geOutlook®
The official publication of IGSHPA

JULY 2024 VOL. 18 NO. 2

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The ground loop heat exchange system on the 1,100-acre campus of Epic Systems Corporation, in Verona, Wisconsin, is among the largest in North America.

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*Life Cycle Analysis study performed by ADM. Michigan State University professors Bruce E. Dale and Seungdo Kim reviewed the study and endorsed the results and conclusions.

* GlycoChill+®P-Series Heat Transfer Fluid is a 100% USDA Certified Biobased Product through the USDA BioPreferred® Program. The USDA BioPreferred program promotes the purchase and use of biobased products by providing trusted verification and making it easy for people to identify renewable natural resource alternatives, as opposed to non-renewable synthetic or petrochemical derived ones.

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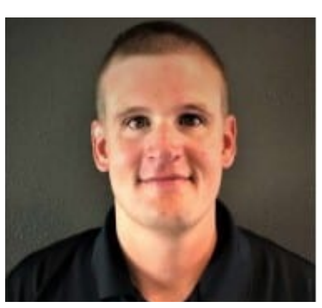

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IF YOU'RE SEEING THIS, LET'S TALK.

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LETTER FROM IGSHPA EXECUTIVE DIRECTOR

BY **JEFF HAMMOND**

IGSHPA
International Ground Source Heat Pump Association

JEFF HAMMOND

It's great to see how well ***GeoOutlook*** is doing, thanks to our members' article writing skills and their investments in advertising. It is so encouraging to see the power of membership. Although this is the second and last issue for 2024 (the next issue will be January 2025), the intent is to go back to quarterly editions as soon as possible, hopefully starting in 2025. In fact, we have had some recent evidence of the power of member participation. In April, ACT (IGSHPA Advocacy & Communications Task Force) declared the month, "National Geothermal Month" and ask members to share/repost IGSHPA LinkedIn and Facebook content. Our LinkedIn clicks went from 148 in March to 656 in April! On Facebook, our reach (number of people who saw any content from the page or about the page) went from 1600 to 2600! So, I know that IGSHPA members can make a difference, and I expect ***GeoOutlook*** to be no exception. Thank you!

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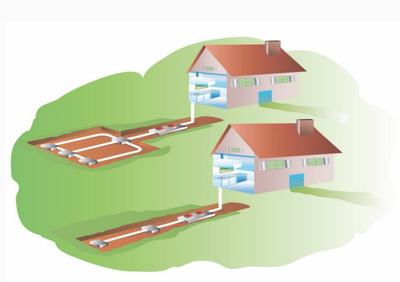
As we continue to grow ***GeoOutlook***, we hope you will take advantage of the great opportunities to showcase your projects, products, and services. You may not be aware of our agreement with BNP Media, publisher of ***ACHR News, Engineered Systems***, and more. Our agreement for an E-Magazine includes distribution to subscribers of the two magazines mentioned above, which provides a much wider audience to readers in the HVACR and Engineering fields. The combination of the IGSHPA database and BNP readers provides nearly 50,000 readers! We expect a big "bang for the buck" for our advertisers and great exposure for authors of articles in ***GeoOutlook.***

In between issues of ***GeoOutlook***, make sure that you stay up to date with the latest IGSHPA news by subscribing to our monthly newsletter (contact info@igshpa.org to be added to the mailing list) and follow IGSHPA on LinkedIn and Facebook. As the industry grows, the need for frequent communication, as well as details on new training programs will be essential for keeping members abreast of the latest industry developments. In fact, just since the last ***GeoOutlook*** magazine, we had a very successful research conference at Polytechnique Montréal in Montréal, Canada on May 28 to 30, 2024, and the 2025 IGSHPA Annual Conference is already getting a lot of attention with a number of sponsors, exhibitors, and speaker abstract submissions. Research conference proceedings are at https://igshpa.org/research-papers/. IGSHPA Annual Conference details are at https://igshpa.org/2025-igshpa-annual-conference/. In January, we announced a brand-new membership program that is already getting a lot of traction. Check out our ***benefactor members*** and the ***new membership program***.

IGSHPA'S NEW GEOTHERMAL APPLICATION DATABASE!

IGSHPA is excited to announce our new Geothermal Application Database that provides a growing number of projects, sorted by Commercial and Residential applications and Case Studies from our IGSHPA Business Community!!



If you are a **current** or **new** IGSHPA Business Member
and would like to submit a Commercial/Residential Project to our database,
head to this link and submit to our IGSHPA team!

Commercial/Residential Projects Form

IGSHPA
www.igshpa.org
IGSHPA's Mission: *Working together to advance ground source heat pump (GSHP) technology.*

There is so much happening at IGSHPA that I quickly ran out of space on a one-page letter. So, I will leave it here for now. Watch your Inbox for details on all of the new training module developments, new member resources and databases, and all of the other new developments with IGSHPA and the industry. Thanks for reading and thank you so much for your support of IGSHPA!

