GEOTHERMAL RESOURCES COUNCIL

Bulletin

Vol. 46, No. 3
May/June 2017

Join the GRC on a Fieldtrip to Yellowstone

First Geothermal Power Plant in South America

Electricity Generation in Central America

-The Important Contribution of Geothermal Energy

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Ormat offers geothermal clients **more** of everything that matters when it comes to developing geothermal resources.

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Bulletin

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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.

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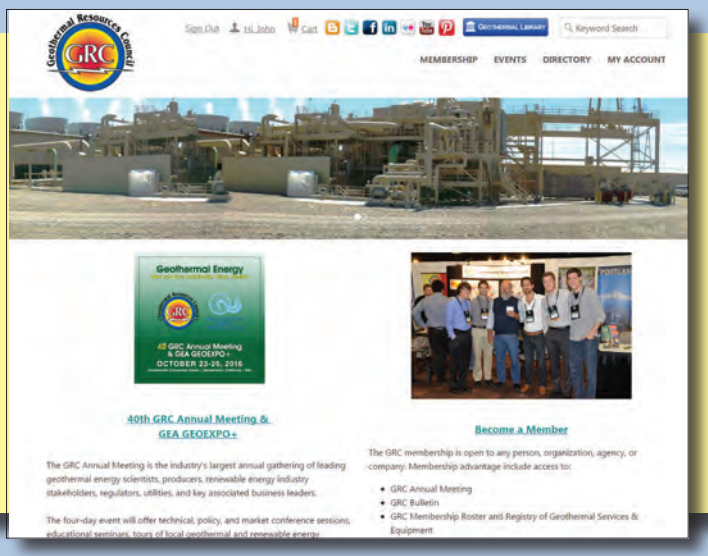
COVER: The Grand Prismatic Spring in the Midway Basin at Yellowstone National Park. Taken by Ian Crawford, June 2015 on a GRC Fieldtrip.

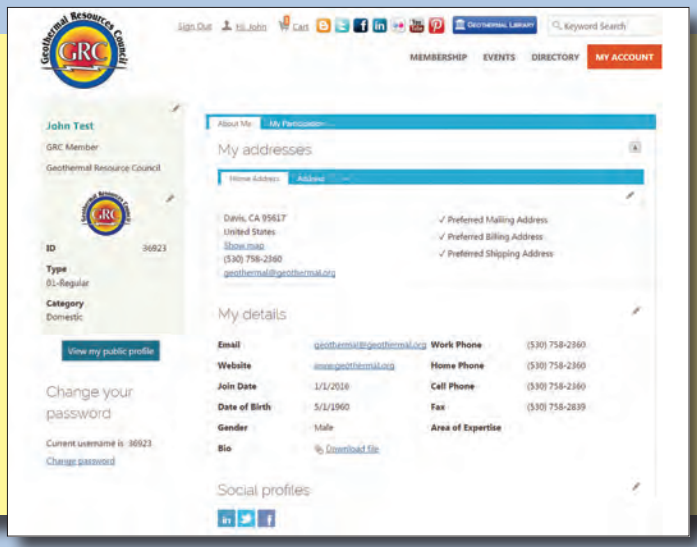
The New GRC Membership Website

www.my.geothermal.org

Highlights Include:

- **Events:** Allows you to register for GRC Events such as the GRC Annual Meeting.
- **Directory:** Allows you to search and view other GRC members' public profile. Only available to current members.
- **My Account:** Allows you view your profile, update your information, renew your membership and pay invoices.
- **Shopping Cart:** You can now pay all your dues and invoices together.





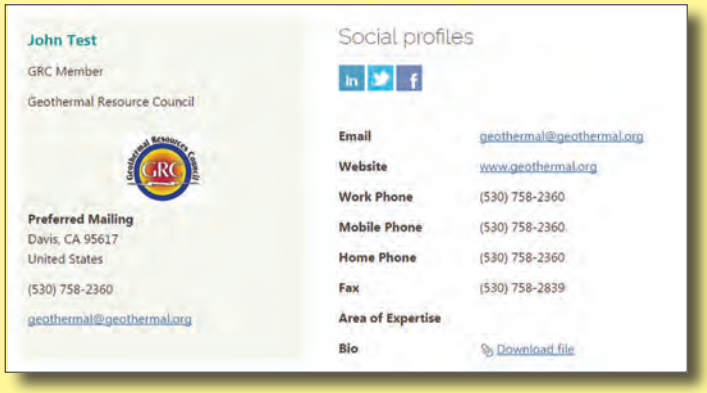
My Account:

- **Photo:** You can now upload a headshot of yourself
- **Bio:** Allows you to upload your bio or resume that can be viewed and downloaded by other GRC members.
- **Social Media Links:** You can now link your personal social media sites to your profile for other members to view.

Update Your Profile Today!

Public Profile:

- **Exclusive Access:** Restricted to current GRC Members only.
- **Advertise Your Services:** Members can find your information and download your bio/ resume.
- **Stay Connected:** Allow members to follow you on your social media links.



President's Message

by Maria Richards

Let's talk Oil and Gas

As you're reading this, I will most likely be on the Southern Methodist University (SMU) Huffington Department of Earth Sciences summer field trip through New Mexico, Arizona, Utah, Colorado and Texas. As we drive through the Permian Basin, which is in a new oil boom (in addition to the gas plays), students will learn about resources. Thus a starting point for discussing the overlap between geothermal resources, mining, and the oil and gas industry.

Congratulations to Dr. Marit Brommer on her position as the Executive Director of the International Geothermal Association! Her experience working for Total and Shell will provide opportunities for all of us to exchange ideas between industries. Doug Hollett, during his tenure as the Director of the Geothermal Technologies Office at the U.S. Department of Energy (DOE), current Deputy Assistant Secretary for Fossil Energy, moved us to use 'their' language with the Play Fairway Analysis funding. It seems simple enough, until you realize the different definitions of the same words. I like the oil and gas industry's playful vocabulary, e.g., "barefoot", "monkey board", "pig", "pickling", "show" (check out Schlumberger's online dictionary).

Why am I focusing on the oil and gas industry? For those of you who don't know, the SMU Geothermal Lab in Dallas, Texas has been researching the ability to use oil and gas fields in sedimentary basins to generate geothermal power. One outcome of our research is the Power Plays conference; the next one is scheduled for January 10-11, 2018. We decided this year to focus the conference on drilling and surface applications, which are two different aspects of development. With the DOE's focus on Deep Direct Use we realized the importance of project developers of surface applications using the geothermal heat being able to understand the language of drilling companies so they can successfully communicate drilling requirements. Other research necessary for geothermal energy to be successful in sedimentary basins includes working with drilling companies, who while highly skilled at extracting gas or oil, will need a paradigm shift to design wells that instead flow maximum amounts of water rather than avoiding it.

I want to conclude by thanking Steve Ponder for his service as the GRC Executive Director from 2013-2017. Steve taught me the value of networking and building bridges between different industries. He is excellent at finding the humor (or providing it) in a conversation. I'm grateful for his four years as Executive Director, one year as Interim Director, years as a Board Member, and 40 years in the industry! During his career, Steve delivered royalty checks to Joe Aidlin and B.C. McCabe in the early 1970s, participated in the development of Unit 15 in the Geysers, and directed Nevada Power projects. As Executive Director of the GRC, Steve connected our new student members to our respected elders. He created conversations between the Geothermal Energy Association and GRC to build a stronger community. This year Steve led a campaign to increase our Foundation funds - Education and Pioneer, to provide additional opportunities for student scholarships and the GRC Library. If you'd like to honor Steve's contribution to the geothermal community, consider a tax deductible donation to the GRC.

I hope you'll share with me geothermal stories and ideas for improving your membership experience. Feel free to call me (214-768-1975) or send me an email at grcpres@geothermal.org. ■

Communication from the GRC

by Ian Crawford, Director of Communications

The biggest geothermal event of the year is just four months away. The GRC team are busy preparing the 2017 GRC Annual Meeting and GEA GeoExpo+. With your input, the feedback from attendees at last year's event together with the experience of the GRC staff, we are confident this will be a very successful meeting.

The latest information is available on the GRC website at: http://www.geothermal.org/meet-new.html. **Registration will open in late June.**

*Use the hash-tag **#GRC2017** on Twitter at twitter.com to share news about the GRC Annual Meeting. Are you or your company attending? Invite your colleagues to attend. Share news about the meeting and the venue.*

Event App

The GRC are again providing an **Event App** for the GRC Annual Meeting & GEA GeoExpo+. It will be available to download to an **iPhone, Android** or **Windows smartphone, tablet** or **laptop computer** giving event attendees better access to information and networking.

Look out for an announcement in the coming weeks. A link to download the app will be available on the GRC Annual Meeting page at: www.geothermal.org/meet-new.html

The GRC is trending towards more information only being available in digital format. The Event App will be the major source of information on the GRC Annual Meeting & GEA GeoExpo+. We strongly recommend that you download the app and spend some time acquainting yourself with the many features that will make your event experience more exciting and profitable!

Call for Papers - Deadline Extended

Draft Paper submission deadline is May 31.

The GRC invites you to present your latest technical work in geothermal research, exploration, development and utilization at the **2017 GRC Annual Meeting in Salt Lake City, Utah,** USA, **October 1-4.**

Authors may submit an oral technical presentation and/or poster at the 2017 GRC's Annual Meeting. **The Draft Paper submission deadline** has been extended to **May 31**.

More information can be found on the GRC Annual Meeting webpage at: www.geothermal.org/meet-new.html.

All of the events of the GRC Annual Meeting and GEA GeoExpo+ are under the one roof of the Calvin L. Rampton Salt Palace Convention Center. COURTESY VISIT SALT LAKE

The GRC Awards – Seeking the Best in Global Geothermal

Nominations must be submitted by Friday, June 16

Nominations can now be made for this year's GRC Awards. The awards recognize **distinguished colleagues in the geothermal community from around the world** and have been one of the highlights of the geothermal calendar since the late 1970s. The winners will be honored at the **GRC Annual Meeting**.

A Nomination Form is available for download from the front page of the GRC website at: www.geothermal.org. **This must be completed and submitted by Friday, June 16, 2017**.

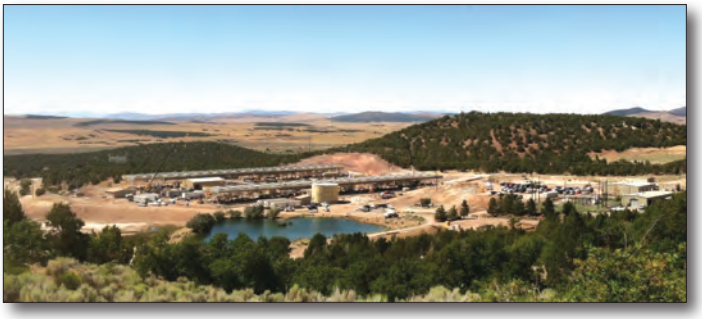
Workshops and Fieldtrips

Two GRC Workshops have been confirmed just before the GRC Annual Meeting in Salt Lake City, Utah, USA. They will be held on Friday & Saturday, September 29 & 30 at the Salt Palace Convention Center. ***Geothermal Resource Decision Workshop*** will be led **by William Cumming, Nick Hiz** and **Peter Stelling; *Operations & Maintenance*** will be led by **Kevin Kitz**.

In addition, **two GRC Fieldtrips** have been organized: A tour of **Yellowstone and Grand Teton National Parks** will offer a guide to the greatest concentration of geothermal features in the world. The fieldtrip will leave Salt Lake City on Thursday September 28 and return on Sunday October 1, in time for the start of the GRC Annual Meeting. The trip guides will be **Duncan Foley** and **Roy Mink**.

More information on the Yellowstone Fieldtrip can be found in a special article on pages 32-36 in this *Bulletin*.

After the GRC Annual Meeting, **a Southern Utah Geology & Geothermal Power Plants** fieldtrip will depart on Wednesday October 4 for an overnight tour of the fascinating geology and geothermal sites in the south of Utah, including Cove Fort, Thermo No. 1 and Blundell geothermal power plants and the Milford FORGE site. The trip guide will be **Rick Allis**.



Enel Green Power's plant in Cove Fort, Utah, is the world's first large scale power generation facility to successfully combine geothermal with hydropower technology. COURTESY ENEL GREEN POWER

More information can be found on the GRC Annual Meeting webpage at: www.geothermal.org/meet-new.html. **Register for the GRC Workshops and Fieldtrips with the regular event registration starting in July.**

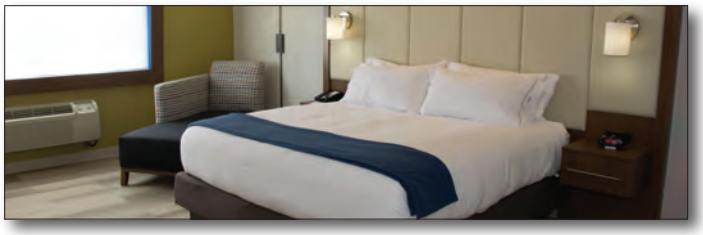
Reserve Your Hotel Room

Discount ends September 5.

Reservations can now be made for hotel rooms for the GRC Annual Meeting & GEA GeoExpo+, being held in Salt Lake City, Utah, USA, October 1-4, 2017. All the events and accommodation are in one central location, at the **Calvin L. Rampton Salt Palace Convention Center** and neighboring **Holiday Inn Express Salt Lake City Downtown** and **Hilton Salt Lake City Center** hotels, a short 4 minute walk from the event space.

The GRC has contracted with the hotels for a discounted block of rooms. At both hotels there is a choice of rooms with either two double beds or a king bed starting at $149 a night excluding taxes and fees. **The discount ends September 5.**

Attendees can make their reservations on secure websites prepared specially for the GRC. The links are available from the GRC Annual Meeting website at: www.geothermal.org/meet-new.html.



A single king bed guest room at the Holiday Inn. COURTESY HOLIDAY INN HOTEL

A standard king bed guest room at the Hilton. COURTESY HILTON HOTEL

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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.
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ENJOY YOURSELF *in* SALT LAKE

NEAR DOWNTOWN

GREENbike • Salt Lake's shareable bikes are a great way to explore the city. You'll see stations all over the downtown area—just follow the simple checkout instructions.

Natural History Museum of Utah • The museum's inspiring exhibitions will change the way you see the natural world and humanity's place within it. Before going in, admire the gorgeous building and its interaction with the landscape.

Avenues Proper & Hatch Family Chocolates Enjoy a creative plate and a pint at Avenues Proper & Publick House, Utah's smallest craft brewery, then buy an espresso and some hand-dipped chocolates from Salt Lake's "Tiny Chocolatiers" next door.

