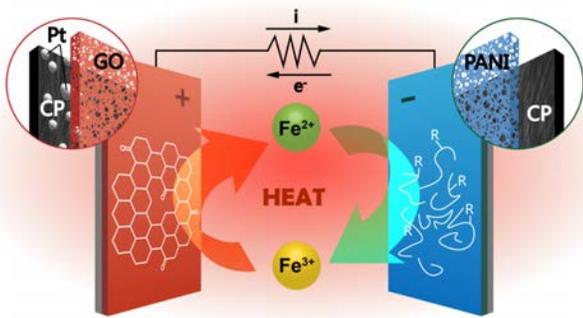
The newly designed DTCC is a game-changing electrochemical technology which can open new horizons for applications to convert low-grade heat to electricity efficiently. It is a simple system with the basic unit sized only 1.5 sq.cm and thickness 1 to 1.5 mm. The cell is bendable, stackable and low cost.

The new thermal charging cell uses asymmetric electrodes: a graphene oxide/platinum (GO/Pt) cathode and a polyaniline (PANI) anode in Fe²⁺/Fe³⁺ redox electrolyte via isothermal heating operation without building thermal gradient or thermal cycle. When heated, the cell generates voltage via a thermo-pseudocapacitive effect of GO and then discharges continuously by oxidizing the PANI anode and reducing Fe³⁺ to Fe²⁺ under isothermal heating on cathode side till Fe³⁺ depletion. The energy conversion works continuously under isothermal heating during the entire charge and discharge process. The system can be self-regenerated when cooled down. This synergistic chemical regeneration mechanism allows the device cyclability.

Dr. Feng said: "Efficient low-grade heat recovery can help to reduce greenhouse gas emission but current technologies to convert this heat to electricity is still far from optimum.

DTCC yields a conversion efficiency of over 3.5%, surpassing all existing thermo-electrochemical and thermo-electric systems, which is either too costly or complicated, or too low in efficiency for everyday applications. DTCC is a revolutionary design with great potentials in smart and sustainable energy devices." *Global Geothermal News.....*

More information: Xun Wang et al, "Direct thermal charging cell for converting low-grade heat to electricity", Nature Communications (2019). DOI: 10.1038/s41467-019-12144-2



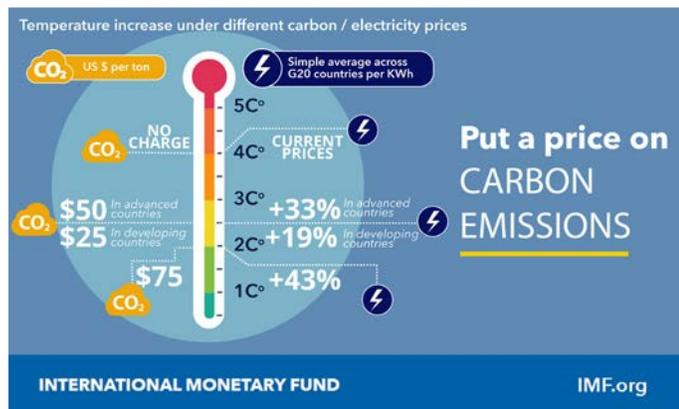
Scheme of DTCC consisting of GO/PtNPs cathode and PANI anode (with carbon paper (CP) substrate) in Fe²⁺/Fe³⁺ redox electrolyte.

CLIMATE CHANGE

Carbon Tax Could Mitigate Climate Change and Boost the Economy - IMF

A global agreement to make fossil fuel burning more expensive is urgent and the most efficient way of fighting climate change, an **International Monetary Fund (IMF)** study has stated.

The group found that a global tax of **USD 75 per ton** by the year 2030 could **limit the planet's warming to 2°C (3.6°F)**, or roughly double what it is now. **That would greatly increase the price of fossil-fuel-based energy** — especially from the burning of coal — but the economic disruption could be offset by routing the money raised straight back to citizens.



In the **United States**, a **USD 75 tax would cut emissions by nearly 30 percent** but would cause on average a 53% increase in electricity costs and a 20% rise for gasoline at projected 2030 prices, the analysis in the IMF's Fiscal Monitor found.

But it would also generate revenue equivalent to 1% of gross domestic product, an enormous amount of money that could be redistributed and, if spread equally, would end up being a fiscally progressive policy, rather than one disproportionately targeting the poor. *Global Geothermal News.....* ■





