SMU | GEOTHERMAL LABORATORY

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Testimony for the Record by
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Chairman Lamb, Ranking Member Weber, and members of the committee, it is an honor for me to testify before you today.  As a geothermal resources researcher, university program coordinator, past president of the Geothermal Resources Council, and as a taxpayer, your willingness to expand your knowledge of geothermal resources is appreciated.  Today I'll share with you mechanisms for growing our country's ability to find new innovative methods to use this nation's resource base for improved energy independence.  By expanding the use of geothermal resources across the United States, we build a more resilient, diversified electric grid, and cleaner environment for generations to come.

Senate Bill S.2657, The Advanced Geothermal Innovation Leadership Act (The AGILE Act) with hearings on June 20, 2019, proposed specific ways to increase geothermal development.  The bill tells you *What* is helpful, yet does not tell you *Why* these items are important.  Using my 25 years of experience in the geothermal community, I will provide background and examples on Why it is important to 1) increase our usage of the geothermal resources, 2) build projects connecting industries, and 3) the importance of university research and outreach.

Google.org, Siemens, Anadarko Petroleum, and Conoco Phillips, all came to the SMU Geothermal Laboratory for geothermal project involvement. Behind each large recognizable company are 1000s of other companies, plus individuals wanting to use the available geothermal resources. Through consistent long-term funding such as the AGILE Act initiates, the geothermal community can reach its full potential. It is important to realize the geothermal value for the entire country. When one examines the main geothermal applications: electrical power generation, direct-use of the fluid, and shallow heat pumps for heating and cooling, it makes sense for all 50 states' representatives to be interested in exploring options for increased geothermal development, from the cold north to the hot south and from New York City to Los Angeles.

## Geothermal by 2050– GeoVison Study

"Earth is a gigantic heat engine. A tremendous amount of heat is constantly transported from its center to the surface by thermal convection and conduction".[1] Geothermal resources sit invisibly below us, *everywhere*! Earth will produce heat from its core 24/7 for billions of years. It is the oil and gas industry who comprehends the volume of untapped heat and fluids sitting idle waiting to be extracted, as they invest considerable effort understanding heat production in the earth and its association with hydrocarbon formation as well as avoidance of overheated subsurface zones when drilling. Petroleum researchers are the main users of our SMU heat flow maps to determine formation maturity. Oil and gas colleagues share that geothermal energy is

[1] Nagihara, S., Brooks, J.M., Bernard, B.B., Summer, N., Cole, G., and Lewis, T., 2002, Application of marine heat flow data important in oil, gas exploration. *Oil and Gas Journal*, 100(27), 43-50.

considered their 'retirement fund' because of how giant it is as a resource.[2] The more we drill, the more we understand how significant our resource is. Today's consumption for U.S. energy is approximately 100 EJ and geothermal stored energy is over $14 \times 10^6$ EJ.[3] It's also considered an emerging green energy, because it produces no direct carbon dioxide. As our society moves away from a carbon-based market, extracting geothermal resources incorporates similar oil and gas industry knowledge and skills. Still, the two industries are different.

The National Renewable Energy Laboratory completed the GeoVision Study for the Department of Energy, providing a roadmap that starts from today's Western US geothermal power production of 3.6 gigawatts to a deployment across our country of 60 gigawatts by 2050. And in parallel, expanding the current 2 million homes heated and cooled already by geothermal heat pumps, with this number increasing to 28 million homes, or ¼ of all homes by 2050. That's 30 years away, yet now is the time to act because geothermal power plants usually take 7 to 10 years from conception to production, and even having enough installers for the geothermal heat pumps requires time for local companies to grow and train employees.