Tracy Aviary • Stroll in the shade and experience a world of exotic and native birds in Salt Lake's beloved 80-acre Liberty Park—a great way to relax during your downtime.

Temple Square • Take a walk through Salt Lake's most iconic historic site. While you're there, admire the temple's beautiful gothic spires and attend a free performance by the renowned Mormon Tabernacle Choir (aka "the MoTab").

Bar X & Beer Bar • Dark, sultry, and stylish, celebrity-owned Bar X is known for its spicy ginger beer and top-shelf spirits. If cocktails aren't your thing, step over to Beer Bar for sunshine, gourmet brats, and a rotating menu of local, national, and international beers.

City Creek Shopping Center • This open, modern shopping center features a bubbling creek and a large selection of stores to please every taste and budget.

Red Iguana • Foodies flock from far and wide for Red Iguana's authentic Mexican fare. The mole is unrivaled, the margaritas refreshing, and the atmosphere bustling. After 5 p.m., expect a (worthwhile) wait.

Finca • For a more peaceful dining experience, head to Finca for an evening of exquisite Spanish tapas and an exclusive Spanish wine list.

The Leonardo • One never knows quite what to expect upon entering the Leonardo, a unique science and art museum with mind-bending installations and exhibits.

Salt Lake Public Library • Designed by internationally acclaimed architect Moshe Safde, the library is a work of modern art, featuring towering crescent glass walls, a rooftop garden, and books galore.

OFF THE BEATEN PATH

Snowbird • A skiers' and snowboarders' thrillfest in the winter, Snowbird Resort is just as blissful in the summer (depending which skier you ask). Take the tram to the top of Hidden Peak, go for a hike, enjoy a spa treatment, or swim in the rooftop pool.

City Creek Canyon • Only two miles from downtown, City Creek Canyon is barely off the beaten path. On odd-numbered days the paved canyon road is closed to cars, creating amazing cycling and picnicking opportunities in a cool forest setting.

Bonneville Shoreline Trail • Marking the rim of prehistoric Lake Bonneville (now shrunk to the Great Salt Lake), this trail covers nearly 100 miles and offers excellent hiking and mountain biking. Bonus: the trail can be accessed from the steps of the Natural History Museum.

Antelope Island • A one-hour-and-20-minute drive from Salt Lake City, Antelope Island is a wonderful anomaly. Fifteen miles long and five miles wide, it's the largest island in the Great Salt Lake, and home to free-ranging bison, pronghorn antelope, bighorn sheep, and millions of birds.

Utah Olympic Park • Located 20 minutes away in Park City, the venue features six Nordic ski jumps, an aerials training and comp hill, and a training pool. Visitors can race the Comet Bobsled at up to 65mph, ride one of the world's steepest ziplines, hike nature trails, or freestyle ski jump into the aerial pool.

Real Salt Lake • For those who crave the energy of a crowd, Real Salt Lake delivers. The Rio Tinto stadium seats 20,000 singing, chanting soccer fans and is easily accessible from the Frontrunner train station.

SHHH ... LOCALS' FAVORITES

Ken Sanders Rare Books • Founded in 1980 by a self-described bibliophile, this charming bookstore is the place to find obscure and interesting books you won't likely find anywhere else.

Whiskey Street • Don't miss this Main Street favorite, with its classic style and extensive yet selective whiskey list. (The lunch menu is almost as mouth-watering.)

Living Room Hike • A short, moderately challenging hike that begins at Red Butte Garden and ends with a stone "sofa" and "chairs" and an awesome view of the valley.

The Urban Lounge & Rye Diner • A little divey, a little hip, and a lot of fun, this bar books some of the best bands that come through town. Next door, Rye Diner serves brunch, late-night plates, and a live feed of the current show.

Antique Row on 300 South • Find vintage board games, retro sweaters, mid-century modern decor, and much, much more. Plan on browsing for hours.

Epic Brewing Company • From IPAs to stouts, there isn't a beer this brewery doesn't knock out of the park. Sample them all (and a sandwich) in the small tasting room.

Broadway Centre Cinema / Tower Theatre
These two cozy, quirky venues are the best places to catch an indie flick, have a snack, and meet a fellow film buff.

Food Truck Thursdays • Thursdays from 11-2 during the summer, you can sample Salt Lake's delicious mobile cuisine at Gallivan Center Plaza—a lovely place for outdoor lunching.

The State Room • This live-music venue is often described as Salt Lake's best. It's intimate but never cramped, with both seated and standing room, and the sound is stellar.

Les Madelines Cafe • Enjoy rich pastries, flaky croissants, artisan espressos, delicate crepes, savory sandwiches ... and the cafe's buttery, caramelized masterpiece: the Koing Aman.

Visit SALT LAKE

For More Top Things To Do In Salt Lake, Go To:

VisitSaltLake.com/quick-guide

Inside Geothermal

NORTH AMERICA

Joint Venture Announced in Geothermal Services Industry

Schlumberger and **Weatherford** have announced an agreement to create **OneStim**[SM], a joint venture to deliver completions products and services for the development of unconventional oil & gas resource plays in the United States and Canada land markets. **Both companies also have a share in the geothermal energy services industry.**

Weatherford will contribute its leading multistage completions portfolio, cost-effective regional manufacturing capability, and supply chain. Schlumberger will provide the joint venture with access to its industry-leading surface and downhole technologies, efficient operational processes and advanced geo-engineered workflows.

Schlumberger and Weatherford will have 70/30 ownership of the joint venture, respectively. The transaction is **expected to close in the second half of 2017**, and is subject to regulatory approvals and other customary closing conditions.

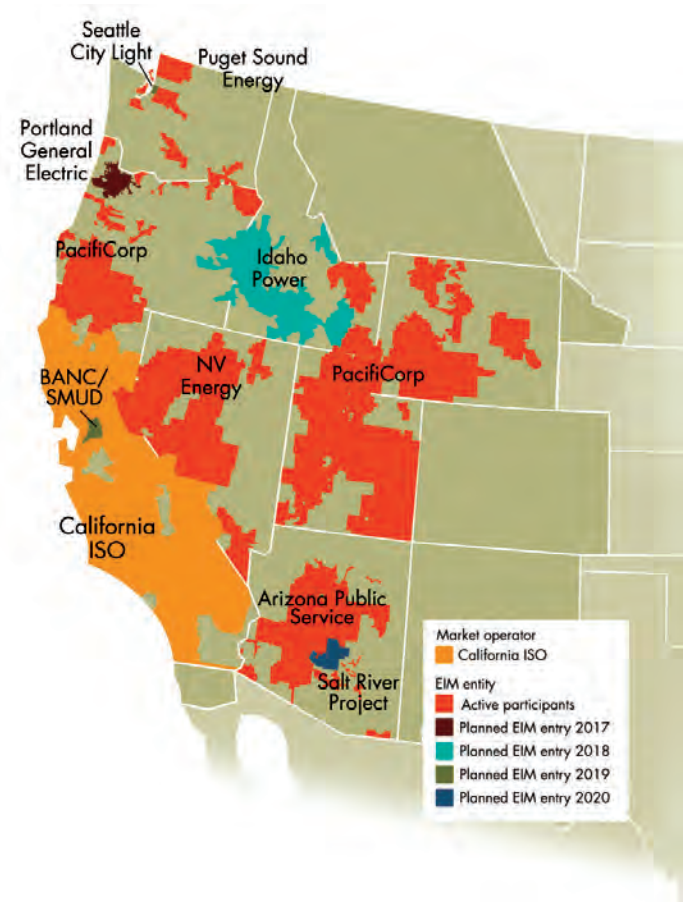
Western Imbalance Market Continues to Grow

The **California Independent System Operator (CAISO)** and Arizona municipal utility **Salt River Project (SRP)** have signed an agreement for SRP to participate in the western **Energy Imbalance Market (EIM) beginning in April 2020.**

The western EIM's advanced market systems automatically find the lowest-cost energy to serve real-time consumer demands of participating utilities. This market enables utilities to buy and sell power more efficiently in the hour before the energy is needed, with five-minute plant dispatching, which result in improved efficiencies and cost savings. **The market also allows for an expanded market for renewable energy producers.**

Current western EIM participants have realized savings totaling nearly USD 142 million since the wholesale market was launched in November 2014.

Utilities now active in the western EIM include Oregon-based **PacifiCorp; NV Energy** of Las Vegas, NV; **Puget Sound Energy** of Washington state; and **Arizona Public Service** of Phoenix, Ariz. Other utilities that have formally agreed to join the EIM include **Portland General Electric** on October 1, 2017, **Idaho Power** on April 1, 2018, and **Seattle City Light** and **Balancing Area of Northern California/ Sacramento Municipal Utility District** on April 1, 2019. The western EIM serves utility consumers in Arizona, California, Idaho, Nevada, Oregon, Utah, Washington, and Wyoming.



EnergySource Gets USD 2.5 Million Grant to Study Lithium Extraction from Geothermal Brine

A **USD 2.5 million grant** has been awarded by the **California Energy Commission (CEC)** to **EnergySource Minerals, LLC** to study extraction of lithium and other metals from the geothermal brine used at the EnergySource **55 MW John L. Featherstone geothermal power plant.**

The **Well To Wheels Lithium Design project** will be launched at the Salton Sea, Imperial Valley site in Southern California.

The grant is from the CEC **Geothermal Grant and Loan Program** or **Geothermal Resources Development Account (GRDA).**

According to the *Desert Sun*, **EnergySource has been testing a new process** to extract lithium and other metals from geothermal brine. The results have been promising enough that **a Texas investment group bought a 38.5-percent ownership interest** in EnergySource. The firm has invested additional money to fund more thorough testing of the extraction process, which is expected to take about six months.

California Energy Commission Awards USD 4.7 Million to Five Geothermal Energy Projects

The **California Energy Commission (CEC)** has proposed to award funding to five projects as a result of the Geothermal Grant and Loan Program Grant funding opportunity GFO-16-505.

- **Modoc Joint Unified School District** (Modoc County, CA) - Modoc Joint Unified School District Geothermal Expansion. USD 880,000.
- **County of Modoc** (Modoc County, CA) - Geothermal Resource Confirmation Drilling. USD 1,638,022.
- **Imageair, Inc.** (Reno, NV) - Application of Surface Deformation and Induced Seismicity to Geothermal Operation and Exploration. USD 604,928.
- **Golden Haven Hot Springs Spa and Resort** (Napa Valley, CA) - Golden Haven Injection Well. USD 134,642.
- **GreenFire Energy, Inc.** (Emeryville, CA) - Demonstration of a Novel Water-Free Method of Extracting Energy from Hot Dry Rock. USD 1,490,757.

The proposed grants **will be considered for approval** by the California Energy Commission at a **June 14, 2017**, business meeting.

GreenFire Energy has announced it will use the grant to design, build, and operate an the first demonstration project for **ECO2G™** – geothermal power generation using **supercritical CO_2** in a closed-loop system – using an underperforming hydrothermal well at the **Coso KGRA** in **Inyo County**, California. This project will be the first field-scale demonstration of ECO2G technology for geothermal power production.

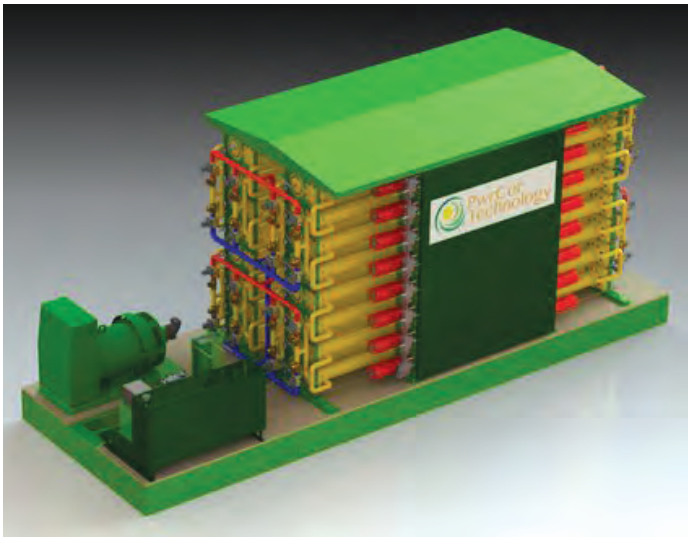
Name Change for Surprise Valley Hot Springs Geothermal Project Company

Receivable Acquisition & Management Corporation, d/b/a **Cornerstone Sustainable Energy**, has announced that it has changed the company's corporate name to **PwrCor**, Inc to reflect the company's focus on power from low-enthalpy geothermal resources.

Tom Telegades, Chief Executive Officer, said that "With the onset of our first geothermal project that will convert ultra-low-grade heat into electricity in northern California advancing our commercialization program, the Board felt that now was the appropriate time for this change."

In 2013, Cornerstone Sustainable Energy entered into an agreement with **Warner Mountain Energy Corporation** to begin the first phase of development of a geothermal energy plant to be located at the **Surprise Valley Hot Springs** in **Cedarville, Modoc County, in northern California.**

The **PwrCor™ technology** utilizes supply heat of temperatures below 200°F. The hot spring water in Surprise Valley comes to the surface at temperatures of approximately 190°F, which is considered ultra-low-grade heat. Using just a small fraction of the water flow from the geothermal resource, the PwrCor™ engine is expected to be able to supply 100% of the power used by the resort.



COURTESY GREENFIRE ENERGY

New Community Choice Aggregators is Opportunity for Geothermal Sales

In April, **Silicon Valley Clean Energy (SVCE)** began supplying 100% carbon-free electricity to customers in **Silicon Valley** in northern California.

Established by twelve local communities, SVCE is a **Community Choice Aggregator (CCA)** chartered to provide new and competitive clean power options for local residential and commercial electricity customers.

Currently, SVCE has contracts with wind, solar and hydropower providers. The local utility **Pacific Gas & Electric (PG&E)** will continue to deliver electricity over existing power lines, maintain the lines, send bills and provide customer service.

Just to the south, **Monterey Bay Community Power (MBCP)** aims to launch next spring as another green alternative to PG&E, reports *Goodtimes*. This will add to a growing list of California CCAs, in **Marin, Sonoma, Lancaster, San Francisco, San Mateo**, and **Silicon Valley**.

In addition, in April the **Los Angeles County** Board of Supervisors unanimously approved the creation of a CCA in Southern California in territory currently serviced by **Southern California Edison**. The area includes the **Coso Known Geothermal Resource Area** and is adjacent to the resources in the **Imperial Valley**.