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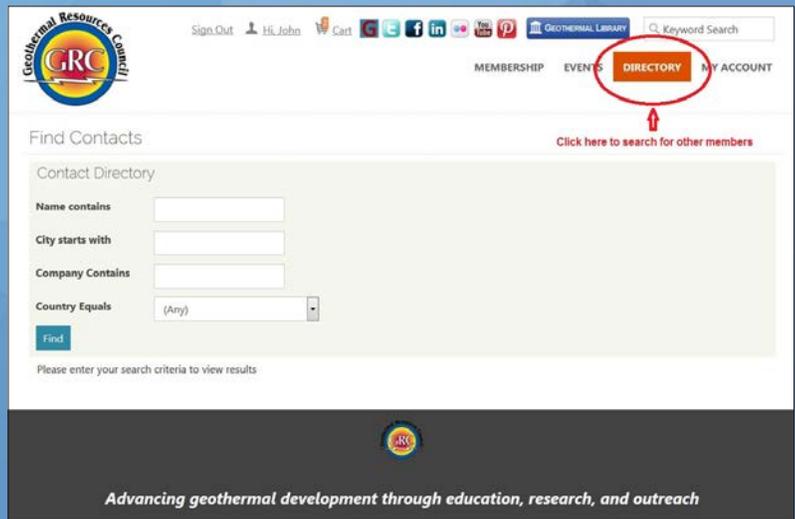
The GRC Membership Directory At Your Fingertips

www.my.geothermal.org

The online membership directory provides the most up to date contact information for all GRC members at your fingertips.

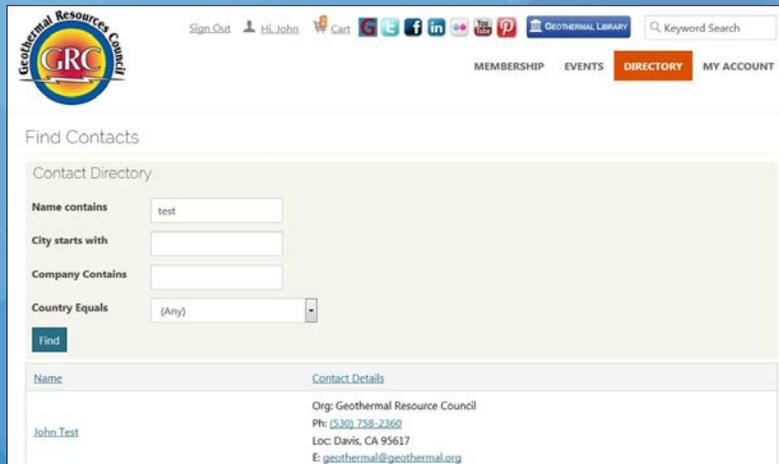
Login to the GRC Membership website: my.geothermal.org
(Tip: Bookmark this webpage on your smart phone for easy access)

Step 1



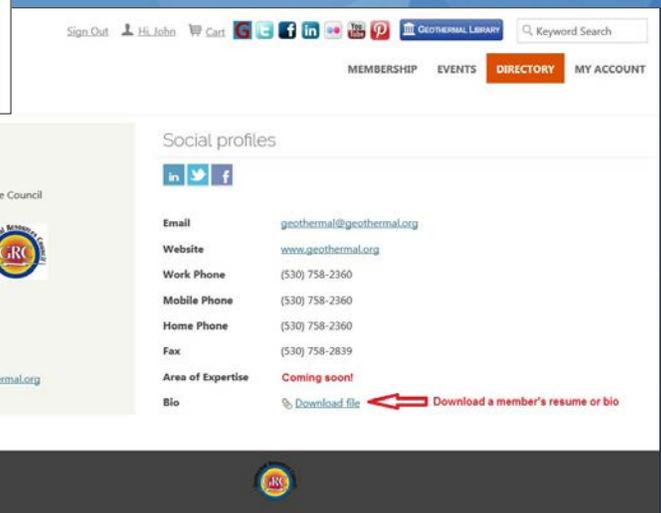
Step 2

Click on the Directory Tab



Step 3

Search by Name, City, Company, or Country
(Coming soon: search by Expertise)



Step 4

Click on the name of the person and view their public profile.

This feature is only available to current GRC members. If you have not renewed, please contact Anh Lay at alay@geothermal.org to renew your membership and update your profile!



The Repowering of the Lightning Dock Geothermal Plant in New Mexico

Joseph Bonafin¹ and Halley K. Dickey²
¹Turboden, Italy
²Industrial Builders, USA

1. Introduction

The Lightning Dock Geothermal (LDG) resource area is located on the east side of Animas Valley in Hidalgo County, in the southwest corner of New Mexico. For over 30 years, starting in 1977, LDG was home to a greenhouse complex that became one of the largest in the U.S. In 2013, a 4 MW plant was installed by Cyrq Energy, Inc. (Cyrq Energy), with plans to further enhance it to 10 MW. However, the second phase of the development with the original equipment supplier was never completed.

In 2017, Cyrq Energy selected Turboden and Industrial Builders to perform a complete repower of the power plant at Lightning Dock. The contractor offered to provide a new power plant producing 11.0 MW net (14 MW gross) electric power with a single Organic Rankine Cycle (ORC) turbine.

The new plant began commercial operation in December 2018 and outputs over 10 MW of electricity onto the grid. The plant provides power for over 10,000 homes in New Mexico with 100% renewable energy, through a *Power Purchase Agreement (PPA)* with PNM, the state's largest utility.

The project was completed ahead of schedule and on budget due to the team effort by the owner, Cyrq Energy, the plant supplier, Turboden, and the engineering procurement and Construction (EPC) contractor, Industrial Builders. Thus, this project is a useful lesson on how an improved design and technology can be utilized for repowering an older plant to create a positive business case, due to the expected higher plant availability and greatly increased efficiency.