Best Regards,
Jeff Hammond
Executive Director

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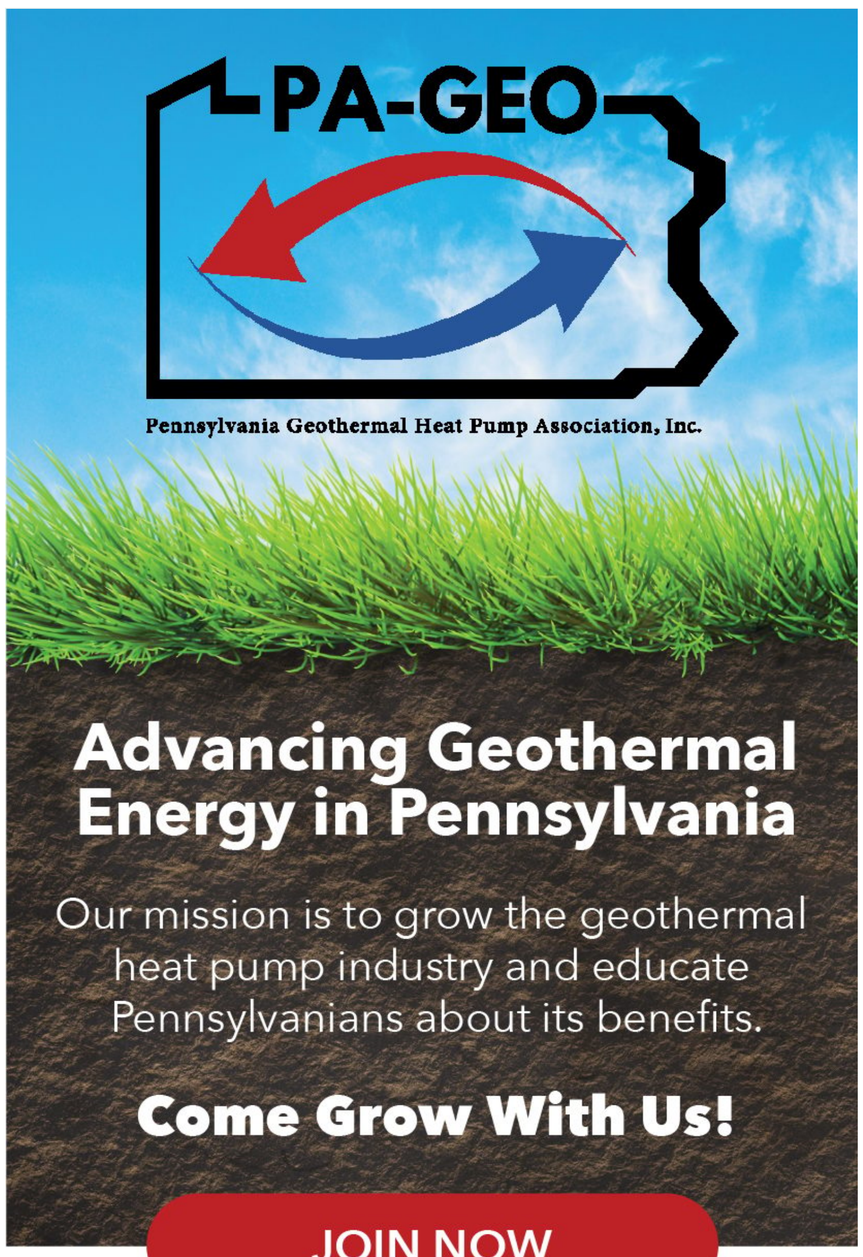
info@chesapeakegeo.com

410-789-5020

BY **RYAN DOUGHERTY**, PRESIDENT GEOEXCHANGE

Dear Geo Outlook Reader,

If you're like me, you probably pay attention to energy and environment news. It is rare that a day goes by when I don't see an alarming article describing how many devastating storms have already occurred this year (with countless more expected). This hurricane season is shaping up to be among the worst ever, and wildfire smoke will soon blanket large swaths of the continent again.



RYAN DOUGHERTY

Combine these climates stories with distressing news about the current and future state of our nation's electric grid. Electric load growth forecasts continue to tick upwards precipitously. Not only must we decarbonize transportation and buildings, but we must do so in the age of artificial intelligence and cryptocurrency which are expected to add massive demand on our nation's already strained grid.

These are the twin challenges of our time – the climate crisis and the once-in-a-century technological shift in our global energy systems. There is a technology that addresses both issues, and you already know what it is – ground source heat pumps.

The importance of the U.S. Department of Energy's recent report on the many benefits of GSHPs for our climate and our electric grid cannot be overstated. It marks a shift in how we ought to communicate key concepts related to GSHPs. Building efficiency is just one part of the value proposition of the technology. The value to our nation's energy security, climate resilience, and overall economy is astounding. GSHPs at scale can change the world for the better and that's not an exaggeration.

Read the report and its findings here. CleanTechnica has a good write-up here. In the coming months, GeoExchange will be undertaking an effort to communicate the report's findings to key stakeholder groups. Utility companies, regulators, lawmakers, environmental advocates, and many others need to hear how GSHP adoption will impact their constituencies.

We have a lot of work to do until GSHPs become a default choice in buildings, but we can get there if we're committed to the cause and working together. Onward and upward!

Ryan Dougherty
President, GeoExchange
ryan@geoexchange.org

IMAGE CREDIT: Bill Oxford / iStock / Getty Images Plus

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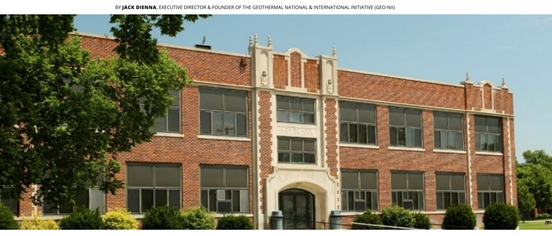
Pre-K to 12 Schools: The "Anchor Tenant" for the Ground Heat Exchanger!

BY **JACK DIENNA**, EXECUTIVE DIRECTOR & FOUNDER OF THE GEOTHERMAL NATIONAL & INTERNATIONAL INITIATIVE (GEO-NII)



Ground Source / Geothermal Technology is finally being recognized as a valued renewable thermal asset by the US DOE (Consolidated Appropriations Act 2021).

This along with the "Climate Change" narrative should have opened the flood gates for this technology ... but it hasn't. We still must fight the lack of awareness for not only the technology but more important the many benefits these systems bring to the table.

This technology centers on the issue of the energy used in buildings which the US DOE states accounts for over 36% of the primary energy used in the US and 40% of that energy is for space conditioning (heating & cooling) and water heating.

PRE-K TO 12 SCHOOLS

Pre-K to 12 schools are the second largest public infrastructure investment in the US and are one of the biggest energy consumers in the public sector.

They consume about 8% of all energy used in commercial buildings and emit as much carbon dioxide as 18 coal powered generating plants and spend over $8 billion annually on energy.

There are over 131,000 Public and Private K to 12 schools in the US with over 3.6 million public and private school students in attendance. According to the National Council for School Facilities, the average age of a K to 12 school in the US is 50 years old and 41% of those have failing HVAC systems.

HOW DOES THIS IMPACT THE GROUND SOURCE / GEOTHERMAL HEAT PUMP INDUSTRY?

That 41% amounts to 53,710, all of which have a need for the repair or replacement of their HVAC and a good portion of those have "heating only" systems which according to research done by both Harvard Medical and Yale Medical points to the fact that this may also be a health issue. Those studies state that "higher relative humidity impedes the transmission of respiratory viruses" (read COVID). It has been said that heating only schools have a relative humidity of approximately 10 to 15%. Installing a Ground Source Heat Pump (GSHP) system increases the relative humidity to over 45% which improves the health and safety of both students and staff.