In an article in the July/August 2016 ***GRC Bulletin***, **Paul Brophy**, past-President, Geothermal Resources Council, and Vice-Chair, Business Operations Committee, Sonoma Clean Power, said "Over the next few years the California retail electricity market is likely to change substantially because of a variety of forces. Changes will be motivated partly by the **2030 RPS requirement of 50%** renewables but also by communities wanting more carbon-free electricity. **Forming a CCA is one of a number of mechanisms that will assist in achieving those goals.**"

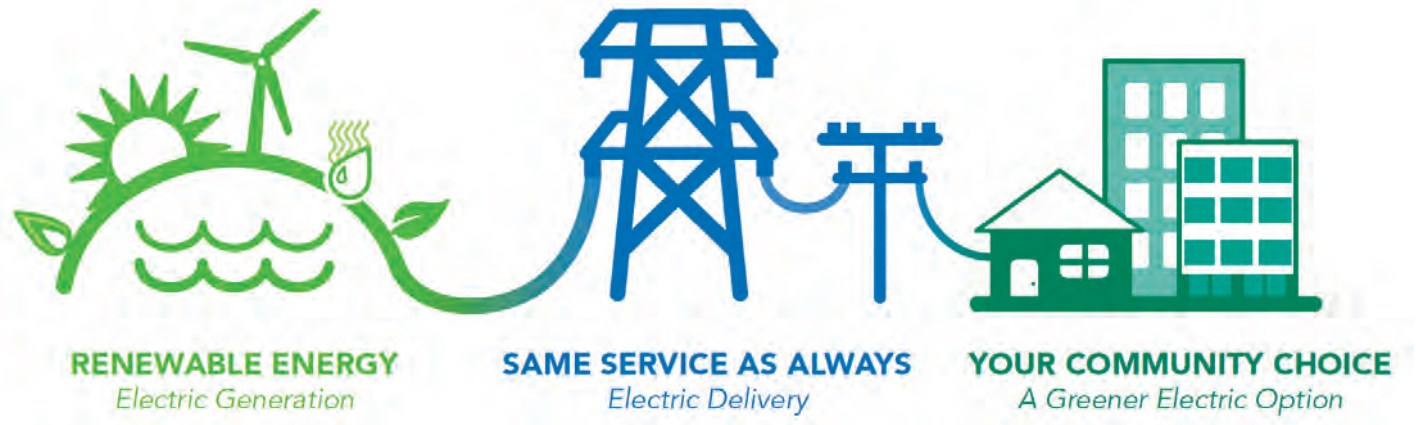
"It is apparent from the rapid growth of the CCA movement over the past 2-3 years that this will have a marked effect on how electricity is purchased and supplied in a variety of energy markets within the state. **Baseload geothermal power is ideally suited to supply a balanced energy supply portfolio that CCAs require to achieve their goals of greater renewable use at a competitive price.**"

US Geothermal Reports on 35-45 MW San Emidio II Project

In a recent Earnings Call transcribed by *Seeking Alpha*, **Douglas Glaspey**, President and Chief Operating Officer, **US Geothermal**, explained how the successful expansion of the **San Emidio II** resource in Nevada has allowed the company to **put into use three second-hand geothermal power plants** they acquired in 2015.

"The significant increase of the size of the San Emidio II resource after the drilling and testing was completed in 2016, has changed our approach to this project. While we previously had planned on Phase II as 10 MW expansion, **we're now considering a 35 to 45 MW size development. Now, we would use those three power plants we own.**

"With a temperature of over 320°F, this new resource is a perfect fit for these three power plants and most of the equipment is already stored on site at San Emidio. **We received permits to deepen three**



COURTESY SAN JOSÉ CLEAN ENERGY

more wells in the new resource area and are **ready to proceed with drilling** as soon as weather allows. Additionally, we had to decline the *Small Generator Interconnection Agreement* that we had received from NV Energy and will now be submitting a new application for a *Large Generator Interconnection Agreement* later this year."

Cyrq Energy to Buy Reno District Geothermal Heating System

A neighborhood of 104 homes adjoining the **Peppermill Hotel** in south **Reno**, a long time venue for the **GRC Annual Meeting & Expo**, is keeping its district heating system, the largest one in Nevada, reports *KRNV*. The plant was scheduled to **go offline on July 31.**

Nevada Geothermal has announced geothermal power plant developer **Cyrq Energy**, headquartered in Salt Lake City, Utah, will take over the system. Company attorney **Curt Ledford** said Nevada Geothermal had been looking for a buyer "that would propose a plan to keep the geothermal system operating. We think Cyrq has that capability."

National Lab Collaboration will Study Integrating Solar at Raft River Geothermal Power Plant

The U.S. **Department of Energy (DOE)** has announced 38 small businesses that will collaborate with 8 national labs through the **Small Business Vouchers (SBV) pilot**, enabling them to tap into the intellectual and technical resources they need to overcome critical technology challenges for their advanced energy products and gain a global competitive advantage.

A GRC Fieldtrip visited the Raft River geothermal power plant in June 2015.
PHOTO BY IAN CRAWFORD

The one collaboration named in the geothermal area will **integrate a solar topping cycle** at the **U.S. Geothermal Inc. Raft River geothermal power plant** in **Idaho**. Two national laboratories will work with small businesses on this project.

In addition, U.S. Geothermal has announced Phase II of the ongoing plan to **increase the output at Raft River** from its current generation level of 10 MW, up to its **contract maximum of 13 MW**, commenced in March with the successful installation of a pump in **well RRG-5**.

Production from RRG-5 is currently **1,100 gallons per minute**, increasing net power production by approximately 0.71 MW.

To date, the reservoir response has been significantly better than projected, with minimal drawdown in well RRG-5 and no impact to water level in the adjoining wells. **The well temperature is currently stable at over 247°F**. The next step to optimize output from the wellfield is to increase the capacity of the injection system. After an injection pump is upgraded, a further increase in fluid flow to the plant is expected, which will result in a corresponding **increase in generation**, plus allow for additional production well increases.

Project HOTSPOT Encounters Promising Geothermal Energy Resource

In a recent issue of *Lithosphere* magazine, a deep drilling program in **southern Idaho** reported on promising results from the suitably named **HOTSPOT project** indicating good potential for geothermal energy.

Part of the **Snake River Scientific Drilling Project** (an **International Continental Scientific Drilling Program**), Project HOTSPOT tested for deep geothermal resources and examined the petrology of volcanic rocks with **three drill-holes** in the **central and western Snake River Plain** in Idaho. The **MH-2 drill-hole** targeted fractured crystalline and hydrothermally altered basalt in the area of the **Mountain Home Air Force Base** to a total depth of 1,821 meters.

At 1,745 meters depth the drill-hole encountered **flowing artesian hydrothermal fluids of at least 150°C (302°F)**.

These data indicate that the transition from the central to western Snake River Plain is characterized by complex structures developed in response to a transitional stress state related to Snake River Plain and western **Basin and Range stress regimes**. This regime may extend from northern Nevada into western Idaho and may **enhance the potential for geothermal resources** by creating interconnected fracture and fault-related permeability at depth.

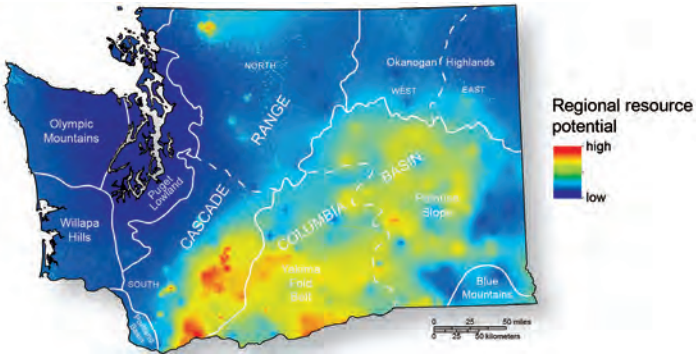
The article was published in *Lithosphere* (doi:10.1130/L609.1, first published on April 4, 2017) entitled *Geology and in situ stress of the MH-2 borehole, Idaho, USA: Insights into western Snake River Plain structure from geothermal exploration drilling*, authors **J.A. Kessler**, et al.

Washington Legislation Improves Permitting Process for Geothermal Exploration

Senate Bill 5470 in the state of Washington, which should boost geothermal development in the Pacific North-West; has been signed into law.

The text of the legislation states "The public has a direct interest in the safe, orderly, and nearly pollution-free development of the geothermal resources of the state. The legislature hereby declares that it is **in the best interests of the state to further the development of geothermal resources** for the benefit of all of the citizens of the state while at the same time fully providing for the protection of the environment."

"The development of geothermal resources shall be so conducted as to protect the rights of landowners, other owners of interests therein, and the general public. In providing for such development, it is the purpose of this chapter to provide for the orderly exploration, safe drilling, production, and proper abandonment of geothermal resources in the state of Washington."



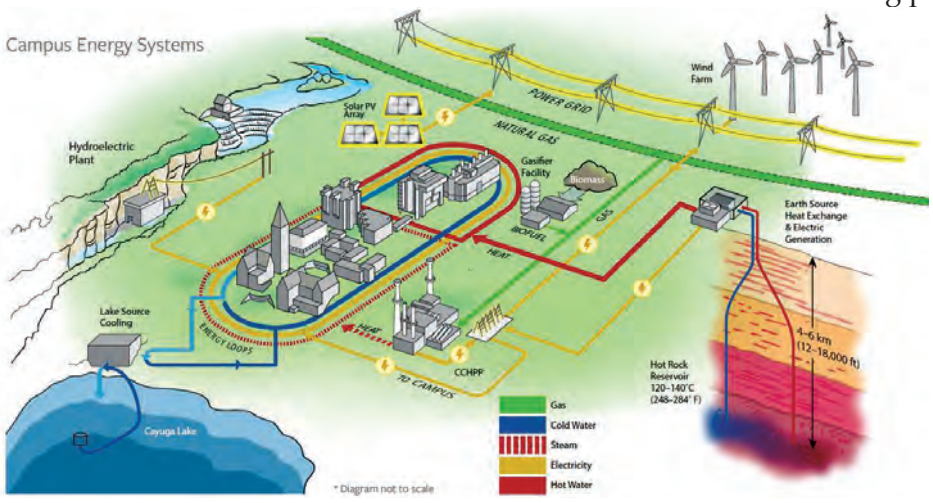
Geothermal resource potential map of Washington State. WASHINGTON GEOLOGICAL SURVEY

Cornell Moving Forward with Geothermal Energy Plan

Cornell University in up-state **New York** is moving ahead with a scheme to use deep geothermal resources to heat the campus in **Ithaca**.

Cornell University's **Senior Leaders Climate Action Group** presented its findings regarding the school's stated goal of becoming **a carbon neutral campus within 20 years** and the use of an "unproven" but intriguing new method of heat production that could greatly **reduce the school's carbon footprint by nearly 40 percent.**

The report, titled *Options for Achieving a Carbon Neutral Campus by 2035*, recommends **a combination of "Earth Source Heat", wind, water, solar and biomass**. The Earth Source Heat or geothermal district heating plan would require **drilling between two and four miles into the ground** in order to find a depth that would properly warm the circulating water to the point that it can be used to heat the campus' buildings.



The Cornell Energy System will incorporate geothermal heat, wind, water, solar and biomass. COURTESY CORNELL UNIVERSITY

Lance Collins, the school's Dean of Engineering, said **Phase 1 will take a year**, to find the acceptable spot to drill, then **Phase 2 of Drilling will take 3-5 years**.

The proposal so far still includes **building two wells at**

first, essentially as a test case, in order to measure the effectiveness while attempting to only heat certain targeted areas of campus. If all goes well with that, the project would continue. Generating electricity from the geothermal resource remains a long-term goal. The report listed several reasons for its findings, including that "**Earth Source Heat is the most promising technology for heating the campus in our climate.**"

Geothermal Energy Could Power Army Camp in West Virginia

The *Preston County News & Journal* reports that someday the buildings at **Camp Dawson**, a **West Virginia Army National Guard** training center, might be warmed by heat coming from deep inside the earth. Indeed, geothermal energy might supply electricity to the base.

Last year, researchers from the **National Energy Technology Laboratory (NETL)** in Morgantown, with help from **West Virginia University** and engineering consultant **AECOM**, completed a feasibility study at Camp Dawson. The base is sitting on a geothermal energy warm spot which could **provide 14-18 MW of electricity**. However, it may cost too much to generate electricity at first. Still, it may be possible to heat the buildings with geothermal energy.

Good Budget for Geothermal in Canada

According to **Alex Kent**, Policy Manager for the **Canadian Geothermal Energy Association (CanGEA)**, the new federal budget announcement on geothermal was the culmination of several years of work by CanGEA and the benefits to the industry will be immediate.

The budget announced that "**Geothermal energy is one renewable energy source with the potential to reliably meet a portion of Canada's heating and electricity generation needs**, including in northern and remote communities, where reliance on fossil fuels remains high."

To encourage greater use of geothermal energy, Budget 2017 proposes to:

- Extend accelerated capital cost allowance [ACCA] to a broader range of geothermal projects and expenses.
- Expand the range of geothermal energy project expenses that are eligible as Canadian renewable and conservation expenses [CRCE], which can be fully deducted in the year incurred.

By making all geothermal projects (heat, power and co generation) eligible for exploration de-risking, **geothermal projects in Canada are a much better investment prospect.**

More Funding for Geothermal Energy Project on Grenada

The Board of Directors of the **Caribbean Development Bank (CDB)** has approved a grant of **USD 231,630** to the government of **Grenada** to build its capacity for planning and implementation of its **geothermal energy development roadmap.**

The grant will fund consultancy expertise for a period of 24 months to establish and operate a **Geothermal Energy Project Management Unit (GPMU).**

The resources are from the **Global Environment Facility (GEF)** through the **Inter-American Development Bank's Sustainable Energy Facility for the Eastern Caribbean** with the CDB.

Potential for 18-36 MW Geothermal Energy on St. Kitts

A feasibility study done by **Teranov**, a French engineering and services company based in Guadeloupe, has proven that there is potential on **St. Kitts** to develop at least **18 to 36 MW of geothermal power**, reports *WINN-FM*.

Minister of Public Infrastructure, Honourable **Ian Patches Liburd**, hailed the findings as "heartening" but said that the government is to consider the way forward. "We have so far done the 3G studies—the geological, geophysical and geochemical studies or the surface studies," indicating that the **next step is to consider the way forward for slim-hole and exploration drilling**.

CENTRAL AND SOUTH AMERICA

Canadian Company Acquires Geothermal Project in Guatemala

Vancouver-based **Bluestone Resources Inc.** has announced that it has entered into a definitive agreement with **Goldcorp Inc.**, also based in Vancouver, and its affiliates in respect of the previously announced acquisition of the Cerro Blanco Project and the **Mita Geothermal Project**

in Guatemala, owned by Goldcorp's indirect wholly-owned subsidiary **Geotermia Oriental de Guatemala S.A.**, reports *Junior Mining Network*.