2. Lightning Dock Geothermal Field

The Lightning Dock Geothermal (LDG) project is in the Animas Valley of Hidalgo County, New Mexico, approximately 12 miles east of the New Mexico/Arizona border and 55 miles north of the US/Mexico border. LDG is at 4236 ft above mean sea level, with an average ambient temperature of 60 °F.



Figure 1: From left to right, inactive direct use heating greenhouses, Pyramid Mountains, and injection well 76-7

The Animas Valley is within the Mexican Highland part of the Basin and Range physiographic province, a large region characterized by steep, well dissected mountains separated by flat-floored desert valleys. North-South trending, range-bounding faults define the Animas Valley on the west and east; thus, the valley is both a topographic low and a structural graben, bounded on the west by the Peloncillo Mountains and on the east by the Pyramid Mountains (Figure 1).

The LDG geothermal system is a “blind” geothermal resource (without any surface manifestations) discovered during drilling for crop irrigation in 1948 (Elston et al., 1983). The thermal anomaly in the Animas Valley is likely the result high regional heat flow and the intersection of several geologic structural features, including the margin of a Tertiary age volcanic caldera

(the Muir Cauldron) that is a potential source of geothermal heat, and one or more large offset Basin and Range normal faults that likely serve as conduits for heated water to rise to shallow depths, resulting in a natural geothermal outflow plume at the site (Crowell & Crowell, 2014).

In 1974, the resource was designated by the Federal government as a Known Geothermal Resource Area (KGRA) encompassing 23,552 acres. Exploration and development of the resource was undertaken by several entities over the years, including Amax Exploration, Inc., who were the first geothermal lease holders from 1979 to ~1984; Steam Reserve Corporation, who drilled well 55-7 and operated the lease from ~1984 to 1987; Lightning Dock Geothermal, Inc. (not related to Cyrq) run by Roy Cuniff and Roger Bowers, who operated the lease from 1987 to 2008; and Lightning Dock Geothermal HI 01, LLC, current operator of the field since 2008 (owned first by Raser Technologies and now by its successor Cyrq Energy).

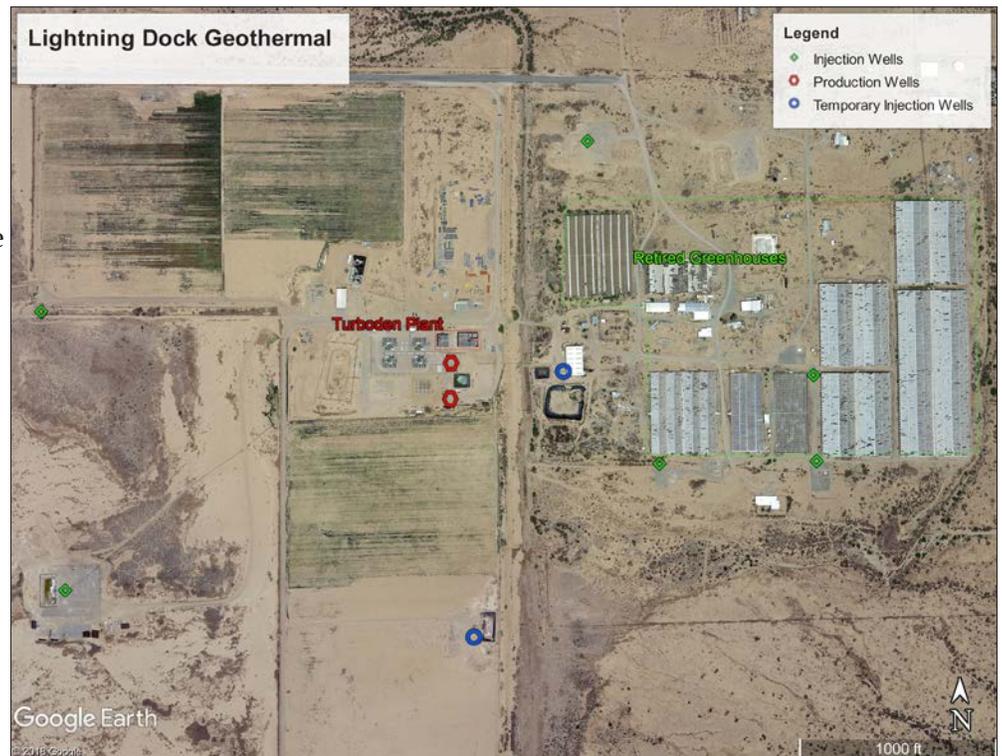


Figure 2: Well field and plant map of Lightning Dock Geothermal Field, New Mexico

Two production wells, 45-7 drilled by Cyrq in 2011 and its nearby twin, 45A-7, completed by Cyrq in February 2018, provide about 5000 gpm of 310 °F water to the plant. After cooling in the plant heat exchangers, the brine is returned to the reinjection wells at about 170 °F. The reinjection field potentially includes up to eight wells with depths between 550 and 6200 ft, including 55-7, drilled by AMAX in 1984. The operators are currently optimizing the injection strategy to maximize pressure support and minimize thermal breakthrough.