K TO 12 SCHOOLS AS THE "ANCHOR TENANT" FOR THE GROUND LOOP HEAT EXCHANGER (GLHE).

This initiative, which is a true "Networked" system, takes advantage of a K to 12 School typically having a large open area such as an athletic field, parking lot, etc. that is an ideal location for the ground loop heat exchanger (GLHE), eliminating the need for street closures and traffic disruptions and ease of access to the surrounding homes and businesses in the community.

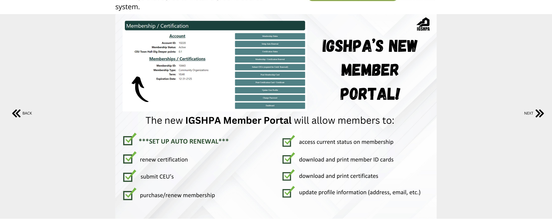
The "Anchor Tenant" program would also take advantage of the diversity of the system, meaning that the main needs of the school are opposite to those of the surrounding community. This is especially evident in the cooling season, when the school, unless it is "year-round" has minimal use allowing, more cooling available for the surrounding community.

Another reason to embrace the "Anchor Tenant" initiative is that our local schools have grown beyond academic institutions. They have become social gathering places, weekend worship centers, as well as safe havens for our communities' children and their families.

Anchor Tenant Concept / Initiative

HOW WOULD IT WORK?

The system would be designed at 100% capacity for the school, but the loop field may be increased to include any of the surrounding buildings that agree to install a ground source system.



If there is interest from the community, a pumping station could be included in the design to ensure delivery of the ground source technology to the community. This initiative also ensures that the system will have a major client for years to come.

Photo Credit: GTD

WHAT COULD THIS MEAN FOR THE GEOTHERMAL INDUSTRY?

Using square footage of Pre-K to 12 school buildings from the National Council for School Facilities, and assuming 400 sq. ft per ton, a Pre-K to 8 school building at 118,500 sq ft., would equate to 296 tons of GSHPs per school.

High schools at 173,727 sq ft., also assuming 400 sq ft per ton, would add up to 434 tons per school.

The number of Public and Private Pre-K to 8 is 35,785, at 296 tons equates to 10,592,360 tons of capacity.

Public and Private High Schools number 11,122 at 434 tons per school, equates to 6,490,000 tons of capacity.

Given these numbers, it points to the fact that this is a major demographic for the Ground Source / Geothermal industry.

It will mean increased opportunity for the drilling community (400 drilling foot per ton equates to 38,500 - 400 ft. bore holes).

It will have a major impact on the manufacturing community. Based on the assumptions made, the total tonnage is 15,420,000 tons of GSHPs, which would mean that all of the manufacturers would have to increase production by 100 times the amount that is being produced now.

The design community would have to increase the number of Certified Geothermal Designers (CGD) through IGSHPA which is the "gold standard" for designing institutional or commercial ground source systems.

There would be a need for a major increase in training for the IGSHPA accredited installer network as well.

WILL THIS IMPACT THE UTILITY COMMUNITY?

It most certainly will. A study conducted by Western Farmers Co-Operative in Oklahoma found that every installed ton of GSHP capacity reduced Peak Load by 0.55kW.

Given the total number of installed tons (15,420,000) in the Pre-K to 12 school market, that could result in a peak load reduction of 28 GW using this renewable thermal asset as the catalyst.

This would also result in emission reductions using a non-wire, non-pipeline alternative to support the utilities' climate mandates and goals.

This initiative could also become a rate based new business opportunity for utilities in the ownership of the ground loop heat exchanger.

HOW CAN I PARTICIPATE?

If you are reading this article and you live in a community, chances are that some of your schools are in the 50-year-old category. Get involved, go to the school board meetings, inform them that your industry has an answer to a better learning environment and healthier schools.

If there is an opportunity, let IGSHPA know through the website (https://igshpa.org). We can put together an informational package for the school board or offer advice, but it all starts with you, the IGSHPA member.

IN SUMMARY!

By using K to 12 schools as the "Anchor" for a Network ground source system, it not only promotes a better learning environment but serves as an educational and solid marketing tool for the residential market. It gives us 25 "geo promoters" in each classroom.

Lastly, it supports a safer and healthier learning environment for our greatest assets....Our Kids!

Remember GSHP technology is not only revolutionary, but also Evolutionary!

JACK DIENNA, Executive Director & Founder of the Geothermal National & International Initiative (GEO-NII). Originator of the "Anchor Tenant" concept for networked geothermal systems installing the ground loop heat exchanger in K to 12 schools' fields, parking lots, etc. Appointed US Department of Energy's Geothermal Visionary team. Member of the American/Canadian BI National GHP Standards Committee. Founding Member of the New York Geo Association and the Pennsylvania Geothermal Association.

GEO for Co-ops! Outreach & Engagement!

GEOFORCO-OPS
A GEOEXCHANGE INITIATIVE

BY **STEVE KOEP**, BE-A (BENEFICIAL ELECTRIFICATION AMBASSADOR) GEO MARKET DEVELOPMENT COORDINATOR

The nation's almost 900 Electric Cooperatives (Co-ops) serve over 40 million people, powering over 22 million homes, farms and businesses across a service area encompassing 60 percent of America's landscape – see map below. Their mission of bringing electricity and electric end-use technologies to rural America motivated them to strongly support the introduction of ground-source heat pumps (aka geothermal heat pumps) for residential and commercial applications. That support ranged from rebates and incentives to the actual formation of new businesses as dealers, loop installers and distributors of GSHP (ground-source heat pump) equipment. In fact, electric cooperatives and the electric utility industry were instrumental in the formation of IGSHPA and central to the early success of the GSHP industry.