Cerro Pabellón Geothermal Power Plant in Chile is First in South America

Apart from Antarctica, South America was the only continent not to have a geothermal power plant. That is no longer the case. In late March, **Enel Green Power** announced the **48 MW Cerro Pabellón geothermal power plant**, located **4,500 meters above sea level** in **Ollagüe** in the **Atacama Desert**, had begun delivering electricity to the **Sistema Interconectado del Norte Grande (SING)** system in northern Chile.

Cerro Pabellón is owned by joint venture **GDN**, which is 81.7% held by **Enel Green Power Chile** and 18.3% by **Empresa Nacional del Petróleo (ENAP).**

Location of the Cerro Pabellón geothermal power plant in northern Chile near the border with Bolivia.

The Cerro Pabellón geothermal power plant is located at 4,500 meters above sea level in the Atacama Desert. COURTESY ENEL GREEN POWER

A great team effort by the Cerro Pabellón geothermal power project - Congratulations! COURTESY ENEL GREEN POWER

Exploration for Colombian Geothermal Energy Resource to Resume

Colombian utility **Chec Group EPM** has announced a resumption of exploration for a geothermal energy resource in the country, reports *La Patria*.

There are plans to start surveying in the areas of **El Páramo, Papayal** and **Playa Larga** in the **Villamaría highlands**, west of the capital **Bogotá**.

Julián López Palacio, coordinator of the geothermal project at Chec, said that the objective is to check the temperature and pressure of existing wells to determine if the conditions are enough to generate electricity.

Exploration had been carried out back in 1997 at the **Nereidas 1 well** on the Pyrenees estate. A temperature of about **200°C was recorded at 680 meters depth**. Exploration continued to 1,400 meters but then paused..... for 20 years.

Location of the exploration area in the Villamaría highlands, west of the capital Bogotá.

Japan to Further Fund Construction of Geothermal Power Plant in Bolivia

The **Japan International Cooperation Agency (JICA)** has signed a loan agreement with the government of **Bolivia** to provide a **Japanese Official Development Assistance (ODA)** loan of up to **61.485 billion yen** for the second stage of the **100 MW Laguna Colorada Geothermal Power Project.**

The loan funds will be allocated to well drilling, the construction of the geothermal power plant and incidental facilities, and consulting services following completion of the first stage of the project, for which a Japanese ODA loan was provided in July 2014.

AUSTRALASIA

Geothermal-Powered Dairy to Open in Kawerau

A group of seven **Māori trusts** is spearheading a first-of-its-kind milk processing plant in **Kawerau** on the **North Island**, which will create 30 jobs, reports *Radio New Zealand*.

Kawerau Dairy will be the first geothermal-powered plant in the country to **process milk from goats, sheep and cows.** The plant is expected to be making products to sell by late 2018.

The processed milk will be used to make protein powder, vitaminized powder, aged-care formula and baby formula.

ASIA

Japan, Russia Propose Joint Geothermal Power Projects on Kiril Islands

Russia and Japan may **jointly build geothermal power plants** on the **Kuril Islands**, reports *Yomiuri Shimbun*. This would help bring the countries together on the issue of ownership of the contested territory by adding to the existing 7.2 MW of geothermal capacity on the archipelago.

The paper said that proposals to build geothermal power plants and a seafood processing plant on the islands were included in recent Russian-Japanese consultations.

In December 2016, Japanese **Prime Minister Shinzo Abe** and Russian **President Vladimir Putin** agreed on joint development economic initiatives on the islands. The two sides adopted a *joint statement*, which said that the beginning of consultations on joint economic activities on the South Kuril Islands would be an important step towards signing **a peace treaty** by the two neighbors.

Location of exploited geothermal resources in the far-east of the Russian Federation.

All the islands have been under Russian jurisdiction since the end of the Second World War. Japan claims the two southernmost large islands (Iturup and Kunashir) as part of its territory, as well as Shikotan and the Habomai islets, which has led to the ongoing Kuril Islands dispute.

A new report published by **The International Renewable Energy Agency (IRENA)** suggests that 1,000 MW of geothermal energy in the Russian Federation could be developed by 2030, mainly in the far-east of the country, mainly in Kamchatka and the Kuril Islands.

Renewable Energy Prospects for the Russian Federation (IRENA) states that total electricity generation in 2015 from geothermal was 477 GWh/yr. Installed geothermal capacity, mainly located in the eastern part of Russia, had reached **86 MW at end of 2015.**

There are three large-scale geothermal power plants in operation in **Kamchatka**: two of them of 12 MW and one of 50 MW total installed capacity. These are located in the Verkhne Mutnovsky and Mutnovsky fields, respectively, while another plant, with a total installed capacity of 11 MW, is located in the Pauzhetsky field.

In addition, on the **Kuril Islands** (Kunashir and Iturup) two small-scale plants are in operation with capacities of 3.6 MW each (Svalova and Povarov, 2015).

The report's authors say the **geothermal potential in Russia is mainly in the eastern parts of Russia (Kamchatka)**. Demand for electricity in these regions is limited, but small scale geothermal plants can be deployed there to meet some industrial electricity demand (e.g. mining and ship building). This is in addition to meeting the electricity needs of Kamchatka's urban areas, in which three-quarters of the peninsula's population lives.

The potential in the REmap scenario for geothermal in Russia **is estimated at 1 GW by 2030**. This is ten times higher than that envisaged under the Reference Case scenario.

The report can be downloaded from the IRENA website at: www.irena.org/DocumentDownloads/Publications/IRENA_REmap_Russia_paper_2017.pdf

Legislation Determines Purchase Price for Geothermal Energy in Japan for Three Years

On April 1, substantial portions of the **Amendments to The Act on Special Measures Concerning the Procurement of Renewable Energy by Operators of Electric Utilities** became effective. These Amendments, enacted on June 3, 2016, represent the most comprehensive set of changes to Japan's feed-in tariff system since the implementation of the Act in 2012.

The amendments provide for the **Ministry of Economy, Trade and Industry** to determine the **applicable purchase price for geothermal projects for a consecutive three-year period**, so as to facilitate potential developers in determining the profitability of any such potential renewable energy project, reports *Lexology*.

These amendments will also **require owners of renewable energy facilities to enter into an interconnection agreement** with the relevant utility before certification.

Philippines Update

Trans-Asia Petroleum Corp. is changing its name to **Phinma Petroleum and Geothermal, Inc.** to better reflect the change in its primary purpose, which will include prospective projects in geothermal energy, its president said.

Francisco L. Viray, Trans-Asia Petroleum president and chief executive officer, said the company would look for geothermal prospects in the Philippines before checking possible ventures outside the country, reports *BusinessWorld*.

Indonesia Update

A **20 MW geothermal power plant** could be built on **Bacan island** in the regency of South Halmahera, **North Maluku** province, on a geothermal field with an estimated capacity of 140 MW.

The Indonesian Energy and Mineral Resources (ESDM) Ministry has told the district administration of South Halmahera that **the tender would open for the project this year.**

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In the last *GRC Bulletin*, we reported that construction has begun of the first phase of the **80 MW Muara Laboh geothermal power project** in **South Solok**, **West Sumatra**.

An update reported by *Rambu Energy* says that once the initial phase has started commercial operation by August 2019, the **PT Supreme Energy Muara Laboh** consortium is planning to embark on **an additional 140 MW project**.

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Chevron Corporation has announced that its wholly-owned subsidiaries have **completed the sale** of its geothermal business in Indonesia to **Star Energy Consortium.**

Chevron received the **USD 600 Million** proceeds upon settlement on March 31, and will reflect the gain in first quarter 2017 results.

The conclusion of the sale of Chevron's geothermal business in the Philippines is expected later in 2017.

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Indonesia's largest liquefied natural gas producer **PT Arun NGL**, in alliance with **World Wide Fund for Nature (WWF) Indonesia**, have announced a plan to develop **72.5 MW** of geothermal energy on **Flores island**, East Nusa Tenggara province.

Head of Provincial Mining and Energy Office, **Boni Marisin**, said the central government has appointed **PT PLN** (the National Electricity Company) to develop geothermal projects in **Ulumbu** and **Mataloko** with a capacity of **50 MW** and **22.5 MW** each. The projects are expected to be completed **by 2020**.
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Thai Company Buys Into Geothermal Power Plants in Indonesia

According to *DealStreetAsia*, Thai renewable energy firm **BCPG (ex. Bangckak Petroleum Public Company Limited)** has secured the approval from its Board of Directors to acquire a one-third stake in Indonesia-based **Star Energy Group** for not exceeding **USD 357.5 million.** Both companies expect to complete the transaction in the second quarter of this year.

Following the acquisition, BCPG will hold stakes in **three geothermal power plants** in Indonesia with a combined production capacity of **182 MW.**

First Geothermal Power Plant In Malaysia Could be Operating in 2019

According to *The Malaysian Reserve*, **Green Energy Sdn Bhd (TGE)** is on track to develop **Malaysia's first geothermal power plant** in **Tawau, Sabah**, in the north-east of the island of **Borneo**, by 2019.

TGE has received all requisite approvals to develop, construct, operate and maintain a geothermal power plant, exporting **30 MW** to the Sabah grid, under a **21-year** *power purchase agreement* (PPA) with **Sabah Electricity Sdn Bhd** at a **feed-in tariff of 0.45 Malaysian Ringgitt per kWh.**

TGE project development GM **Andrew Amaladoss** said initial studies at the project area indicated **a potential of 67 MW**.

Location of the Tawau, Sabah, geothermal project on the island of Borneo.

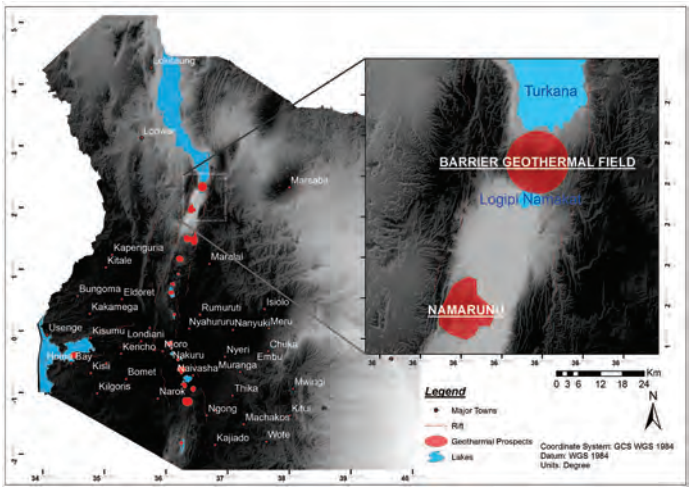
AFRICA

Kenya Update

GRC Member **Sam Abraham** has provided some information about a geothermal energy project he is carrying out next to **Lake Turkana** in northern Kenya. As Project Manager for Nairobi-based **Olsuswa Energy Limited**, Sam gave *ThinkGeoEnergy* an update on progress at the **Barrier Volcanic Complex** (BVC) geothermal project.

The **upcoming geo-scientific studies** are geological, geochemical, geophysical, structural analysis, and micro-seismics. Each discipline will be required to produce a conceptual model. The approach of each of these disciplines will consist of numerous tests, producing scientific data that will be integrated to characterize the geothermal resource at the BVC.

Plans for **subsequent drilling** include accessing additional financial support, continuing community engagement, a work plan for exploratory drilling, further project development activities and ultimately power plant commissioning.



Location of the Barrier Geothermal Field in northern Kenya. COURTESY OLSUSWA ENERGY LIMITED

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KenGen has **started the construction** of the **158 MW Olkaria V geothermal power plant.** Costing over Shilling 55 billion, the plant is slated to **be completed in 2019.**

President Uhuru Kenyatta broke ground on the Olkaria V power project on April 28 and also **commissioned 14 geothermal wellhead units** producing **75 MW** of electricity, reports *Capital FM*.

The 'wellhead unit' is a unique technology reducing the duration between the first drilling of a well and installation of a geothermal plant from five years to two years.

President Uhuru Kenyatta said Kenya has one of the largest reserves of geothermal energy and **more plants will be constructed to harness the power for the benefit of Kenyans.** "That this form of energy is not subject to the vagaries of the weather, and that it runs at a respectable rate more than 90pc of the time every year, means that we can bring reliable power to every Kenyan home," said the President.
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The Kenyan treasury has signed *letters of intent* for financing of the **Unit VI Olkaria I geothermal plant extension.** The **EUR 113 million** financing will support the addition of a **70 MW turbine**, as well as the construction of the necessary wells, steam gathering system and interconnection facilities.

The Kenyan government has also signed off on loans for a **Sh6.7 billion** project to enable **an additional 1.5 million citizens access to electricity.** The loan signed with the **European Investment Bank (EIB)** targets **universal access to electricity for the Kenyan population by 2020.**

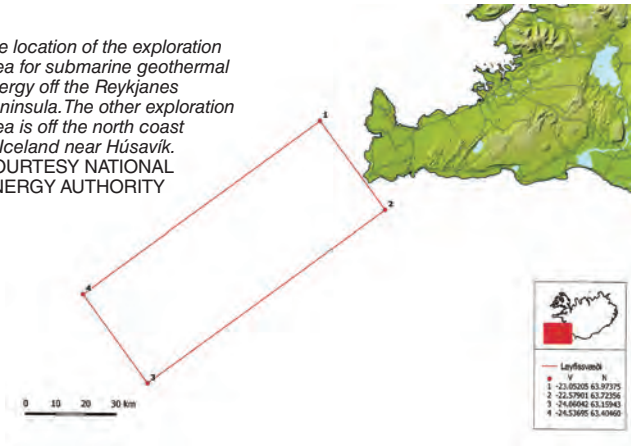
EUROPE

Company Given License to Locate and Research Geothermal Energy on the Seabed

The Icelandic **National Energy Authority** has granted a local company **North Tech Energy** a license to locate and research geothermal energy **on the seabed** around Iceland, reports *Iceland Magazine*.

North Tech, based in Reykjavik, has been granted permits for geothermal research on the sea floor in two locations: one on the **Reykjanes Ridge** - off the coast in south-west Iceland, and the other off the **coast of north Iceland.**

The goal of the research is to find out if the underwater geothermal areas can be used for energy production. North Tech envisions generating electricity from off-shore geothermal power plants **on platforms not unlike those used in off-shore oil drilling.**



The location of the exploration area for submarine geothermal energy off the Reykjanes Peninsula. The other exploration area is off the north coast of Iceland near Húsavík. COURTESY NATIONAL ENERGY AUTHORITY

British Company to Supply 5 MW Modular Geothermal Wellhead Power Plant

London-based **Green Energy Geothermal (GEG)** has been awarded a contract to supply and build a **5 MW turbine-generator** package for the **Bjarnarflag geothermal power plant** in the northeast of **Iceland** to help reverse declining power output.