Faults identified on seismic profiles act as both barriers and conduits, resulting in surprising reservoir compartmentalization for a relatively small geothermal field and unpredictable permeability distribution.

3. The Repower Team

Cyrq Energy is a leader in renewable energy with geothermal energy generation in New Mexico, Utah, and Nevada, and more than a decade of experience in utility scale power plants and renewable energy production.

In 2017, Cyrq Energy selected Turboden and Industrial Builders to construct the new power plant for LDG. Turboden offered to provide a power plant producing 11.0 MW net (14 MW gross) electric power with a single ORC turbine, compared to four ORC expanders in the old plant.

Turboden (MHI) is a world leading ORC Technology provider. Turboden has engineered, manufactured, and delivered 389 plants in 45 countries and 649 MWs of high efficiency ORC power generation.

Industrial Builders (IB) is an EPC constructor of eight (8) modular ORC power plants over the past 12 years, along with numerous industrial power and process plants.

4. The Turboden Plant Design

Turboden and Cyrq designed the plant to utilize geothermal brine from two geothermal wells. After careful study and testing, isobutane was selected as the most efficient working fluid for the produced geothermal fluid temperature, ambient temperatures, and air-cooling. This choice of the working fluid was made after other alternatives were carefully studied. For example, pentane was

also considered and tested but failed to produce as efficiently as isobutane.

The plant has been configured to utilize a single turbine. The power plant is composed of heat exchangers, a single turbine directly coupled with a generator, a recuperator, a condenser, and feed pumps (Figure 3).

Based on the low corrosivity potential of the geothermal water observed during five years of operations in the previous installation, carbon steel was adopted as the material for the parts in contact with geothermal water (e.g. tube sheet, distributor channel, partition plate and heat exchanger tubes). Likewise, on the ORC working fluid side, carbon steel was employed. Cyrq suggested the minimum reinjection temperature to be considered in the plant design, in order to avoid any risk of deposition of silica or other solids.

The single turbine designed and manufactured by Turboden is axial, multistage and operates at 1800 rpm. The Turbine is directly coupled to the electric generator. The turbine design inlet pressure is about 400 psi. The expected turbine isentropic efficiency is about 90% (total to static, including all the stage losses). The axial geometry is the most suitable to achieve high efficiency in the widest range of operation. The expected efficiency derate is only -1% during summer operation, and -4% during winter operation. The turbine is designed to maximize the energy production according to the ambient conditions at the LDG site.

The air-cooled condenser, a Turboden design, is composed of many tube bundles interconnected to each other in parallel. To limit the influences of different condensing pressure of the bundles and to mitigate potential upsets such as one bay of cooling fans out of order, the pipeline collecting the liquid phase includes routing with a syphon and vapor trap. The favorable properties of isobutane ensure that it will never be under vacuum, and the condenser is expected to operate at constant volumetric flow (on the air-side) to maximize energy production. This factored into the decision to eliminate variable speed drives for the cooling fans. This simplification also removes additional maintenance and complexity of the control system.

The ORC working fluid feed pumps are centrifugal multi-stage, driven by 3-phase motors connected to a variable frequency drive in order to



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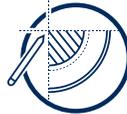
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achieve optimal control and to minimize the power consumption. This solution is required particularly considering the operating pressure of the working fluid; in fact, the traditional solution of pump regulation by means of valves would significantly decrease the net energy production.

The operation of the ORC turbogenerator is automatic: continuous monitoring by personnel during operation, will not be required. The ORC turbogenerator can operate at partial load, the process and the generated electric power self-adapt to the available thermal power.