In an effort to re-engage with the electric cooperative community, the GeoExchange JUICE Team (Joint Utility Initiative for Co-op Engagement) is partnering with IGSHPA's newly formed Utility Committee to launch **GEO for Co-ops!** a market development initiative specifically intended to provide electric cooperatives with the resources needed to update their GSHP market development programs or introduce new ones. This effort, in conjunction with the introduction of IGSHPA's **GEO101** training program, is designed to bring co-ops up to speed on the tremendous potential of GSHP technologies to positively impact the electrification and decarbonization of new and existing buildings. Leading the GEO for Co-ops! and GEO101 program development effort is Jeremiah Strode, GeoExchange's Director of Cooperative Engagement. "Prior to joining GeoExchange, I worked as a Member Service Advisor for a small electric cooperative in Mid-Missouri. To say that most cooperative employees wear many hats is an understatement. Limited resources and manpower are among the challenges that cooperatives face today. So our goal was to create a program that reduces the time and effort it takes to promote GSHPs, and Geo for Co-ops! does just that."

GSHP technology is uniquely positioned as the most efficient and effective, grid-friendly infrastructure choice for sustainable, all-electric space conditioning and water heating. The U.S. Department of Energy recently identified GSHPs as fundamental grid assets that have the potential to impact generation and transmission requirements, as well as the overall cost of decarbonizing the electric grid.

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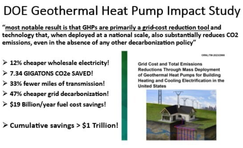
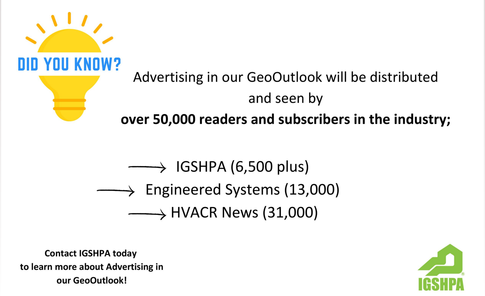
In addition, the Inflation Reduction Act of 2022 recognizes the 'Clean Energy' functionality of GSHP equipment, including 10-year tax credit extensions for both residential and commercial GSHP installations, an increase in the commercial tax credit to 30% (establishing GSHP parity with solar and wind) and direct payments to non-profits for GSHP installations.





Electric cooperatives are non-profit organizations, and these provisions will have a significant impact on the market and drive adoption of third-party ownership (TPO) models. For all those reasons, the entire electric utility industry has a renewed interest in GSHP technology and applications. Seeing the opportunity, GeoExchange and IGSHPA have teamed up to provide the necessary marketing and program development resources for our electric cooperative partners by introducing GEO for Co-ops! From training to marketing to program development resources, GEO for Co-ops! is designed to meet the needs of electric cooperatives, now and into the future. Ryan Dougherty, President of the Geothermal Exchange Organization (trade association for the geothermal heat pump industry) stated, "Rural Electric Cooperatives and the GSHP industry have a long and mutually beneficial relationship. With the enactment of the Inflation Reduction Act and a growing trend of building decarbonization, there's no better time to strengthen and reaffirm this relationship. The GEO for Co-ops! program will serve as a springboard to greater support and adoption of GSHP technology by our nation's co-ops."

These resources can be used by electric cooperatives as well as GSHP manufacturers, distributors and dealers to support GSHP program introduction and development. State-level organizations are particularly well-positioned to utilize the GEO for Co-ops! program resources to engage with the electric cooperatives in their state and encourage them to become members. All interested parties are invited to consider conducting a GEO for Co-ops! webinar and inviting local cooperatives to sponsor and attend.

The 'cooperative' business model recognizes that local programs, managed by local utilities for local members/customers is a win-win-win model that works for all involved. We're all in this together! Let's get to work!

GEO for Co-ops! resources will be hosted on the GeoExchange website, effective July 1, 2024.

STEVEN KOEP, BE-A (Beneficial Electrification Ambassador). GEO Market Development Coordinator.

IMAGE CREDIT: SimonSkafar / Royalty-free / iStock / Getty Images Plus

MARK YOUR CALENDARS!

2025 IGSHPA Annual Conference

LOCATION: iHotel & Illinois Conference Center
1900 S 1st Street, Champaign, IL 61820

IGSHPA is Breaking NEW Ground in many ways with the 2025 Annual Conference! Over the last 3 years, IGSHPA has partnered with NGWA's Ground Water Week with great success and will continue to support NGWA conferences. This year, IGSHPA is excited to be venturing out in partnership with GAOI (Geothermal Alliance of Illinois) in an effort to involve and build relationships with State & Provincial Associations. For 2025 we are choosing a Midwest location and renting out an entire conference center that will provide ample space for exhibits, workshops, break out sessions and much more! We look forward to seeing you in Champaign!

IMPORTANT NOTES: Conference schedule will include Exhibit Hall open for all 3 days, Tuesday, Wednesday, and Thursday, closing at Noon on Thursday. IGSHPA will be hosting an Awards Dinner and Banquet on Tuesday evening. Lunches are included on Tuesday and Wednesday. Breakfast is available each morning. Workshops will be held all 3 days.

Don't miss out on Advertising and Sponsorship Opportunities, click the link here

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IGSHPA Spotlight Interview with Sheri Rice

Name:
Sheri Rice

Company, Position & Title:
Fire & Ice Geothermal, LLC, General Manager

How long have you worked in the Geo Industry?
22 Years

How did you get into the Geo Industry/Why did you choose to work in Geo?
I was trying to be a stay-at-home mom with my 3-year-old daughter at the time and realized that she and I both needed much more contact with other people in our lives. My dad was working for Fire & Ice Geothermal at the time. So, I knew the owner, Ray Bayliff. I kept asking Ray if there was anything I could do, like mow his pastures, clean the barns, fill in at the office, etc. He finally sat me down and showed me how to read a set of plans and conduct a material take off, and the rest is history! Over the years I have had the incredible opportunity to learn from this pioneer in the industry and take multiple classes and expand on my geothermal education. I have had the pleasure of getting involved with the design of some incredibly unique systems and outside-the-box projects.

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Tell us what you love about your job.

I love the challenge that goes along with creating a design for a project that is unlike any other. There are so many unique challenges and so many opportunities to create systems that do so much more than the typical space heating and cooling that people think of. It is enjoyable to work through the challenges and come up with something that not only works but is incredibly efficient and gives the customer a better system than they even hoped for.

What do you want to see for the future of the Geothermal Industry?