GEG was awarded the contract by **Landsvirkjun**, the National Power Company of Iceland, to design, manufacture and supply a replacement **back-pressure turbine and generator**, which will be delivered, installed and commissioned on site.

The Bjarnarflag geothermal power plant. COURTESY THINKGEOENERGY, CREATIVE COMMONS LICENSE

Opportunity for Deep Geothermal Energy Projects in Scottish Rural Areas

The **Scottish Government** has announced a **GBP 10 Million fund** to support innovative low-carbon energy projects in rural parts of Scotland, reports edie.net.

Up to **GBP 100,000** will be allocated for each scheme that shows the potential to increase energy efficiency, reduce carbon emissions and boost local economies. The funding, made available through the **Low-Carbon Infrastructure Transition Programme (LCITP)**, will target rural and remote areas in order to help bridge gaps in capacity, skills and resources.

Opportunity for Deep Geothermal in UK to Compete for Contracts for Renewable Projects

The United Kingdom Department for **Business, Energy & Industrial Strategy (BEIS)** has published information on the next **Contracts for Difference (CfD)** round.

The round opened on 3rd April. The strike price for geothermal starts at **GBP 140/MWh.**
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Under the CfD, **low carbon electricity generators are incentivized for the power they produce.** Companies are able to compete for an initial **GBP 290 million** worth of contracts for renewable projects under the second round which is focused on support of "**less established" technologies**, including **geothermal energy**.

Belgium Regional Government Provides Guarantee Scheme for Deep Geothermal Drilling

Flanders' energy minister hopes to boost the geothermal sector in the Belgium region with **a guarantee scheme** for companies that invest in deep geothermal energy projects, reports *Flanders Today*.

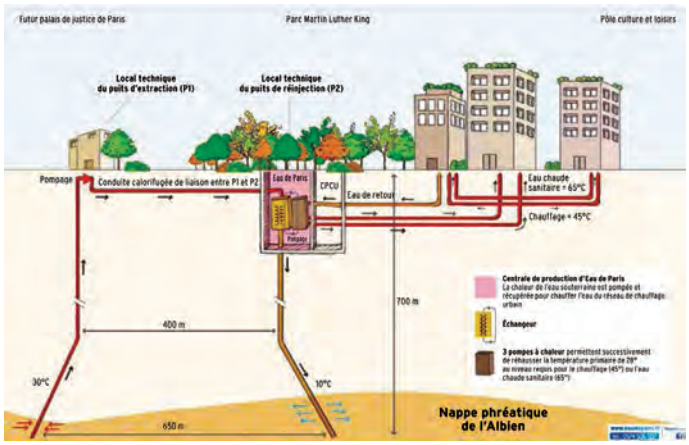
"With the guarantee scheme, we hope to convince companies to invest and to facilitate a breakthrough of deep geothermal energy in Flanders," energy minister **Bart Tommelein** said. Drilling for deep geothermal energy requires major investment, with significant risk that it will generate less energy than hoped for as there is still a lack of detailed knowledge about the local subsurface.

Companies that want to drill in deep earth layers can submit a dossier to the government. **If it turns out after drilling that the estimated energy production is not achieved, the government will pay back certain costs.** The companies contribute to the scheme by paying a premium.

Geothermal District Heating Network Launches in Paris Suburb

In February, **Paris City Hall** inaugurated a new geothermal plant in the **Clichy-Batignolles** suburb, providing heat and hot water to the local eco-district.

Future plans include electricity generation from the geothermal resource, reports *l'Energeek*.



The Clichy-Batignolles district heating project taps the geothermal resource of the Albian aquifer under Paris.

Holzkirchen Geothermal Project Delivers 150°C Resource from 5,000 Meters

Dr. Jochen Schneider, Managing Director of **Hydrosion GmbH & Enerchange GmbH & Co. KG** reports on *LinkedIn* that a temperature of **150°C** was reached with a continuous pumping rate of **50 liters per second** at the **Holzkirchen geothermal project** in southern **Bavaria, Germany.**

The production tests were carried out after **drilling was completed to a depth of about 5,000 meters** and a length of about 6,100 meters.

Testing has now completed and construction of the geothermal power plant will begin in the Fall. The local utility wants to produce electricity and heat for the community of **Holzkirchen**, located south of **Munich**.

Testing at the Holzkirchen geothermal project. COURTESY GEMEINDEWERKE HOLZKIRCHEN

Romanian Government to Support Development of Geothermal Energy

The government of **Romania** has approved a new state aid scheme to support energy production from less exploited renewable resources, namely biomass, biogas and geothermal energy, reports *Lexology*.

The **New Support Scheme** is applicable until 2020 and has a total allocated budget of EUR 100,630,588 (85% from the European fund for regional development and 15% from the state budget).

The unexploited technical potential is approximately 8,000 ktoe, where biomass and biogas represents 47%, solar energy represents 19%, wind energy represents 19%, hydropower energy represents 14% and **geothermal energy represents 2%.**

Inside Geothermal

295°C Bottom Well Temperature Recorded at Bozköy Geothermal Project

ThinkGeoEnergy reports that a new record geothermal temperature has been achieved in Turkey. Istanbul-based **3S Kale Enerji** announced a record bottom well temperature of **295°C** at a depth of 3,816 meters at the **Bozköy Geothermal Project** in **Cappadocia**, in central Turkey. This is the hottest geothermal well ever drilled in Turkey. The temperature at the well-head varies between 165 and 190°C.

Financing for Construction of 65 MW Unit 2 of Kızıldere III Geothermal Power Plant

Istanbul-based **Zorlu Enerji** has announced that wholly owned unit **Zorlu Dogal Elektrik** has received project financing credit of **USD 190 million** from the **European Bank for Reconstruction and Development (EBRD), Akbank, Is Bankasi** and **TSKB**, reports *Reuters*.

The funds are to be used for the construction of the **65 MW unit 2 of the Kızıldere III geothermal power plant** in **West Anatolia** in western Turkey. The extension will **increase the plant's capacity** from 100 MW **to 165 MW**. Kızıldere III unit 1 is currently under construction.

Somewhere Over The Rainbow: Kızıldere Power Plant, by Erdinç Sentürk. GRC PHOTO CONTEST.

Tender for Construction of 30 MW Geothermal Power Plant in Armenia to be Issued Next Year

The Armenian Ministry of Energy Infrastructure And Natural Resources has announced there will be a tender for the construction of a **30 MW geothermal power plant** near the town of **Sisian** in southern Armenia in late 2018, according to Deputy Minister **Hayk Harutyunyan**.

Two wells of 1,495 and 1,682 meters deep have already been drilled.

Location of the geothermal power project in southern Armenia.

EDUCATION

SMU Power Plays Conference

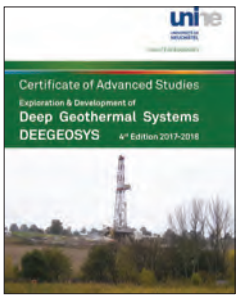
January 10-11, 2018 on the Southern Methodist University (SMU) Campus in Dallas, Texas

The SMU Geothermal Lab invites you to submit an abstract for the upcoming conference, *Power Plays: Drilling into Geothermal Energy Applications.*

You're invited to submit an abstract for the poster session, a 15-20 minute oral presentation, or a panel discussion. **Submit your abstract** by email to geothermal@smu.edu **by Friday October 13, 2017**.

Power Plays will advance the understanding of geothermal resources, providing you with insights into developing this clean energy reserve. Join others with expertise in field operations, project development, technology, finance, engineering and resource assessment from the geothermal, oil & gas, and renewable energy sectors to explore economic solutions for geothermal energy at the *Power Plays: Drilling into Geothermal Energy Applications* conference.

Certificate of Advanced Studies in Deep Geothermal Systems



A training course in deep geothermal systems is being organized by the **Centre for Hydrogeology and Geothermics** of the **University of Neuchatel** in **Switzerland.**

The course includes **4 modules of 5 days each between September 2017 and March 2018** in Neuchatel.

- September 11-15, 2017 - Module 1: Geothermics and Geophysics
- November 13-17, 2017 - Module 2: Geochemistry and Hydrochemistry
- January 15-19, 2018 - Module 3: Drilling and Logging
- March 12-16, 2018 - Module 4: Reservoir Evaluation and Production

The participants include scientists and engineers from the fields of earth sciences and energy. The main objective of this course is to train specialists in deep geothermal systems, who will be then be able to set up and lead geothermal projects in their company or public institution of planning. Participants who complete the training will receive a *Certificate of Advanced Studies.*

All the courses will be given in English by international experts in geothermics. **Deadline for application is June 15, 2017**. More information can be found on the University of Neuchâtel website at: **www.unine.ch/cas-deegeosys.** ■

5 Common Geothermal Energy Myths Debunked

Erin Tulley, Communications Lead, Geothermal Technologies Office

Geothermal energy is safe, reliable, and resides just beneath our feet. It can help meet U.S. energy demands by supplying power to our electric grid and can even be used to heat and cool homes and businesses.

So what are the facts about geothermal energy?

We've targeted five common misunderstandings and reveal the remarkable truths about this amazing natural resource.

Myth: We could run out of geothermal energy

Geothermal energy is a renewable energy and will never deplete. Abundant geothermal energy will be available for as long as the Earth exists.

Myth: Renewables cannot supply energy 24/7

Geothermal power plants produce electricity consistently, running 24 hours a day, 7 days a week, regardless of weather conditions. The power output of a geothermal power plant is highly predictable and stable, thus facilitating energy planning with remarkable accuracy. Geothermal power plants are also an excellent means of meeting base load energy demand (i.e. the minimum level of demand on an electrical grid during a 24-hour period).

Myth: Geothermal power plants take up a lot of space

Geothermal energy has the smallest land footprint of any comparable energy source in the world. They are compact and use less land per gigawatt hours (404 m2) than coal (3642 m2), wind (1335 m2), or solar photovoltaics plants (3237 m2).

Myth: Generating electrical power from geothermal sources causes pollution

Electrical power does not, by its nature, create pollution. Modern closed-loop geothermal power plants used to generate electrical power do not emit greenhouse gases. Additionally, they consume less water on average than most conventional power generation technologies.

Myth: Geothermal energy is only accessible in certain parts of the United States

Geothermal heat pumps can be used just about anywhere in the United States because all areas have nearly constant shallow ground temperatures—although systems in different locations will have varying degrees of efficiency and cost savings.

Thanks to the U.S. Department of Energy's Geothermal Technologies Office for this article. ■

Electricity generation in Central America: Some relevant comments on the importance of renewables, including geothermal

Marcelo J. Lippmann[1] and Ronald DiPippo[2]

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Introduction

The purpose of this note is to point out the growing importance of renewable energy sources on the electricity market (and the economy) of a country, or even a region. We will use Central America, particularly Costa Rica, Guatemala and Panama as illustrative examples.

The effects of recent droughts on Central America's electricity market

The rise of the global average temperature has been extensively documented and is manifest in widespread changes in weather patterns. Scientific studies indicate that extreme weather events such as heat waves and large storms have led to droughts as well as floods, and are likely to become more frequent or more intense with climate change. The lack (or excess) of precipitation has been felt in many parts of the globe; Central America has not been exempt.

The recent drought events felt in parts of Central America strongly impacted the region's economies (ReliefWeb, 2017). The inadequate amounts of available water affected the local population, industry and agriculture; subsistence farmers were particularly hit because of crop failures that, in some instances, led to famine.

Here we will focus on one particular effect of the droughts on this part of Latin America, i.e., the reduced levels of hydroelectric generation. We also will highlight the role of renewables in reducing the need to import (and burn) larger amounts of fossil fuels, which are not indigenous to any of the countries, to satisfy the region's growing electricity demand.

Central America's electricity generation is highly dependent on hydropower and fossil fuels, more so in some of the countries than others. Please note that in this article we will cover the countries of Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama, leaving aside Belize because of its small electricity market.

Years ago when geothermal, solar, and wind plants were not a commercial option, when droughts occurred that led to lower hydropower production, fossil power plants had to increase their output to satisfy local electricity demands. This meant burning larger amounts of imported oil products, coal and/or natural gas, which increased electricity costs. During the last five years, and even before, some (not all) of those deficits were more and more covered by geothermal, wind and solar plants; see Table 1 and Figure 1. The data for this and other tables presented here were obtained from reports (in Spanish) issued by the Economic Commission for Latin America and the Caribbean (ECLAC in English or CEPAL in Spanish).

Table 1. Central America: Electricity Sector; Net Generation Totals for Years 2010-2015

	Net Generation (GWh)							
Year	Geo	Hydro	Wind	Solar	Bio	Cogen	Fossil	Total
2010	3131.1	20,974.4	519.0	-	0.1	1775.9	14,267.5	40,668.0
2011	3188.2	20,626.0	737.7	-	19.5	1717.3	16,003.2	42,291.9
2012	3542.4	22,143.6	1191.5	0.3	23.1	1729.9	15,650.9	44,281.7
2013	3778.8	21,671.4	1351.4	1.4	32.8	2305.9	16,665.9	45,807.6
2014	3819.0	21,341.6	2079.9	10.1	33.0	2530.6	17,044.9	46,859.1
2015	3664.6	22,235.7	2869.8	586.4	37.1	3698.1	15,681.7	48,773.4

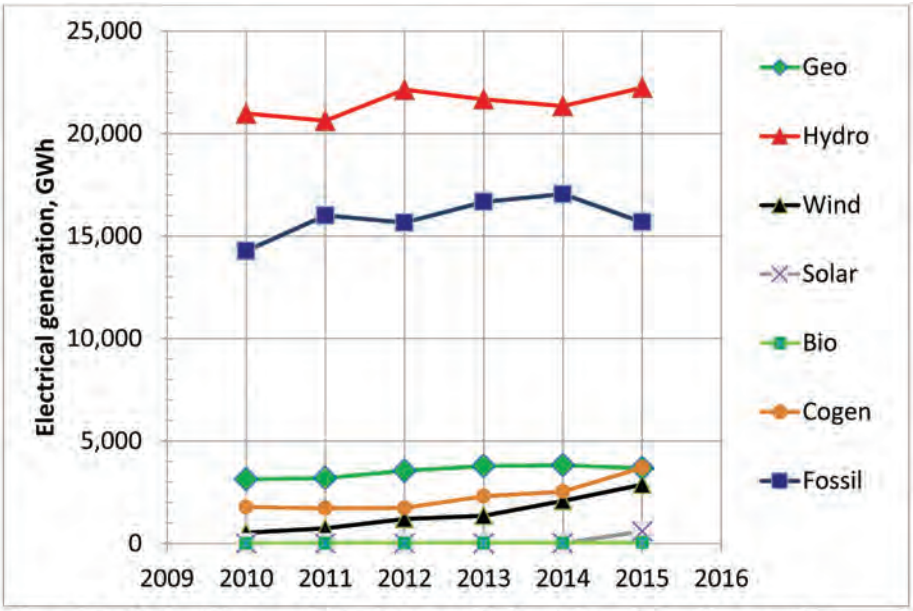


Figure 1. Total electricity generated by all sources for the six Central American countries included in this report.