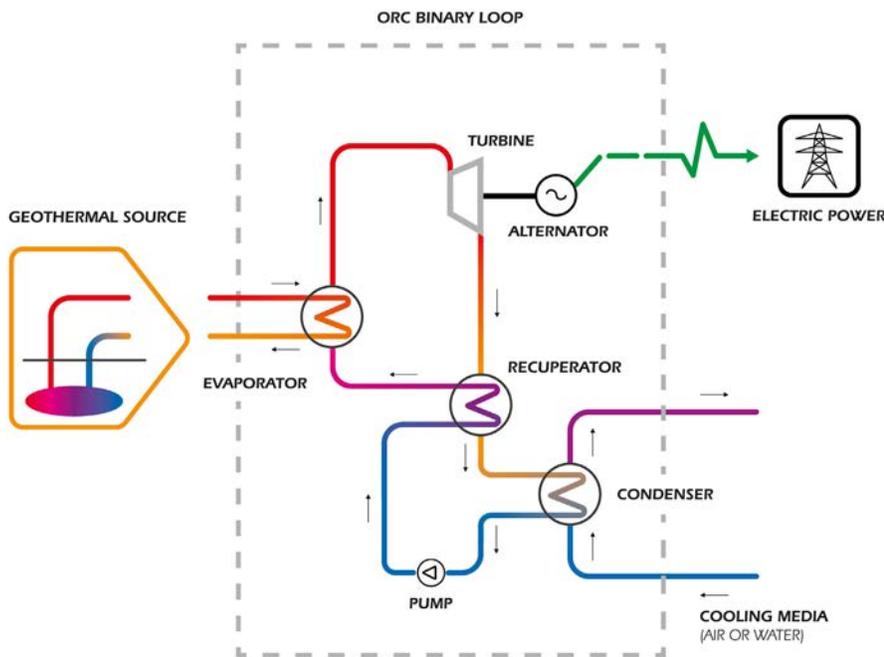


Figure 3: Turboden Plant Diagram

5. Plant Construction Activities

The procurement and construction duration, from order release to commercial operating date (COD) for geothermal power plants normally ranges from 20 to 24 months. The LDG repower project was completed 6 months faster than normal, due to a unique partnership between all parties. The partnership succeeded due to superior project communication and planning, parallel path schedule management, advanced collaborative development of all project facets, and close vendor coordination. Each team member's previous geothermal experience and incorporation of lessons-learned was also invaluable to the success.

Cyrq, Turboden and IB adopted a TEAM strategy for moving forward and constructing

this project. The TEAM together finalized a "value engineered design", specific to; the LDG site, project parameters, specific equipment, integrating and fabricating as much of the equipment as possible in the shop for rapid deployment and smooth installation and execution.

This TEAM effort facilitated a project that capitalized on all of our previous geothermal ORC and plant experience in design and manufacture, modularization and prefabrication. As much of the plant as possible was packaged, pulling man hours out of the field and into a controlled shop fabrication

environment. This allowed the team to mitigate virtually all risk, greatly improving project simplicity and speed to COD, minimizing costs to the Owner and meeting all financing requirements. The roles and responsibilities of each team member are enumerated below:

- IB, the EPC, installed the power plant equipment. Turboden, the power plant manufacturer, guaranteed and backstopped equipment delivery, with a 100% Performance and Payment Bond
- IB guaranteed/backstopped construction schedule and cost – Turboden, the technology provider, guaranteed and backstopped overall ORC performance, schedule, and cost.
- IB performed all necessary site layouts and other engineering for permitting, including preliminary engineering, purchase specifications necessary to maintain schedule, installation of ORC power plant equipment, as well as obtain all construction-related permits, including; logistics and transportation, building, etc.
- ALL TEAM members collaborated on the schedule. Schedule collaboration included long lead procurements needed to maintain schedule, including expedited completion schedule and continuous review, and preparation for construction of necessary electric and heat exchange interconnections, providing and performing EPC; testing and

startup, including utility interconnection and permitting, achieving COD on or before the scheduled completion date.

- ALL TEAM members cooperated together in prosecuting any guarantee or warranty claims.

With the proper TEAM coordination with Turboden, IB completed site work with all foundations, underground Electrical, Sub-station and completed Fire Water System, before any ORC equipment arrived at site. When the ORC equipment arrived, it was off-loaded, set into place quickly and in a single pick as often as possible to avoid doubling of crane lifts, and all prefabricated piping and electrical connections could then immediately take place.

While waiting for long lead items from Turboden, IB built the prefabricated modules for the Power Distribution Center, Equipment Center (housing all Variable Frequency Drives), Control Room and Office, and the Compressor Module for the plant air system. All Equipment Modules were delivered, set-in-place, installed and field connected, before any long lead items arrived from Turboden, saving significant time and costs, minimizing lifts and downtime.

Equipment deliveries from Turboden were staged, so that the work could be completed in an optimized and orderly manner, without the crew stacking, adding labor inefficiencies and costs.

All Structural Steel was set-in-place, and the air-cooled condensers were erected before the large heat exchanger vessels; pre-heaters and evaporator, and turbine and generator - arrived at site. Large equipment piece delivery was well-coordinated and set-as-they arrived. Piping and electrical crews could start without interference with the erection crews.

With IB as EPC, designing and coordinating the balance of plant work and the Owner furnished production well system, along with the coordination with the local Utility for interconnection and power distribution, all potential problems and schedule interruptions were mitigated during construction and start up. The project struck first power nearly two weeks

ahead of schedule, and IB began to demobilize early.

The project was completed ahead of time and on budget by performing all work and services as smoothly as possible, relative to; design, permitting support, engineering, procurement, quality assurance, inspection, construction, start-up, performance testing, and system optimization.

6. Plant start-up

The plant commenced delivery of electricity to the grid in December 2018 and passed initial performance testing in January 2019.

The start-up activities for the plant were performed very timely and effectively. The installation and commissioning processes were completed in five and two months respectively. The first start-up was performed on December 21, 2018 with a net power of 4 MW limited by the grid. On January 7, 2019, with grid limits lifted, the power provided to the grid increased to 11.0 MW.

During the performance test (with internal load bank) on January 24, 2019, a production of gross 15.29 MW and net 13.09 MW was achieved. Later on, a capacity test, a reliability test and a capability demonstration test customized according to the client's requests, were performed. The duration of the reliability test was 14 days. The start-up activities were finalized with success with the effort and collaboration of all parties involved.