I would like to see people look at Geothermal Systems as the norm instead of something only the rich can do. Geothermal HVAC should be the most common type of system out there. I would also like to see equipment manufacturers focus more on affordability than on efficiency. Geo Systems are highly efficient but can be made much more affordable for the common homeowner while retaining the high efficiency that is unique to Geothermal Systems.

Three interesting facts about yourself?

Since the loss of my husband, I have been setting up a 10-acre homestead with chickens, ducks, meat rabbits, and mini cattle.

I have been making homemade soap for about 8 years and have not purchased a single bar of soap in that time!

I enjoy gardening, reading, knitting, and spending time with my grown daughter.

GSHP System: The Top Mechanical Choice for Facilities in Gunnison County, Colorado

BY **TIMMY FRAPPIER, CEM**, GEOTHERMAL MANAGER, MAJOR GEOTHERMAL

The city of Gunnison and Gunnison County in Colorado is known for its summer and winter outdoor recreation, including mountain biking, hiking and the ski resort town of Crested Butte. Gunnison is the location of Western Colorado University, a public university currently enrolling about 3,000 students. The local economy also includes farming and ranching. With an elevation range of 7,700 feet to mountains approaching 14,000 feet at the area low level, the area is also known for its cool summers and mild winters. Due to its cold climate, ground source heat pump (GSHP) systems are particularly attractive for their lower operating costs.

CLIMATE

- The city of Gunnison's historic climate data[1] describes a chilly environment:
- 35°F average annual temperature, including summer highs,
- 10,019 heating degree days, base 65°F
- 0 cooling degree days, base 70°F - hot days and extended cooling duration loads are limited
- Lowest recorded winter temperature, -47°F below zero

RESIDENTIAL INSTALLATION EXAMPLE

Believed to be the first GSHP installation in the Gunnison Basin, the Cox residence just east of the city of Gunnison was completed in 1997, with a 3,500 ft² floorplan and heated by a radiant floor (no cooling). The GSHP system consists of a nominal 6.0-ton water-to-water unit tied to a closed loop trenched 4-Pipe field of four 300' long x 4' deep trenches 2.4' wide using ¾" DR11 circuit pipe. To maximize thermal momentum, the buffer tank is a 120-gallon unit, and the radiant floor was designed to run warm water from 100°F supply water temperature to maintain zone setpoints. There is no backup boiler or other heating system. The heat pump was sub metered to break out actual power consumption and operating cost.

During the first year of operation (1998) 1998 the homeowner reported a total power consumption for the GSHP system of 3,251 kwh. The power rate at the time was $0.09/KWH, equating to a total first year heating cost of $227.24, or about $0.065 per ft² per year[2]. The original system is still operating, due to its sealed closed-loop ground heat exchanger, the installation requires very little maintenance.

OTHER AREA GSHP INSTALLATIONS

The exact number of GSHP installations in Gunnison County is unknown, but several residential installations are accounted for between Gunnison and Crested Butte, and various rural areas throughout the county. Western Colorado University recently completed a new facility that utilizes a closed loop GSHP system, the Paul M. Rady School of Computer Science & Engineering, which includes the Mechanical Engineering department.

REASONS FOR PURSUING GSHP INSTALLATIONS FOR GUNNISON COUNTY FACILITIES

Mr. John Cattles, Assistant County Manager of Operations & Sustainability, has been involved with evaluating the various county facilities for several years, including operating cost and maintenance. He noted that over the years the most expensive cost was related to the mechanical systems, both in terms of operating and maintenance. Mr. Cattles began investigating alternate mechanical systems, including GSHP technology.

He also noted other considerations; "Gunnison County is concerned with environmental impacts and mitigating our greenhouse gas emissions. We want to lead by example in electrification of our buildings. We try to do things ourselves before we consider regulations or code changes. We are remote and are interested in the resilience of distributed HP systems."

As a county executive, John also hears from employees about comfort and mechanical reliability, as these are priority subjects where exterior conditions can be extreme. John notes that since their first GSHP installation "Comfort and control is improved compared to other systems."

John states that "GSHP technology has been a game changing strategy to reduce energy use and GHG emissions. We have found that GSHP installations result in much greater savings than previous efficiency efforts, and GSHP technology aligns well with our on-site Pv for additional benefits".

Original Gunnison County courthouse, circa 1880s.

GUNNISON COUNTY COURTHOUSE

The first GSHP system for the county was installed in the county courthouse. In 2014-2015 the facility underwent a remodel involving a new construction update of the facility, while retaining some of the historic architecture of the original 1881 construction.

The combined new construction and retrofit of the building has 40,000 ft² of conditioned space. The peak cooling load is 624 kBtuh and peak heating load is 492 kBtuh, the peak cooling load is higher than the heating load due to internal gains during the summer. The facility has an all packaged water-source GSHP system with 20 nominal tons of bore. The 400' long grout-filled vertical bores (GFVBs) consist of 4 bores of 315' depth using ¾" DR11 u-bend pipe. The original design called for 400' depth bores but was scaled back due to difficult drilling conditions found during the thermal conductivity test.

A predesign of the field was done to make certain the field layout was compatible with existing and planned infrastructure, and to select the best bore location that could be integrated into the final field design regardless of final number of bores, trenching configuration, spacing, and other variables.

As this was the first GSHP system for a county facility, a backup boiler was installed to temper the ground loop water should it drop below the operating temperature of the heat pumps. The only time the boiler is operated is to exercise it.

Completed roof Phase

From John Cattles;

- Since 2015 when the facility became operational, utility costs have been reduced from $1.76 to $0.52 per ft² per year.
- With the later addition of a 100kW photovoltaic solar array in 2020, providing up to 50% annual power demand, operating cost has been further reduced to $0.38 per ft² per year.
- Heat pumps were originally programmed to all come online at once from evening setback, but later staggered to reduce peak power demand (lessons learned).
- Comfort is exceptional.

The 2x 60HP Waterstrong Building Cylinder Gas Fired Boiler Package Unit for HP back-up and DHW

BLACKSTOCK BUILDING

The Blackstock Building has served as a local government administration and community space since its construction in 1926. The building was originally heated using steam from a coal fired boiler. The last renovation to the building was in 1999 when the county upgraded to boilers and chillers, but gradually those systems experienced multiple failures.