Table 2 is based on 2015 data taken from a 2016 CEPAL report; (CEPAL, 2016). That year, Central America got 45.6% of its electricity from hydro (22,235.8 GWh out a total of 48,773.4 GWh). The corresponding hydro percentages for the region's individual countries were: Costa Rica 75.2 %; Panama 66.0%; Guatemala 37.4 %, Honduras 27.7%; El Salvador 25.2%, and Nicaragua 6.9%.

Table 2. Central America: Electricity Sector: Net Generation for Year 2015

	Net Generation (GWh)						
Source	Total	Costa Rica	El Salvador	Guatemala	Honduras	Nicaragua	Panama
Geothermal	3664.6	1375.6	1432.4	251.5	---	605.0	---
Hydro	22,235.8	8066.6	1419.4	3851.8	2340.1	289.7	6268.2
Thermal[1]	19,416.8	190.4	2773.5	5942.0	5037.8	2419.4	3053.7
Wind	2869.8	1079.5	-	107.3	664.6	852.8	165.6
Solar	586.4	1.5	-	149.3	417.2	2.1	16.3
Totals	48,773.4	10,713.6	5625.3	10,301.9	8459.7	4169.0	9503.8

[1]Power plants burning fossil fuels and biomass/biogas plus cogeneration.

Gauging the effect of droughts on hydropower and fossil power generation

We use the capacity factor (CF) to quantify the impact of droughts on hydropower and fossil power generation. Note that this factor can be applied to one given power plant, and is equal to the actual generation (in MWh or GWh) divided by the installed capacity (in MW or GW) times the number of hours in the year, 8760 or 8784 for a normal or Leap Year, respectively;

$$CF = \frac{Actual\ annual\ electricity\ generated\ (MWh)}{Installed\ capacity\ (MW) \times hours}$$

However, the CF can also be used to characterize an entire generation system for a given country. For more details, consult Mines et al. (2015) discussing the correct (and incorrect) definition of "Geothermal Plant Capacity Factor."

Application of region-wide capacity factor to Central America's electricity generation

At this stage one should be reminded that geothermal is the only renewable energy resource whose plants' ability to generate electricity is not impacted by time-of-day or typical weather conditions. Of course, extraordinary, catastrophic weather events such as hurricanes, typhoons, earthquakes and tsunamis can take geothermal plants off-line, but once transmission lines are repaired, the plants usually resume producing power. For example, following the March 11, 2011 magnitude 9.0 earthquake and tsunami off the northern coast of Japan that destroyed the Fukushima-Daiichi nuclear power station, of the nine geothermal plants in the vicinity that were in operation, three never went off-line, while the other six tripped but were back operating within four days (taken from IGA News, No. 84, April-June 2011, pp. 8-10.)

The electricity output of geothermal plants does vary depending on the prevailing local temperature and humidity conditions, with the effect being small for flash-steam plants that use wet cooling towers (usually less than 5% of their gross output)

Table 3. Central America: Electricity generation from fossil fuels for years 2010–2015

Year	2010	2011	2012	2013	2014	2015
Net generation (GWh)	14,267.5	16,003.2	15,650.9	16,665.9	17,044.9	15,681.7
Installed capacity (MW)	5237.6	5279.7	5226.7	5408.8	5376.8	5596.8
Capacity factor	0.3110	0.3460	0.3409	0.3517	0.3619	0.3199

Table 4. Central America: Hydroelectric generation for years 2010–2015

Year	2010	2011	2012	2013	2014	2015
Net generation (GWh)	29,974.4	20,626.0	22,143.6	21,671.4	21,341.6	22,235.7
Installed capacity (MW)	4490.8	4967.6	5284.3	5380.7	5724.6	6008.6
Capacity factor	0.7619	0.4740	0.4771	0.4598	0.4256	0.4224

Table 5. Central America: Solar & wind electricity generation for years 2010 – 2015

Year	2010	2011	2012	2013	2014	2015
Net generation (GWh)	519.0	737.7	1191.8	1352.8	2090.0	3456.2
Installed capacity (MW)	182.6	297.8	396.8	417.7	598.1	1415.3
Capacity factor	0.3245	0.2828	0.3419	0.3697	0.3989	0.2788

Table 6. Central America: Geothermal electricity generation for years 2010 –2015

Year	2010	2011	2012	2013	2014	2015
Net generation (GWh)	3131.1	3188.2	3542.4	3778.8	3819.0	3664.6
Installed capacity (MW)	506.8	558.6	635.6	625.6	625.6	625.5
Capacity factor	0.7053	0.6515	0.6345	0.6896	0.6969	0.6688

and considerably larger for binary plants, especially ones with air-cooled condensers (up to 40% reduction in very hot weather). Whereas this can be a major concern in many locations in the United States, in the context of this article, it should be noted that day-to-day average temperature and humidity variations in Central America are not drastic.

Given their reliability and the nature of the resource, most geothermal plants operate a significant fraction of the time and their CF is higher than those of fossil, hydro, solar and wind plants. Tables 3 to 6 show the CFs calculated using the data for all fossil, hydro, solar & wind, and geothermal plants in all Central America for the years 2010 to 2015. The combined Central American geothermal plants have the highest CFs, i.e., between 0.635 and 0.705; see Table 6. On the contrary, those of the solar and wind plants taken together have the lowest, i.e., between 0.279 and 0.399 (see Table 5), which is not surprising considering the intermittent nature of these resources.

Let us now use the data from the three countries of the region that most depend on hydropower: Costa Rica, Guatemala and Panama (see Table 1) to illustrate the effects of the droughts on electricity generation.

Tables 7 to 9 show the net electricity generated by all hydro and fossil plants for the period 2010-2015 in Costa Rica, Guatemala and Panama, respectively. These three countries are examples where hydroelectric and fossil fuel generations tend to complement one another. In general, whenever hydro generation dips owing to drought, more fossil fuels must be used to compensate for the loss. From Tables 7 to 9 and from Figures 2 to 4 one can

Table 7. Costa Rica: Hydropower & fossil fuel electricity generation for years 2010-2015

Year	2010	2011	2012	2013	2014	2015
Hydropower						
Net generation (GWh)	7261.7	7134.6	7233.2	6851.0	6717.2	8066.6
Installed capacity (MW)	1553.2	1643.9	1700.3	1725.3	1834.2	1935.4
Capacity factor	0.5337	0.4954	0.4843	0.4533	0.4181	0.4758
Fossil Fuels						
Net generation (GWh)	641.2	863.3	830.3	1196.0	1043.2	108.1

Table 8. Guatemala: Hydropower & fossil fuel electricity generation for years 2010-2015

Year	2010	2011	2012	2013	2014	2015
Hydropower						
Net generation (GWh)	3767.0	4094.2	4434.9	4630.8	4823.7	3851.8
Installed capacity (MW)	884.7	902.3	986.0	996.6	1032.9	1087.0
Capacity factor	0.4861	0.5180	0.5121	0.5304	0.5331	0.4045
Fossil Fuels						
Net generation (GWh)	2908.8	2917.5	3012.2	2906.9	2927.0	3251.8

Table 9. Panama: Hydropower & fossil fuel electricity generation for years 2010-2015

Year	2010	2011	2012	2013	2014	2015
Hydropower						
Net generation (GWh)	4220.9	4071.9	5368.0	5154.3	5025.7	6268.2
Installed capacity (MW)	934.7	1293.4	1468.1	1493.8	1623.1	1721.9
Capacity factor	0.5155	0.3594	0.4163	0.3939	0.3535	0.4156
Fossil Fuels						
Net generation (GWh)	3027.5	3630.5	3016.9	3706.0	4055.6	3053.7

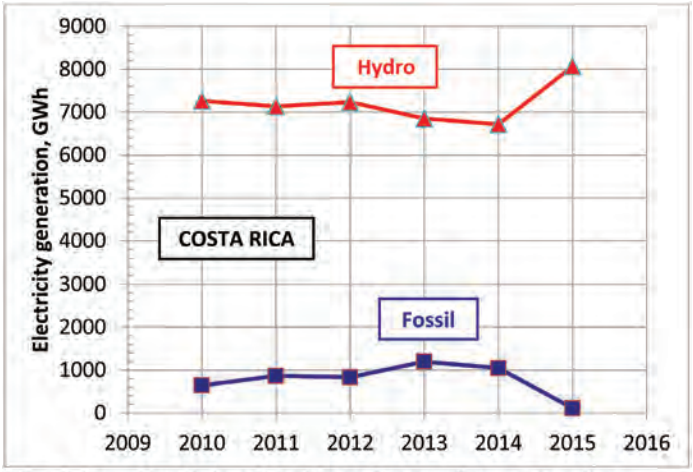


Figure 2. Costa Rica: Hydro and fossil generation complement one another.

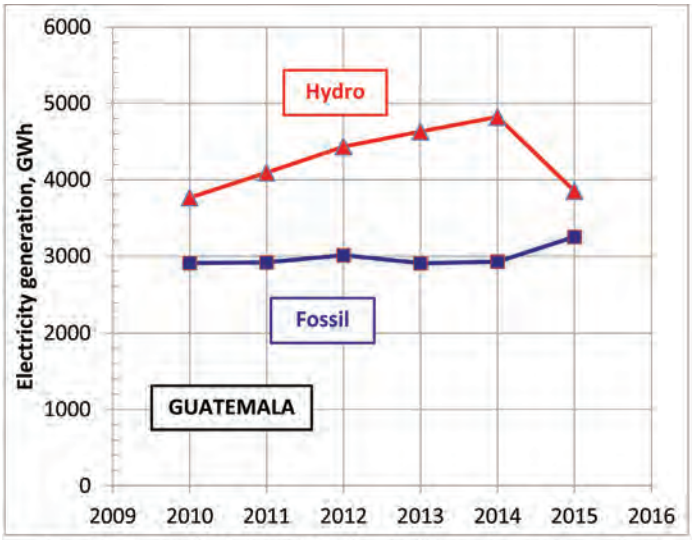


Figure 3. Guatemala: Hydro and fossil generation complement one another.

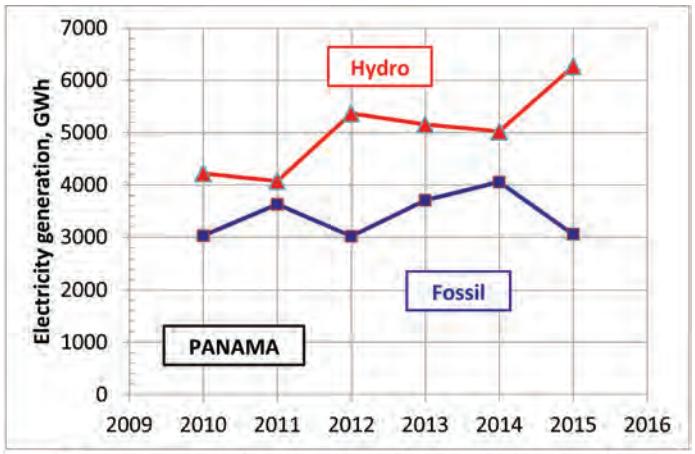


Figure 4. Panama: Hydro and fossil generation complement one another.

observe that the highest hydro and lowest fossil generation occurred in Costa Rica in 2015, likewise for Panama. On the other hand, lows in hydro were accompanied by highs in fossil plant generation in Costa Rica in 2013 and 2014 and in Panama in 2014. Similar correspondence also exists in the case of Guatemala, but not as strongly as in Costa Rica and Panama (see Table 8 and Figure 3).

There is a definite inverse relationship between the levels of hydro and fossil power generation, not only in the three countries most dependent on hydro, but for the entire Central American region, as can be seen from the upper two curves in Figure 1. One can speculate that that correlation would have been even stronger if the Central American Electric Interconnection System (SIEPAC) transmission line and the Regional Electricity Market (MER) had not existed; (Proyecto Mesoamérica, 2017).

The construction of that line began in 2006 and completed in 2014, but parts of it started operating before that. Once this transmission line was functional, it was possible to exchange power between the Central American countries. One should remember that the droughts were not felt in the same intensity in all areas of the region and not at the same time. [Note that Guatemala is on the northern part of Central America, while Costa Rica and Panama are at the southern end of the region.]

Our speculation is supported by what was (and is) happening in Kenya, a country that is highly dependent on hydropower, but is not connected to a regional interconnected transmission line. An article on the Internet mentions that the current drought has resulted in lower hydropower production and required the use of the country's thermal power stations, pushing up electricity prices; (Richter, 2017). The article added that "Geothermal energy remains an important tool for Kenya's future energy mix and lower electricity prices. [It] is seen as a key tool to improve the country's energy mix and decrease electricity prices for the general public and businesses in the country."

Final Remarks

One should stress that worldwide not only geothermal, but also solar, wind and biomass help reduce the amount of fossil fuel that has to be burned to generate power when droughts occur. That dependency on polluting and non-renewable fossil energy sources should greatly diminish as the installed capacity of geothermal and other renewable resources continue to increase in the future.

The following reports/references include discussions on the effects of climate change (and droughts) on electricity generation:

1) van Vliet, M.H.T., Sheffield, J., Wiberg, D., and Wood, E.F., 2016. Impacts of recent drought and warm years on water resources and electricity supply worldwide. Environ. Res. Lett. 11 (2016) 124021. http://iopscience.iop.org/article/10.1088/1748-9326/11/12/124021/pdf

2) CEPAL, 2015. Climate Change in Central America: Potential Impacts and Public Policy Options. CEPAL report, 176 pp. http://repositorio.cepal.org/bitstream/handle/11362/39150/S1501174_en.pdf;sequence=1

3) IRENA, 2016. Renewable Energy Market Analysis – Latin America. IRENA report, 160 pp. http://www.irena.org/DocumentDownloads/Publications/IRENA_Market_Analysis_Latin_America_2016.pdf

Citations

CEPAL, 2016. Estadísticas de producción de electricidad de los países del Sistema de la Integración Centroamericana (SICA): datos preliminares a 2015. CEPAL report, 57 pp. http://repositorio.cepal.org/handle/11362/40325.