Figure 4: Lightning Dock geothermal power plant Christmas Morning, four days after startup

7. Repower Celebration and Renaming

Cyrq held a celebration of the repowering at the plant in October 2019. The event was attended by New Mexico Governor Michelle Lujan Grisham and Ron Darnell, Senior Vice President of PNM Resources. At that time, Cyrq named the new plant after geothermal pioneer Bruce Levy, whose accomplishments included work on the

New Mexico site. Levy concluded his career in geothermal energy of over 30 years with Cyrq Energy, where his years of experience in the industry proved invaluable to Cyrq's development and engineering efforts. Levy, who died last year, loved the Animas Valley and will be sorely missed by all in the industry that had the pleasure of working with him.

Bruce Levy was a true champion of geothermal energy and naming this plant after him is a tribute to his pioneering vision and brilliant work in development of resources.

In 2019, The Geothermal Resources Council awarded a posthumous Geothermal Special Achievement Award to Bruce Levy "For his lifelong passion for power generation, the development of new power plants, and his love of all the wonderful, diverse personalities in the geothermal industry." Nick Goodman, Chairman/CEO at Cyrq Energy, received the award at the GRC Annual Meeting & Expo in Palm Springs, California, in September 2019.



Figure 5: GRC Annual Meeting Honors & Awards Committee - Chair, Marcelo DeCamargo (left) presents a Geothermal Special Achievement Award in memory of Bruce Levy to Nick Goodman (right).

8. Conclusion

The Lightning Dock Geothermal repower was a very successful project because Cyrq, Turboden, and Industrial Builders, worked together from the initial stage, through design and final installation, as a TEAM. The result was that Cyrq received a quality project exactly as envisioned, planned, and contracted, ahead of schedule and on budget, in a smooth well executed project.

The repowering of the Lightning Dock geothermal project has been a resounding success, and the plant is well poised to deliver geothermal

energy to the grid for the next 25 years. All of the required components, including a confirmed geothermal resource, transmission access for delivery of the electricity, and a long term PPA with a solid off-taker are in place, allowing the development team to execute in the design, installation and operation of this binary plant. The commitment and teamwork demonstrated by Turboden, Industrial Builders and Cyrq Energy has proven binary projects can be installed on schedule and generate efficiently, even in the remote region of the desert Southwest of the US.

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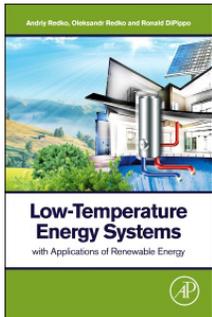
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Publications, Websites, Videos & Maps

by Ian Crawford

Publications

Instead of a lengthy description of each of these recommended publications, we ask you to open the relevant webpage or download the document itself. Click on the live links in blue to open them in your browser.



Low-Temperature Energy Systems with Applications of Renewable Energy - Elsevier

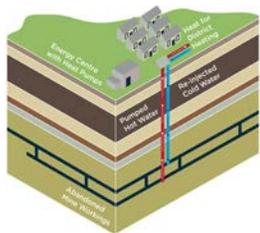
Authors: Andriy Redko, Oleksandr Redko and Ronald DiPippo
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A review of this publication by Susan Fox-Hodgson will appear in the January/February *Bulletin*.



2050 Vision for 100% Renewable Heating and Cooling in Europe - Renewable heating Cooling - European Technology and Innovation Program

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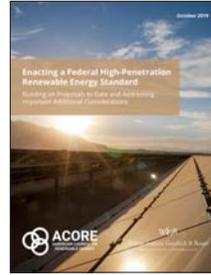
New Website for The Eden Geothermal Project www.edengeothermal.com



Combined Geothermal Heat, Power and Metal Extraction Project - Final Results - CHPM2030

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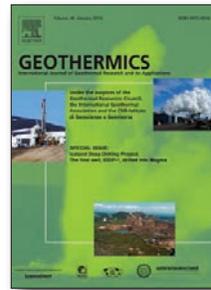
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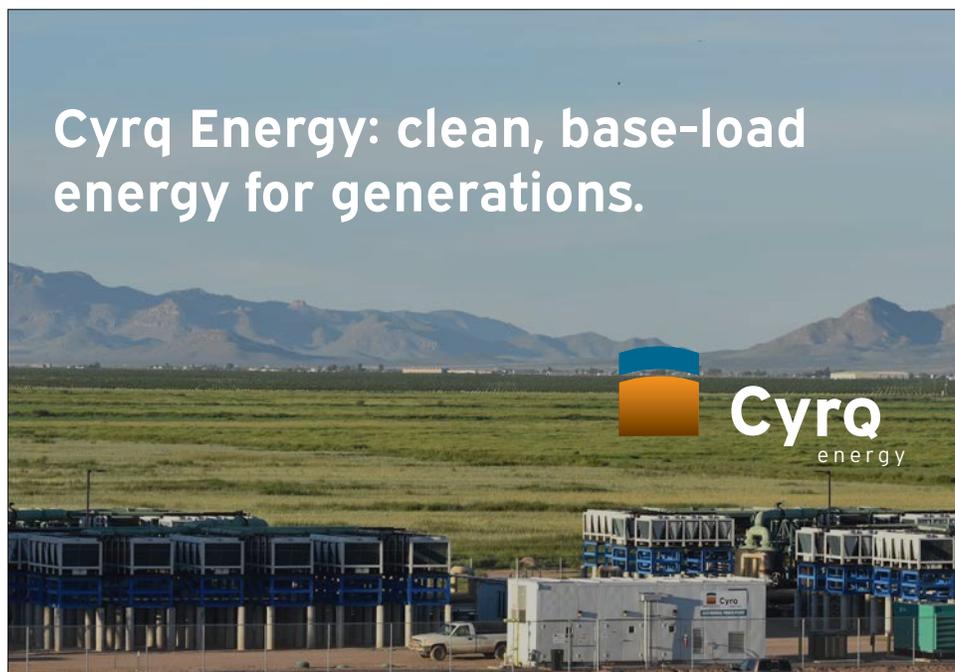