When the building was retrofitted to a GSHP mechanical system, completed in 2021, the facility remained open, and the mechanical transition time, the facility was at times being conditioned by both the new GSHP and the existing mechanical systems.

The GSHP system consists of the following:

- 30 tones x 340'
- 20 nominal tons of water-water heat pumps
- 72 tons of packaged water-air heat pumps

From John Cattles:

- The older central boiler/chiller system was more to failure and could take down the entire building.
- The former 4-Pipe system driven by boiler/chiller plant was uncomfortable and controls were problematic.
- Since retrofitting to distributed heat pumps, reliability is high and has added resilience to the facility.
- Utility costs have been reduced from $1/ft to $0.58 per ft² per year.
- Maintenance is lower with the GSHP system and controls are simplified.

The 2 x 60HP ZT Stealth-Fi Water Technologies Building Cylinder Gas Fired Boiler Package Units for Backup

HEALTH & HUMAN SERVICES BUILDING

Gunnison's Health and Human Services building, built in 1952, houses the County's Human Services, Public Health, and Child Welfare departments. As the building aged, the original heating and cooling system struggled to maintain comfortable temperatures for the staff. The facility was retrofitted in 2017 with a GSHP mechanical system. In 2020 a 25kW solar array was added.

The GSHP system uses a closed loop ground heat exchanger of 18 boreholes of 350' depth, with a total of 28 nominal tons of heat pump capacity between eight water-air packaged heat pumps.

Since the building is a retrofit, and detailed operating costs have been recorded, the before and after energy use reduction is impressive as described in this graph[3].

GUNNISON COUNTY LIBRARY

The new 15,000 ft² Gunnison County Library was completed in 2022. Conditioning is by a GSHP system and electrical power is supplemented with a 25kW solar array. The calculated building loads are 192 kBtuh cooling and 298 kBtuh heating.

The GSHP system is composed of a closed loop GHX of 18 bores x 400' depth using 1.25" DR11 bends, servicing 12 water-air packaged heat pumps totaling 36 nominal tons of capacity. There is no backup heat of any kind.

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MECHANICAL ROOM, GUNNISON LIBRARY;

From Mr. Drew Lockhart, Executive Director, Gunnison County Libraries: "The December 2022 and January 2023 electric bills were $62 and $72 dollars. This is amazing considering that the heat for the 15,000 square foot library shows up in the electric bill. Library increased its square footage by 10,000 *(from the original facility)* and reduced its average energy costs by $350 per month. The library has been at 70 degrees all winter, it's very comfortable with an even heat."

Mechanical Room, Gunnison Library

Heating & Cooling, Gunnison Library

GUNNISON-CRESTED BUTTE REGIONAL AIRPORT, MAIN TERMINAL RENOVATION

The 42,000 ft² main terminal at Gunnison-Crested Butte Regional Airport (GCBRA) was originally built in 1983 and retrofitted with a GSHP system in 2021.

The hourly load analysis determined a peak cooling load of 576 kBtuh and a peak heating load of 752 kBtuh. While the peak cooling load is higher than that of the heating peak, the total annual loads are heating dominant, the high peak cooling loads are of short duration due to those times of high occupancy related to airline arrivals and departures.

The heat pumps are tied to a closed loop GHX consisting of thirty-two 400' bores using 1.25" DR11 u-bends. There are two large water-water heat pumps and 36 water-air packaged units totaling 165 nominal tons of heat pump capacity.

Based upon the most recent utility invoicing, the total electric cost is coming in at about $0.84 per ft² per year[4].

Interior photo of terminal (Photo: Gunnison-Crested Butte, used with permission)

Installing one of the ground loops for CY 2020 Terminal project.

GUNNISON VALLEY EMERGENCY MEDICAL SERVICES

Currently under construction, the GVEMS facility is slated to be operational later in 2024. This 17,500 ft² facility has a peak cooling load of 134 kBtuh and a peak heating load of 144 kBtuh, as determined from the hourly load analysis.

The offices and administration areas are conditioned by packaged water-air heat pumps and the apparatus bays by radiant floor heat driven by water-water heat pumps. The GHX is a closed-loop vertical system composed of twelve bores of 440' depth with 1.25" DR11 u-bends.

Architect's conceptual image, courtesy Pult Architects.

OTHER PROJECTS

There are two housing developments currently in design, the Sawtooth affordable housing apartments, and the Whetstone workforce project. The Sawtooth facility will be a three-story complex and is located adjacent to the Gunnison-Crested Butte Regional Airport. The Whetstone project will be comprised of several apartment and condominium complexes, located between the cities of Gunnison and Crested Butte. Both projects will use GSHP mechanical systems as influenced by Gunnison County.

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TAKEAWAYS

By tracking utility and maintenance costs of various buildings, Gunnison County has determined that GSHP mechanical systems are advantageous for lowest operating and maintenance costs. Therefore, GSHP systems are the first choice, when planned, for any new construction or retrofit county facilities.

Gunnison County management not only tracks mechanical costs, but they have also undertaken to understand the design process for any mechanical system option and are an active participant with the mechanical design team when a GSHP system is planned for any county buildings. Their objectives are for the least complex, lowest to maintain, and most efficient system for meeting their operational requirements, and to maintain a comfortable working environment in their facilities. They also realize that if designed and executed correctly, backup heating measures are unnecessary, which aids in their net zero objectives.

Footnotes:
[1] Western Regional Climate Center, https://wrcc.dri.edu/Climate/cliMAIN.php
[2] Personal communication with owner
[3] Courtesy of John Cattles
[4] Personal communications with John Cattles

TIMMY FRAPPIER, CEM, Geothermal Manager, Major Geothermal

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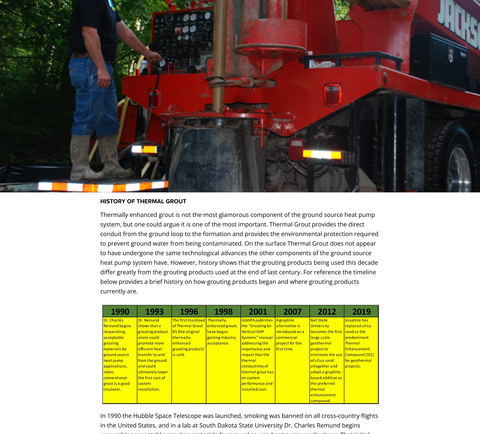
Sampling Procedures and Sample Frequency Using New Age Thermally Enhanced Grouting Products

BY **TYLER HARBECK**, GEOPRO, INC., LEAD PRODUCT ENGINEER



HISTORY OF THERMAL GROUT

Thermally enhanced grout is not the most glamorous component of the ground source heat pump system, but one could argue it is one of the most important. Thermal Grout provides the direct conduit from the ground loop to the formation and provides the environmental protection required to prevent ground water from being contaminated. On the surface Thermal Grout does not appear to have undergone the same technological advances the other components of the ground source heat pump system have. However, history shows that the grouting products being used this decade differ greatly from the grouting products used at the end of last century. For reference the timeline below provides a brief history on how grouting products began and where grouting products currently are.