Mines, G., Richard, C., Nathwani, J., Hanson, H. and Wood, R., 2015. Geothermal Plant Capacity Factors. In: Proc. Fortieth Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, CA., 8 pp. https://pangea.stanford.edu/ERE/db/GeoConf/papers/SGW/2015/Nathwani.pdf

Proyecto Mesoamérica, 2017. Sistema de Interconexión Eléctrica de los Países de América Central (SIEPAC). http://www.proyectomesoamerica.org/joomla/index.php?option=com_content&view=article&id=171&Itemid=100

ReliefWeb, 2017. Central America: Drought - 2014-2017. http://reliefweb.int/disaster/dr-2014-000132-hnd.

Richter, A., 2017. Dry period and low hydro output highlights importance of geothermal in Kenya. ThinkGeoEnergy, 19 February 2017. http://www.thinkgeoenergy.com/dry-period-and-low-hydro-output-highlights-importance-of-geothermal-in-kenya/ ■

This Just In...

Late breaking news from the global geothermal community

by Ian Crawford, GRC Director of Communications

Calpine Sounding Out Possible Buyers

The *Wall Street Journal* reports that **Calpine Corp.**, owner of geothermal power plants at **The Geysers** in northern California, is exploring a sale.

The Houston company, which owns a total of 80 power plants and has a so-called enterprise value of more than **USD 15 billion**, is working with investment bankers at **Lazard** to sound out possible buyers, according to people familiar with the matter.

Calpine has attracted interest from a number of private-equity firms in an auction that is at an early stage, the people said. As always, there is no guarantee there will be any deal.

Japanese Company Acquires 22% Stake in Ormat

Ormat Technologies, Inc. and **ORIX Corporation**, a financial services group headquartered in Minato, Tokyo, and Osaka, Japan, have announced that ORIX will acquire an approximately **USD 627 million** ownership stake in Ormat by purchasing approximately 11.0 million shares of Ormat common stock from **FIMI ENRG Limited Partnership, FIMI ENRG, L.P., Bronicki Investments, Ltd.**, and senior members of management, representing in the aggregate an approximately **22.1% ownership position** in Ormat.

The parties expect **closing to occur in the third quarter of 2017.**

EUR 10 Million Available to Research Enhanced Geothermal Systems in Different Geological Conditions

The **European Commission** has announced the last call for funding under the current **Horizon 2020 'Secure, Clean and Efficient Energy'** Work Programme. Applicants are invited to **submit their project proposals** aiming to demonstrate innovative renewable energy technologies **by 7 September 2017**. The total available budget is EUR 105 million.

The topic entitled **Enhanced Geothermal Systems in different geological conditions**, will be awarded **EUR 10 million**.

Proposals should aim at **testing EGS systems to ensure reservoir productivity in different geological settings and energy production at competitive costs.** Proposals could propose up-scaling existing EGS systems.

More information can be found on the European Commission website at: https://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/lce-18-2017.html

4,000 Meter Deep Geothermal Well Being Drilled for Greenhouse Warming Project in Netherlands

DutchNews.nl reports that work has begun on boring a **four-kilometer-deep** well below the **Westland** greenhouse growing region near **The Hague.**

The pilot **Trias Westland** well will be **operative in September** but it will be December before the first geothermal heat is pumped up to serve the vast flower and vegetable growing greenhouses in the area. The heat comes in the form of **water heated to 140°C.**

The **EUR 50m pilot project** will be twice the size of other geothermal heating plants in the Netherlands. **43 growers** have committed to buying the geothermal heat which, if successful, is expected to **provide between 10% and 20% of annual heating needs.** ■

Yellowstone - A Geothermal Wonderland

A GRC Fieldtrip led by Duncan Foley and Roy Mink

Half the world's geysers! 10,000 thermal features! Bubbling mud pots! A restless caldera!

GRC Fieldtrip: Thursday September 28 - Sunday October 1, 2017

Join the GRC on a trip of a lifetime to experience the wide range of hydrothermal features in Yellowstone immediately before the GRC Annual Meeting. Our focus will be on surface manifestations of hydrothermal systems, what is known about their subterranean plumbing, and how the systems fit into their geologic and volcanic contexts. Yellowstone has a unique concentration of heat, water, and geologic structures, which allows us to experience the world's greatest concentration of geysers, mud pots and hot springs.

The trip will be over four days, leaving mid-morning on Thursday September 28 and returning to Salt Lake City in time for the Sunday night GRC/GEA Opening Reception on October 1. We plan to travel by luxury bus, and include stops on our way to and from Yellowstone. A tentative itinerary is described below.

The specific plans for each day may be modified to accommodate various interests expressed by trip participants and changes encouraged by geological events, such as unanticipated geyser eruptions. We may experience a wide range of weather conditions, from sunny and warm to cold, wet and snowy. Old Faithful is at an elevation of about 7,300 feet (or slightly more than 2,200 meters), so our walks will offer an option for a pace suitable to accommodate those from lower elevations. We will be walking on improved trails and boardwalks throughout our trip. Participants need to be prepared for inclement weather, but do not need to be prepared for off-trail or backcountry trekking.

Thursday, September 28

- **We leave Salt Lake City** mid-morning on Thursday to start our drive to West Yellowstone, Montana. As we drive north along highway I-15, we will point out important geologic and geothermal features along the Wasatch Fault, the Wasatch Mountain Range, and the Great Salt Lake.

Panoramic view of Norris Geyser Basin. Joe Moore, June 2015.

- Our first geologic stop will be south of Idaho Falls. Here we will discuss the geology of the **Snake River Plain**, the sequence of buried calderas that marks the plain, and have the chance to walk along improved trails through a several thousand-year-old basalt flow. We leave the interstate at Idaho Falls, and drive toward West Yellowstone.

Tour leader Duncan Foley explains the geology of the Snake River plain on a GRC Fieldtrip in 2015. PHOTO BY IAN CRAWFORD

- We plan to stop at **Mesa Falls**, a scenic waterfall along the Henry's Fork River. We will continue our discussion of calderas while we are at the waterfall, as the rocks here mark the second of three major super-volcano eruptions that compose the Yellowstone volcanic field.

Mesa Falls. PHOTO BY ROY MINK

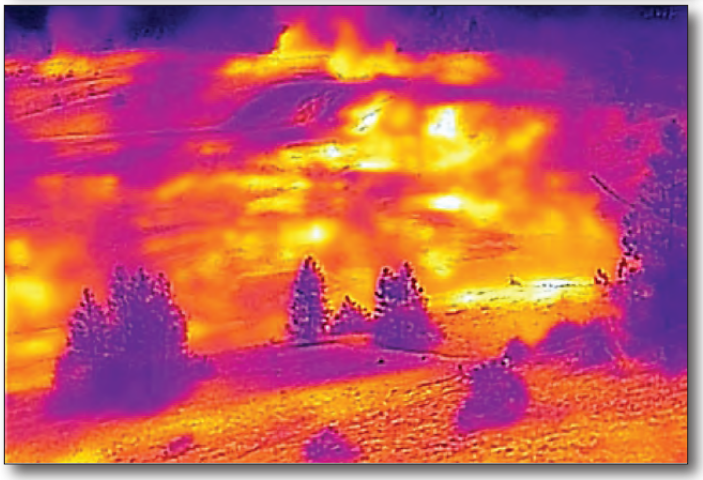
- After the falls, we will head to **West Yellowstone** where we will settle into our motel for the next two nights, and enjoy the local cuisine (Buffalo Burgers anyone?!).

The Three Bears Lodge in West Yellowstone. COURTESY THREE BEARS LODGE

Friday and Saturday, September 29 and 30

We will spend most of Friday and Saturday exploring geothermal and geologic features of Yellowstone. Our travels will emphasize the geology and hydrothermal features that are within or immediately adjacent to the Yellowstone Caldera. At each stop, we will review the local geological and geophysical environments and introduce trip participants to important hydrothermal features. The geochemical data will be used to infer what might be happening in the subsurface. We will describe results from recently-published research, as well as older data, such as the results of drilling that occurred in 1929, 1930 and the 1960s. Where appropriate, we will weave in links among geological, biological and cultural (human history) factors as part of our conversations.

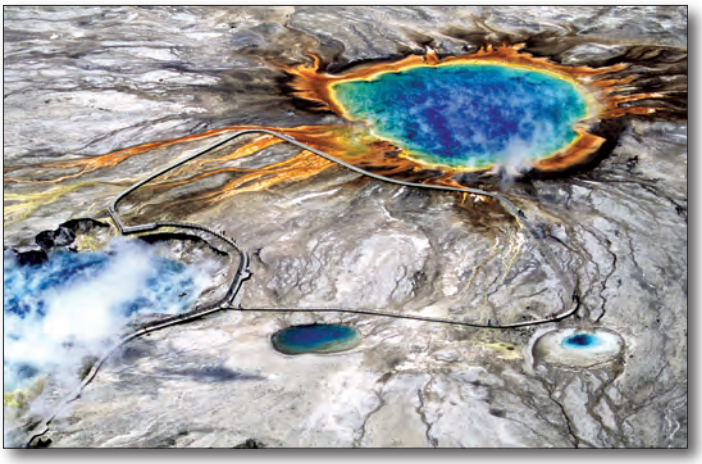
Among the sites that we plan to see are:



Two views of Porcelain Basin at Norris. On the top is a normal view. On the bottom is a Forward Looking Infrared (FLIR) image showing the same scene. The hot areas show up as paler areas in the image. PHOTOS BY DUNCAN FOLEY

- **Norris Geyser Basin** – This geyser basin features highly dynamic thermal systems, which tap some of the deepest and hottest waters in the park. Norris Geyser Basin is located where an old fault zone intersects the margin of the Yellowstone Caldera and where the zones are kept permeable by seismic activity. Geysers at Norris erupt at intervals ranging from a few minutes to several decades. It's impossible to predict which of these geysers will erupt during our visit. This area also has unusual acidic waters in some of its geysers and thermal features.

- **Midway Geyser Basin** – This is the site of Grand Prismatic Hot Spring, which is the largest in the park, and among the most colorful. We will travel along the boardwalk to see both Grand Prismatic and the crater left by Excelsior Geyser.



Grand Prismatic and Excelsoir Hot Springs from above. PHOTO BY DUNCAN FOLEY

- **Upper Geyser Basin** – This area is home to many of the Park's most famous geysers. We will see Old Faithful, and discuss what is currently inferred about the subterranean plumbing of geysers, and look at potential interactions between thermal systems and human activities. We will select the route of our walks based on short- term forecasts for other major geysers, such as Grand, Riverside and Daisy. There will be options for short walks, as well as an option for a walk of several miles.

Beehive (foreground) and Old Faithful geysers erupting simultaneously. PHOTO BY DUNCAN FOLEY

Riverside Geyser. PHOTO BY ROY MINK

- **Grand Canyon of Yellowstone** – The Grand Canyon provides a three-dimensional crosscut through highly altered rocks, which host hydrothermal systems. We will look at the intricate fracture networks that occur in the rocks as analogues for water circulation beneath geyser basins.

- **Mud Volcano area** – This is a large zone of vapor-dominated features, such as mud pots, fumaroles and vapor-driven churning pools. We will discuss the geologic history of this area, as well as caldera unrest, while we walk the boardwalks here.

- **Mary Bay** – Hydrothermal explosion craters are one of the manifestations of a highly active volcano. Mary Bay, located on the north shore of Yellowstone Lake, is one of the largest such craters in the world. We will walk along its hot shoreline and discuss the origins of hydrothermal explosions and the risks such explosions currently present to visitors.

- **West Thumb Geyser Basin** – This area is home to Fishing Cone and other thermal features that poke through the lake's surface. West Thumb will be our last look at geysers before we head south.

Fishing Cone Geyser - Walter Trumbull of the 1870 Washburn-Langford-Doane Expedition described a unique event while a man was fishing adjacent to the cone:"…in swinging a trout ashore, it accidentally got off the hook and fell into the spring. For a moment it darted about with wonderful rapidity, as if seeking an outlet. Then it came to the top, dead, and literally boiled." PHOTO BY IAN CRAWFORD

- On Saturday afternoon we will leave Yellowstone and drive to Jackson, Wyoming, where we will stay Saturday night. Our drive will take us past the **Teton Range**. We will stop at least once on our drive to stretch our legs and view the spectacular mountains.

A GRC Fieldtrip in Grand Teton National Park, 2015. PHOTO BY IAN CRAWFORD

Sunday, October 1

For those who are interested, we will to offer a sunrise trip to photograph the Tetons. After returning to town for breakfast and joining with those who didn't want to rise well before the sun, we will drive back to Salt Lake City. We will travel via a different route than we took northbound, which will take us through the overthrust belt. This route will give us the opportunity to discuss the geology and thermal features of this fascinating, complex geological environment.

The Teton Range rises to more than 13,000 feet above sea level. PHOTO BY DUNCAN FOLEY

Registration

Sign-up on the GRC Annual Meeting webpage at https://geothermal.org/meet-new.html. There are only 24 places available so register as soon as you can.

Included in the cost of the fieldtrip is transport in a luxury minibus, double occupancy accommodation at two hotels, daily breakfast and lunch and one group dinner at the Old Faithful Inn.

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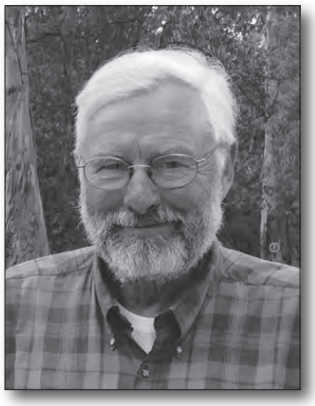
Trip Leaders

GRC Fieldtrips offer the opportunity to observe geothermal features in beautiful surroundings and learn about the science of geothermal energy from world-renowned experts in the field. This trip will be no exception.

Roy Mink



Leland "Roy" Mink began his career as a hydrogeologist with the Idaho Bureau of Mines and Geology. He was a geothermal energy project manager for the Department of Energy, spent eight years as a hydrology project engineer for Morrison-Knudsen Co in Boise, and for more than ten years directed the Idaho Water Resources Research Institute at the University of Idaho. Most recently, he was Program Director of the Geothermal Technologies Program for the Department of Energy in Washington DC.