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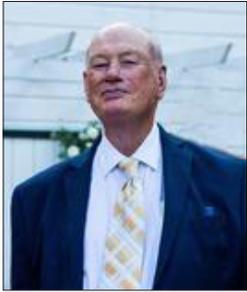
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In Memoriam

George Albert Frye 1938 - 2019

By Louis E. Capuano, Jr.



I first met George Frye when he and I were transferred to Santa Rosa, California in May 1974 to open Signal Oil and Gas Company's Geothermal regional office. George was coming up from Huntington Beach and I came

in from Lafayette, Louisiana. We opened a two-man office in the Coddington area of Santa Rosa. My wife and I had a small 2 year-old daughter at the time and my wife was excited to meet the wives of other employees. Well, George was single and not knowing anyone in the area so the three of us and George did a lot of things together. We ate at remote restaurants that George would seek out as well as attend special events in Santa Rosa. Being the only two employees in the Santa Rosa Office we got to know each other quite well. In 1974 the GRC was just beginning and we were involved in its formation and tried to meet as many people in the industry as we could.

Many of us received and will miss our weekly allotment of "Frye-Grams". George was very diligent in trying to keep us all informed. To give a little history of George, he was friendly to all, a bon vivant world traveler and a citizen of the world. He was born and raised in Southern California to a large family of him and three sisters. He graduated from Fullerton Union High School in 1956. He attended the University of Colorado on a Naval Reserve Officer Training Corps Scholarship, majoring in chemical engineering and business management. After graduation he served four years in the U.S. Navy primarily on WestPac tours, and remained in the naval reserves for 20 years where he rose to the rank of commander.

After the Navy George entered the petroleum and energy related businesses until moving into the newly emerging geothermal energy industry in 1974. During this time George earned a professional degree in Petroleum Engineering from Stanford University. He worked for Signal Oil and Gas which became Burmah Oil and Gas and then Aminoil USA. Through various acquisitions that company soon became Calpine.

In 1976 George purchased a new home off of Mark West Springs Road in Santa Rosa. He enjoyed his home and its location in close proximity to the wine country. George immersed himself in the local viticulture industry, owning a small portion of a local vineyard where he helped stomp grapes, fill barrels and then bottle his own wine. Santa Rosa was his home base for over 43 years until he lost his home in the 2017 Tubbs fire. A new house is under construction on that site at the time of his death.

George was a avid traveler, often traveling with groups from Stanford University. He was an active scuba diver, a food and wine connoisseur. George was a great friend to all in the geothermal industry and we will miss him greatly. I always looked forward to seeing him at the various industry and social conferences and events, it gave us a good opportunity to catch up on his travels and adventures.

George passed away on September 27, 2019. He was preceded in death by his father Albert Lawrence Frye and his mother Ruby Mayer Frye and a sister Judy Frye Nay. His survivors include his sisters Judy Roos and Jackie Afram, six nieces and nephews and two grand nieces and two grand nephews.

I will miss my friend as will all the geothermal industry and his many friends.

Gerald “Jerry” Niimi 1943 - 2019

By Louis E. Capuano, Jr.



I met Jerry Niimi in 1977 when he and I worked for a geothermal developer, Thermogenics. Jerry was hired and moved up to Santa Rosa from the Los Angeles area. Jerry was a native of Hawaii, having graduated from Purdue University.

Upon graduation

he served in the U.S. Navy Seabee in Vietnam. After the Navy he and his wife Naomi settled in Southern California where Jerry worked for Exxon as an electrical engineer on offshore oil rigs near Santa Barbara. He moved to Santa Rosa in 1977 and we worked together until we founded an engineering consultant company, ThermaSource, Inc. in May 1980. He worked in the geothermal industry until his retirement in 1998. Jerry was a geothermal reservoir engineer and had worked on many geothermal fields. He was active in the GRC and the geothermal industry throughout his time working for ThermaSource.

Jerry was great sports fan and a avid golfer. His wife Naomi said that he had a great short game but his drives suffered since his illness. He was a horse ring aficionado and was a partner in owning two race horses. After retirement from the geothermal industry Jerry volunteered for 15 years as an AARP tax aid.