1990	1993	1996	1998	2001	2007	2012	2019
Dr. Charles Remund begins researching acceptable grouting materials for ground source heat pump installations. Remund's research paves the way for the conventional grout in a grout circulator.	Dr. Remund develops the first known grout system to allow closed loop systems to promote more efficient heat transfer to and from the ground which significantly lower the first cost of system installation.	The first traditional TC formulation is developed by a thermally conscious grouting industry.	Thermally Enhanced grouts become a staple in the grouting industry.	GSHPA publishes the 1st edition of their "Closed Loop/GSHP Systems" manual addressing the importance and impact that the thermal conductivity of thermal grouts has on system performance and installed cost.	Graphite enhanced TC is introduced to commercial grout for the first time.	Bell State University pioneers the first large scale geothermal project to eliminate the use of fossil fuel boilers and chillers by utilized a graphite based additive as the preferred thermal conductivity compound.	Graphite has become the industry standard for geothermal projects.

In 1990 the Hubble Space Telescope was launched, smoking was banned on all cross-country flights in the United States, and in a lab at South Dakota State University Dr. Charles Remund was researching accepting grouting materials for ground source heat pump applications. That initial research in 1990 highlighted that grouting products available at that time were very good insulators. Further research ultimately discovered that adding a Thermal Enhancement Compound (TEC) would positively impact system design and first cost. Over the next 30 years the industry has seen two dominate TECs 1) Silica Sand and 2) Graphite. The introduction of a graphite-based TEC is the type of technological advancement that is on par with some of the equipment advancements this industry has seen over this same 30-year period.

ANATOMY OF A THERMAL GROUT

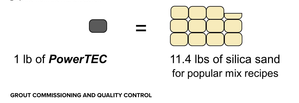
First let us look at the basics and what composes a thermal grout. Almost all thermally enhanced grouts are made up of primarily three components 1) a sealing component which is typically bentonite or cement or a combination of the two, 2) a Thermal Enhancement Compound (TEC) which is either silica sand or graphite, and 3) a known mix water volume which is specified by the manufacturer. Below is a comparison to the two TEC options.

SILICA SAND:

Silica Sand is abundant, locally sourced, and a relatively inexpensive TEC. Sand is abrasive making it hard on equipment and is a relatively heavy material making it very labor intensive. As the industry moves towards deeper bores the higher density of silica sand prevents it from being used on these types of projects. The weight creates enough pressure from the grout column on the outside surface of the U-bend that the piping's pressure rating may be exceeded during grouting. In addition, because sand is not sourced by the geothermal grouting company it is not held to the same stringent quality control standards that graphite products are and finding a good quality silica sand source can prove difficult.

GRAPHITE:

Graphite TECs are a lighter more conductive alternative to silica sand. They are supplied directly from the grouting manufacturer and should be specifically designed to exceed the published thermal conductivities specified by the manufacturer. Graphite is a non-abrasive material that helps prevent formation loss. Due to their lighter density graphite grouting products are the recommended choice especially when bore depths exceed 600 ft. But graphite enhanced grouts are far more sensitive to mix water volume than silica sand. This is due to the small amount of graphite needed to achieve the same level of thermal performance. For reference 1 lb of graphite can replace as much as 11.4 lbs of silica sand. This statement will be dependent on the quality of graphite from the manufacturer.



GROUT COMMISSIONING AND QUALITY CONTROL

The timeline above depicts how manufacturer's grout offerings have changed. However, very few adjustments have been made to the recommended field management and quality control processes used to verify the thermal performance of the grouting products being installed. Historically this has been done by collecting 3 samples for every 50 bores in combination with material usage reporting. Both are great practices and highly recommended as a minimum for any geothermal project. However, 3 samples per 50 bores as a rule of thumb is likely no longer the correct answer if graphite is used. In addition, history seems to be repeating itself as there has been a recent influx in geothermal projects requesting sample testing for every borehole. This too is likely not the correct answer. Testing at this high of a frequency provides very little additional value over lower testing frequencies and increases the cost of a project. The requested increase in sample testing frequency indicates the industry is not comfortable with the current manufacturer recommended testing procedures.

A field commissioning and QC program is an integral part of system installation. The process starts long before the first bore is ever drilled. All product specifications and submittals should be in order prior to grouting the first bore hole. All products on site should be verified ahead of time that they are the right product for that specific application. A comprehensive material volume calculation should have been completed including any expected loss to formation. This verifies that the amount of material needed to complete the project is on site and material usage reports can then be used to verify the correct amount of material is being installed as the project progresses. A sample testing schedule should be in place and the contractor should collect samples occasionally throughout the process and send them to a lab capable of testing thermal conductivity in accordance with ASTM-5334. This sample collection process is not meant as a pushing aspect, but rather a field verification technique to ensure the product is performing according to the manufacturer's specifications. The frequency and volume of sample collection should be totally dependent on the size of the project and the **TEC** that will be used to complete the project. It needs to be understood that delivering a specific grout TC value is as simple as counting bags and measuring water. Repeatable results should be the expectation.

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SAMPLING RECOMMENDATIONS - SILICA SAND

To meet any manufacturer's published mix recipes, a silica sand source must contain over 99% silica dioxide. Silica dioxide content is the driving force for sands thermal performance. If a sand product is in question most manufacturers can verify whether it is approved for use with their products. Two common thermal grout mix recipes are highlighted in Figure 1. Each can achieve a minimum thermal conductivity of 1.20 *btu/hr-ft-°F*. Note the amount of bentonite is the same for each recipe. Differences include yield, density, the amount, and type of **TEC**.