Currently, he is consulting in water and geothermal energy in both domestic and international projects and is a GRC Board Director. Roy has taught summer courses at the Yellowstone Institute for 25 seasons. Over the years, he has led many field trips through the park and surrounding areas.
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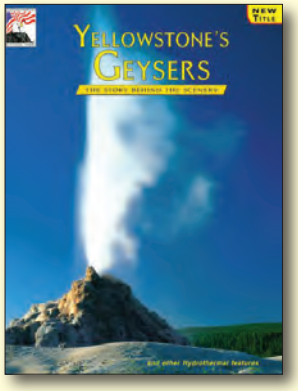
Duncan Foley

PHOTO BY MANUEL CANALES

Duncan Foley has been leading field trips and conducting research in Yellowstone Park for more than forty years. He has taught the geology of Yellowstone to geothermal professionals, park guides, tourists, and the Park Service. He is currently conducting research on the near-surface geology of Old Faithful Geyser and the nearby thermal deposits.

Duncan's photographs of Yellowstone's thermal features and descriptions of their geology are highlighted in his book, "Yellowstone's Geysers and other hydrothermal systems", which is in now in its third printing.



All attendees on the fieldtrip will get a copy of the 40-page full-color book "Yellowstone's Geysers and other hydrothermal systems" by tour leader Duncan Foley.

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For the most up-to-date information on this fieldtrip go to the Fieldtrips webpage for the GRC Annual Meeting at: https://goo.gl/CHspdO ■

Registration Opens Late June
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Publications, Websites, Videos & Maps

by Ian Crawford

2016 Annual Report from Geothermal Technologies Office

The **Geothermal Technologies Office (GTO)** of the U.S. **Department of Energy (DOE)**, Department of **Energy, Office of Energy Efficiency and Renewable Energy (EERE)**, has released its *2016 Annual Report* recognizing advances in transformative, high-risk/high-reward science and engineering from GTO's portfolio.

The 2016 issue highlights project successes and continued efforts in **Enhanced Geothermal Systems (EGS), Hydrothermal, Low Temperature and Co-produced Resources**, and **Systems Analysis** – which are flanked by useful tools, resources, and links to more information. Highlights include **FORGE** and EGS advancements, projects reducing geothermal costs and risks, and advancements in technology research and development.

Download the *GTO 2016 Annual Report* from the GTO website at: https://energy.gov/eere/geothermal/geothermal-energy-us-department-energy

IRENA Suggests Adding 283 GW of Geothermal to help Reduce CO_2 Emissions

Global energy-related carbon dioxide (CO_2) emissions can be reduced by 70% by 2050 and completely phased-out by 2060 with a net positive economic outlook, according to new findings by the **International Renewable Energy Agency (IRENA).**

In the report *Perspectives For The Energy Transition: Investment Needs For A Low-Carbon Energy System*, a base is set at 12 GW of geothermal in 2015 and projects an **increase to between 36 GW and 126 GW by 2030** and between **63 GW and 283 GW by 2050.**

In the more extreme **66% 2°C Scenario**, renewable energy technologies taken together

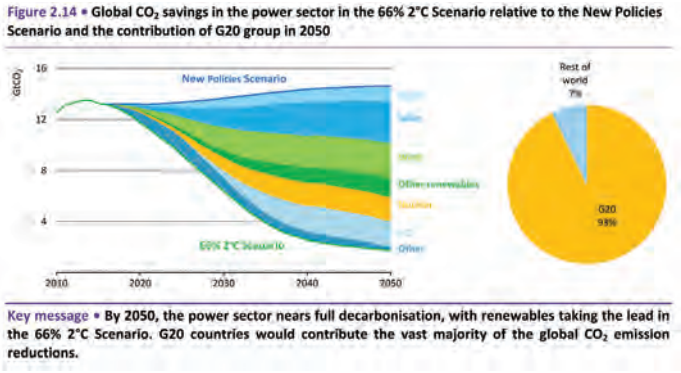


Figure 2.14 • Global CO_2 savings in the power sector in the 66% 2°C Scenario relative to the New Policies Scenario and the contribution of G20 group in 2050

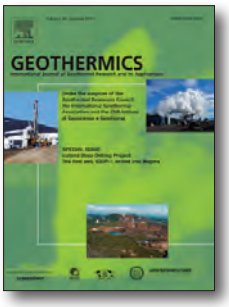
Key message • By 2050, the power sector nears full decarbonisation, with renewables taking the lead in the 66% 2°C Scenario. G20 countries would contribute the vast majority of the global CO_2 emission reductions.

would account for about 60% of CO_2 emissions reduction to 2050 relative to the more moderate **New Policies Scenario** in the power sector.

Additional use of Solar PV, wind power, hydropower, bioenergy, geothermal and concentrated solar power (CSP) will contribute to emissions reductions. Nuclear and CCS-equipped power plants account for the remaining one-quarter of emissions reduction by 2050 in the 66% 2°C Scenario, compared with the New Policies Scenario.

The full report can be downloaded at: www.irena.org/DocumentDownloads/Publications/Perspectives_for_the_Energy_Transition_2017.pdf

Geothermics, July 2017



The Table of Contents for Geothermics Volume 68 follows:

"Research of production of CO2 from non-condensable gases in geothermal fluid and cost analysis", by R. Karabacak et al., pp. 1-8.

"Pavement temperature mitigation by the means of geothermally and solar heated air", by A. Chiarelli et al., pp. 9-19.

"Resistivity imaging of geothermal resources in northern Kenya rift by joint 1D inversion of MT and TEM data", by C.M. Lichoro et al., pp. 20-32.

"Using ground penetrating radar, scanning electron microscopy and thermal infrared imagery to document near-surface hydrological changes in the old faithful Geyser area, Yellowstone National Park, U.S.A.", by B.Y. Lynne et al., pp. 33-53.

"The impact of reduction of doublet well spacing on the Net Present Value and the life time of fluvial Hot Sedimentary Aquifer doublets", by C.J.L. Willems et al., pp. 54-66.

"Conceptual model of the Gülbahçe geothermal

system, Western Anatolia, Turkey: Based on structural and hydrogeochemical data", by T. Uzelli et al., pp. 67-85.

"Pore structure development of blended G-oil well cement submitted to hydrothermal curing conditions", by E. Kuzielová et al., pp. 86-93.

"Snapshot of hot-spring sinter at Geyser Valley, Wairakei, New Zealand, following anthropogenic drawdown of the geothermal reservoir", by N. Watts-Henwood et al., pp. 94-114.

"Erratum to 'On the impact of spatially heterogenous permeability on free convection in the Perth Basin, Australia' GEOT, 66 (2016) 119-133", by J. Niederau, pp. 115.

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Through affiliation with the **International Geothermal Association (IGA)** the GRC offers a discount to the professional journal *Geothermics*, which publishes articles on the theory, exploration techniques and all aspects of utilizing geothermal resources.

Members can contact the publisher Elsevier at JournalsCustomerServiceEMEA@elsevier.com in order to subscribe to the journal. Upon request Elsevier will send a *proforma* invoice to the member e-mail ID.

Members can make their payment via bank transfer, fax their card details or call Elsevier with the information provided in their invoice.

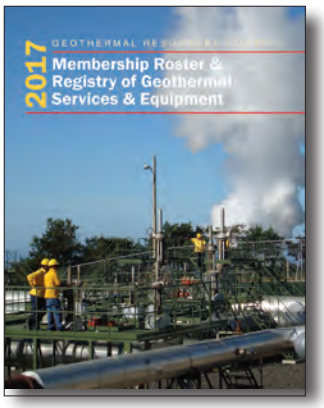
The discounted price details for IGA/GRC members is $285. ■

GRC New Members

New Members of the Geothermal Resources Council

The 2017 edition of the *GRC Membership Roster and Registry of Geothermal Services and Equipment* has been sent to all GRC members.

The "Phone Book" for the world geothermal industry, the *GRC Membership Roster* provides contact information for more than 1,000 corporate and individual members of the GRC in cross-referenced lists for speedy access. In addition, this



premier publication offers contact information for additional geothermal associations and a number of federal and state geothermal offices. This valuable publication is also available to non-members for a low price of $25. More information on ordering at: www.geothermal.org/roster.html

The following have recently joined the global community of the GRC and are not listed in the GRC *Membership Roster*:

GeothermEx, A Schlumberger Company	California, USA
TNG Energy Services Inc.	California, USA
Veizades & Associates, Inc.	California, USA
Alban, Ethan	Canada
Barnett, Peter	New Zealand
Bloomquist, R. Gordon	Washington, USA
Broadhurst, Travis	North Carolina, USA
Carter, Anna	Oregon, USA
DuToit, Dana	South Carolina, USA
Fan, Kevin	Canada
Gerner, Edward	Australia
Glaspey, Doug	Idaho, USA
Gustafson, Emily	Colorado, USA
Johnson, Molly	Washington, USA
McCloud, Mary	Florida, USA
McCurry, Michael	Idaho, USA
Mink, Roy	Idaho, USA
Nakagawa, Masami	Colorado, USA
Pedamallu, Lakshman	Portugal
Permata, Ilham	Colorado, USA
Pollack, Ahinoam	Massachusetts, USA
Smith, Clinton	Kentucky, USA
Song, Yoonho	South Korea
Swanson, Robert	California, USA
Van Hof, Ralph	Netherlands
Williams, Colin	California, USA

Contact information for these and all other GRC Members can be found in the online GRC Member Database at https://eseries.geothermal.org (access for Members only). ■
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Calendar of Events

National Geothermal Academy - Module 1: Geothermal drilling engineering
19-23 June, Reno, Nevada, USA
www.gbcge.org/education-NGA.php

National Geothermal Academy - Module 2: Geothermal reservoir engineering
26-30 June, Reno, Nevada, USA
www.gbcge.org/education-NGA.php

Indonesia International Geothermal Convention & Exhibition 2017
2-4 August, Jakarta, Indonesia
www.iigce.com/

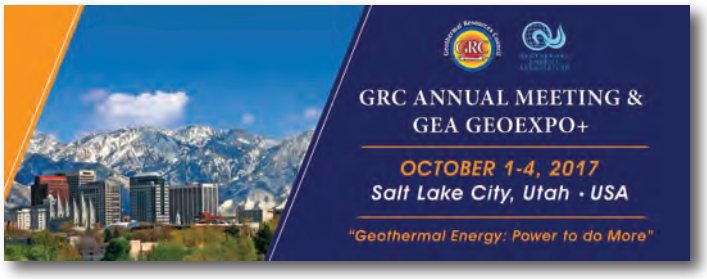
Clean Power for the South Pacific Conference 2017
7-11 August, Vanua Levu, Fiji
www.geothermalcities.com/en

Praxisforum Geothermie
11-12 September, Munich, Germany
www.praxisforum-geothermie.bayern/en

CAS Deep Geothermal Systems - Certificate of Advanced Studies
Module 1: Geothermics and Geophysics
11-15 September, Neuchâtel, Switzerland
www.unine.ch/cas-deegeosys

DGK 2017 - Der Geothermiekongress 2017
12-14 September, Munich, Germany
www.geothermie.de

GRC Annual Meeting & GEA GeoExpo+
1-4 October, Salt Lake City, Utah, USA
www.geothermal.org/meet-new.html



5th European Geothermal Workshop
12-13 October, Karlsruhe, Germany
www.agw.kit.edu/EGW2017.php

IGC Invest Geothermal
8-10 November, Frankfurt am Main, Germany
www.investgeothermal.com/

Renewable Iran 2017 - Incorporating Iran Geothermal Expo
13-14 November, Tehran, Iran
www.greenworldconferences.com/ri2017/

CAS Deep Geothermal Systems - Certificate of Advanced Studies
Module 2: Geochemistry and Hydrochemistry
13-17 November, Neuchâtel, Switzerland
www.unine.ch/cas-deegeosys

SMU Power Plays Conference (SMU Geothermal Lab)
10-11 January, 2018 , SMU Campus, Dallas, Texas, USA
www.smu.edu/Dedman/Academics/Programs/GeothermalLab/Conference

CAS Deep Geothermal Systems - Certificate of Advanced Studies
Module 3: Drilling and Logging
15-19 January, 2018, Neuchâtel, Switzerland
www.unine.ch/cas-deegeosys

GeoTHERM – Expo & Congress
1-2 March, 2018, Offenburg, Germany
www.geotherm-germany.com/

CAS Deep Geothermal Systems - Certificate of Advanced Studies
Module 4: Reservoir Evaluation and Production
12-16 March, 2018, Neuchâtel, Switzerland
www.unine.ch/cas-deegeosys ■

Transitions

U.S. Geothermal Inc. have announced that the company will not extend the employment agreement for CEO **Dennis Gilles** beyond its current term expiring on July 18, 2017. ■

Save the date
Oct 1-4, 2017

GRC ANNUAL MEETING & GEA GEOEXPO+

"Geothermal Energy: Power to Do More"

GRC WORKSHOPS
- Geothermal Resource Decision Workshop
- Operations & Maintenance

GRC FIELD TRIPS
- Yellowstone National Park
- Geothermal Plants in S. Utah

GRC MIXER & NETWORKING SOCIAL
The GRC will host the geothermal social event of the year at the National History Museum of Utah.

GRC TECHNICAL SESSIONS
Three days of technical sessions bringing the latest geothermal research from around the world. Dozens of poster presentations on display throughout the event.

GRC INTERNATIONAL LUNCH AND STUDENT NETWORKING RECEPTION
Special informational meetings with presentations and discussions led by globally known experts in the geothermal community. Great networking opportunities!

GRC ANNUAL CHARITY GOLF TOURNAMENT
Sign-up early for this popular networking event.

GEA GEOEXPO+
Entry to the trade show is free with GRC Annual Meeting registration.
More information at www.geothermalenergy2017.org

Note: All events are a work in progress and may change at any time.

Get the latest news on the geothermal event of the year at www.geothermal.org

DEADLINES
May 31 – Draft Paper Submission
August 18 – GRC Amateur Photo Contest
September 5 – Discounted hotel room block expires

Geothermal Resources Council GRC

GEOTHERMAL ENERGY ASSOCIATION

41st GRC ANNUAL MEETING & GEA GEOEXPO+

Salt Lake City, Utah • USA
October 1-4, 2017

Smarter Subterranean Strategies

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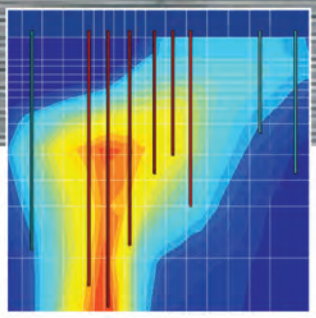

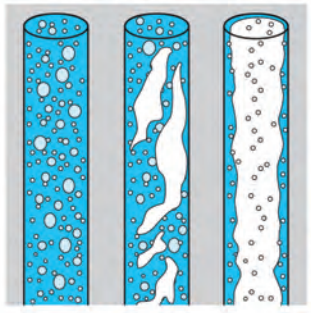

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