Jerry passed away on October 15, 2019 from an incurable lung disease. He is survived by his wife Naomi and their son Greg of Irving, Texas. Preceded in death by his parents and also survived by his brother, Gilbert and his family of Mesquite, Nevada and a sister Grace and her family of Hawaii.

I will miss Jerry - he was a good friend and a great partner in business. ■

Calendar of Events

Tenth session of the IRENA Assembly - Thematic meeting (Global Geothermal Alliance)

Enabling Frameworks for Accelerated Geothermal Energy Development

12 January, 2020, 13:15 – 14:30, Saadiyat Island, Abu Dhabi

<https://www.irena.org/events/2020/Jan/IRENA-10-Assembly>

Geothermal Technology in Canada: Future Pathways Workshop

23-24 January, 2020, Waterloo Institute for Sustainable Energy, Ontario, Canada

<https://www.eventbrite.ca/e/geothermal-technology-in-canada-future-pathways-workshop-tickets-80481342863>

GT'2020 Türkiye Jeotermal Kongresi

5-6 February, 2020, Ankara, Turkey

<https://geothermalturkey.org/>

Geothermics for Petroleum Engineers (IGA Academy)

5-6 February, 2020, Aberdeen, Scotland, UK

<https://www.geothermal-energy.org/event/geothermics-for-petroleum-engineers/>

Stanford Geothermal Workshop - 45th Annual

10-12 February, 2020, Stanford, California, USA

<https://geothermal.stanford.edu/events/workshop>

GEMex Final Conference (GEMex Project)

18-19 February, 2020, Potsdam, Germany

<http://www.gemex-h2020.eu/>

European Geothermal PhD Days (EGPD 2020)

24-26 February, 2020, Pamukkale University, Denizli, Turkey

<http://www.pau.edu.tr/egpd2020/en>

Geothermal Production Technology (IGA Academy)

4-5 March, 2020, Amsterdam, The Netherlands

<https://www.geothermal-energy.org/event/geothermal-production-technology/>

GeoTHERM - Expo & Congress

5-6 March, 2020, Messe, Offenburg, Germany
https://www.geotherm-offenburg.de/de/geotherm_messe_kongress_geothermie

Geothermal Project Development, Economics and Risks (IGA Academy)

11-12 March, 2020, Basel, Switzerland
<https://www.geothermal-energy.org/event/geothermal-project-development-economics-and-risks/>

DGG/SEG Joint Geothermal Workshop: Geophysical Exploration from Fossil to Geothermal Reservoirs

27 March, 2020, Munich, Germany
<https://dgg2020.dgg-tagung.de/deutsch/veranstaltungen/seg-dgg-workshop/>

Joint GRC-SPE Workshop - High Temperature Well Cementing “Exploring Geothermal and Oil and Gas Synergies”

30 March - 1 April, 2020, San Diego, California, USA
<https://www.cement.mygeoenergynow.org/>

9th ITB International Geothermal Workshop 2020

1-2 April, 2020, Bandung, Indonesia.
<https://geothermal.itb.ac.id>

World Geothermal Congress 2020

27 April - 1 May, 2020, Reykjavik, Iceland
www.wgc2020.com/

EGU General Assembly 2020

Including session: Exploration, utilization and monitoring of conventional and unconventional geothermal resources
3-8 May 2020, Vienna, Austria
<https://www.egu2020.eu/>

Geothermal Regulations, Legislations and Incentives (IGA Academy)

6-7 May, 2020, Basel, Switzerland
<https://www.geothermal-energy.org/event/geothermal-regulations-legislations-and-incentives/>

The 7th International Meeting on Heat Flow and the Geothermal Field

(GFZ German Research Centre for Geoscience)
12-14 May, 2020, Potsdam, Germany
<http://www.ihfc-iugg.org/meetings/2020-potsdam>

1st Inaugural Canadian Geothermal Summit 2020 (UAlberta Geothermal Research Group) Commercialization and research of Canada’s vast geothermal resources

9-10 September, 2020, Edmonton, Alberta, Canada
<https://www.cgsummit2020.com/>

Geothermics for Petroleum Geoscientists (IGA Academy)

16-17 September, 2020, London, UK
<https://www.geothermal-energy.org/event/geothermics-for-petroleum-geoscientists/>

44th GRC Annual Meeting & Expo

18-21 October, 2020, Reno, Nevada, USA
www.reno2020.mygeoenergynow.org

Eighth Africa Rift Geothermal Conference (ARGeo-C8)

2-8 November, 2020, UNEP headquarters, Nairobi, Kenya
<http://theargeo.org/>

COP 26 - Climate Change Conference

9-20 November, 2020, Glasgow, Scotland, UK
<https://unfccc.int/>

Geothermal for Heating and Cooling (IGA Academy)

18-19 November, 2020, Warsaw, Poland
<https://www.geothermal-energy.org/event/geothermal-for-heating-and-cooling/>

45th GRC Annual Meeting & Expo

3-6 October, 2021, San Diego, California, USA
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