The first highlighted recipe contains 400 lbs of silica sand within a batch that yields 42.2 gallons. Assuming a completely uniform slurry this means that 9.48 lbs of sand is suspended in every 1 gallon of slurry. For the recipe in question silica sand makes up roughly 63.5% of that grout slurry. A uniform batch is very easy to achieve and identify due to the sheer volume of solids present. Standard sampling collection at a frequency of 3 samples for every 50 bores is more than adequate. Pair this sampling frequency with documented material usage reports and no further QC practices are required. A side note when using silica sand on a job site: As thermal conductivity changes so does density. The correlation is strong enough that a mud balance can be used to spot check batches on site. This is not a direct TC measurement but is an effective field QC measure that eliminates the need to sample more frequently than 3 times per 50 bores.

Figure 1

Thermal Grout - Silica Sand Mix Table:

Weight of Bentonite (lbs)	Weight of Silica Sand (lbs)	Weight of Water (lbs)	Total Weight (lbs)	Volume of Water (gal)	Volume of Slurry (gallons)	Density (lbs/gal)	Grout Yield (gal/batch)
0.40	50	0	24	26.7	9.37	5.35	
0.57	50	50	14.5	19.0	11.27	15.23	
0.80	50	100	10.5	21	12.14	19.75	
0.79	50	150	16.5	26.2	12.89	23.61	
0.88	50	200	17.5	29.1	13.51	26.87	
1.00	50	250	18.5	32.6	13.94	29.06	
1.07	50	300	19.2	35.2	14.25	30.9	
1.14	50	350	20.4	39.1	14.58	32.42	
1.20	**50**	**400**	**20.8**	**42.2**	**14.92**	**34.24**	

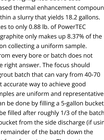
Thermal Grout – PowerTEC Mix Table:

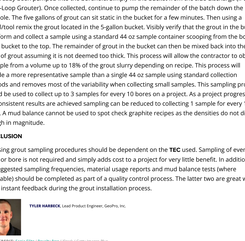
Weight of Bentonite (lbs)	Weight of PowerTEC (lbs)	Weight of Water (lbs)	Total Weight (lbs)	Volume of Water (gal)	Volume of Slurry (gallons)	Density (lbs/gal)	Grout Yield (gal/batch)
0.79	50	8	15	17.8	10.4	10.66	
0.88	50	10.7	15	17.8	10.8	10.87	
1.00	50	16	16.5	19.6	10.4	10.61	
1.07	50	16	16	19.1	10.4	10.9	
1.14	50	16	15.5	18.6	10.5	11.18	
1.20	**50**	**16**	**15**	**18.2**	**10.5**	**11.39**	

**Fill per 100 ft. of column height, assuming the u-bend is completely full of water during grout placement*

SAMPLING RECOMMENDATIONS - GRAPHITE

Graphite thermal enhancement compounds are supplied directly from the grout manufacturer and should undergo a comprehensive quality control process before ever being put into a bag. Therefore, the contractor can be confident that when mixed in accordance with the manufacturer's recipes the product will meet or exceed the minimum published thermal conductivity.





However, collecting quality samples in the field with a graphite-based **TEC** proves difficult, and different sampling techniques should be used. The second recipe highlighted above uses PowerTEC, which is the trade name for a specific graphite based thermal enhancement compound. The recipe shows that only 16 lb. of graphite is contained within a slurry that yields 18.2 gallons. Again, assuming the slurry is completely uniform, this equates to only 0.88 lb. of PowerTEC suspended in every gallon of slurry. For the mix in question graphite only makes up 8.37% of the grout slurry. Therefore, more emphasis needs to be placed on collecting a uniform sample. Increasing the frequency of testing and collecting samples from every bore or batch does not guarantee those samples are uniform and is typically not the right answer. The focus should change to how one collects a uniform 4# oz sample from a grout batch that can vary from 40-70 gallons in volume. GeoPro, Inc. has discovered that the most accurate way to achieve good consistent samples in this manner is to guarantee those samples are uniform and representative before they are ever collected and sent in for testing. This can be done by filling a 5-gallon bucket full of grout from the batch in question. This bucket should be filled after roughly 1/3 of the batch has already been pumped into the borehole. Simply fill the bucket from the side discharge (if using a Geo-Loop Grouter). Once collected, continue to pump the remainder of the batch down the borehole. The five gallons of grout can sit static in the bucket for a few minutes. Then using a shovel/tool remix the grout located in the 5-gallon bucket. Ideally verify that the grout in the bucket is uniform and collect a sample using a standard 44 oz sample container scooping from the bottom of the bucket to the top. The remainder of grout in the bucket can then be mixed back into the next batch of grout assuming it is not deemed too thick. This process will allow the contractor to obtain a sample from a volume up to 18% of the grout slurry depending on recipe. This process will provide a more representative sample than a single 44 oz sample using standard collection methods and removes most of the variability when collecting small samples. This sampling process should be used to collect up to 3 samples for every 10 bores on a project. As a project progresses and consistent results are achieved sampling can be reduced to collecting 1 sample for every 10 bores. A mud balance cannot be used to spot check graphite recipes as the densities do not differ enough in magnitude.

CONCLUSION

In closing grout sampling procedures should be dependent on the **TEC** used. Sampling of every batch or bore is not required and simply adds cost to a project for very little benefit. In addition to the suggested sampling frequencies, material usage reports and mud balance tests (where applicable) should be completed as part of a quality control process. The latter two are great ways to get instant feedback during the grout installation process.

TYLER HARBECK, Lead Product Engineer, GeoPro, Inc.

IMAGE CREDIT: Sorge Fritz / Royalty Free / iStock / Getty Images Plus

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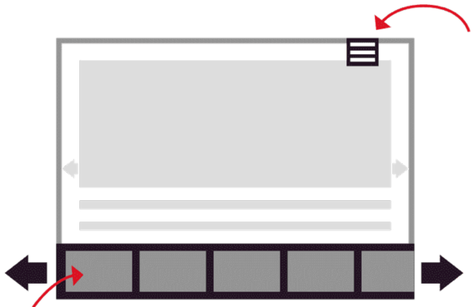

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