For a comparison of what can be accomplished in 30 years, we can use the success story of today's shale play in the oil and gas industry.[4] Experimenting how to drill horizontal wells began in the 1970s. 20 years later it reaches production capability in the Barnett Shale. By early 2000s horizontal drilling reaches economic viability, and by 2010 it became widespread throughout all U.S. shale plays.[5]

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[2] Cutright, B.L., 2012, The Transformation of Hydrofracked Reservoirs to Thermal Energy Production. AAPG Annual Convention presentation, Search and Discovery Article #80223.

[3] Blackwell, D.D. and Richards, M.C., 2006, Chapter 2. In Tester et al., *Future of Geothermal Energy*, MIT.

[4] Davids Hinton, D., 2018, *Shale Boom: The Barnett Shale Play and Fort Worth*. TCU Press. ISBN-10: 0875656854

[5] https://www.enverus.com/blog/unconventional-play-development-in-one-map/

Thus the DOE's focus on reservoir research for FORGE and Enhanced Geothermal Energy (EGS) are key to keeping us on the trajectory necessary for the United States to achieve the GeoVision roadmap to 60 gigawatts of electrical energy by 2050.

### Build Projects through Connecting Industries

The SMU Geothermal Laboratory is known for its research on geothermal resource assessments and for our outreach program where we convene bridge-building conferences[6] between geothermal and other industries. The SMU conferences found collaborations between geothermal and the oil and gas industries, geothermal and waste-heat to power technologies, geothermal brines and desalination, geothermal deep direct-use of fluids and inlet cooling of natural gas plants, geothermal planning and district energy systems, geothermal power and transitioning of coal plants, and geothermal pumps for heating and cooling homes and buildings as part of off-grid projects. I see geothermal energy as the friendly and flexible energy option.

### Energy Development in Rural America

We drive across the country pointing out to each other the wind turbines and solar arrays. The oil and gas well pads show-up from airplanes with their grid patterns. Yet the geothermal energy constantly being released by the Earth is invisible. Invisible because we can't normally feel or see it rising from the ground. Plus geothermal power plants are clean and have a small surface footprint.[7]

Rural America is where there is high economic growth creating undue pressure on cooperative electric utilities. As our coal plants age out of production, we see investments in

[6] SMU Geothermal Lab conference website and past papers available at http://www.smu.edu/geothermal
[7] https://www.energy.gov/eere/geothermal/geothermal-basics

natural gas plants and non-baseload renewable energy. Incorporating geothermal development into the mix will provide long-term security through increased diversification. Here are examples of possible projects:

Geothermal heat pumps for heat *and* cooling, are being incorporated into a microgrid for 7,500 net-zero homes in Austin, Texas in the Whisper Valley neighborhood.[8] New smaller binary turbines (less than 500 kW) can plug and play with watered out oil and gas wells as shown by the Denbury Resources demonstration in central Mississippi[9]. Using deep direct-use resources can reduce hot inlet temperatures to improve efficiency of a natural gas plant as shown at the Eastman Chemical power plant, Longview Texas.[10] Models show how retrofitting an aging coal plant to incorporate geothermal generation could keep plant workers employed while simultaneously transitioning to a cleaner environment.[11]

The shale plays produce high volumes of fluids along with the oil and gas production. Finding ways to generate electricity from the low-temperature produced fluid, in the range of 150 – 185 °F, could off-set the need for burning on-site fuels. The Southwest Research Institute in San Antonio, is working with a small company to get to market a technology that could generate electricity from produced water in many states (Figure 1).

[8] Whisper Valley, Texas 78653

[9] ElectraTherm Report, 2012, Mississippi Oilfield Generates Low-Temperature, Emission Free Geothermal Energy at the Wellhead. Denbury White Paper, *SMU Geothermal Lab website*: http://www.smu.edu/geothermal

[10] Turchi, C., McTigue, J., Akar, S. Beckers, K., Tillman, T. 2018, Deep Direct-Use for Industrial Applications: Producing Chilled Water for Gas-Turbine Inlet Cooling, *Geothermal Resources Council Transactions*.

[11] 2018 SMU workshop on Coal and Geothermal: A Path Forward; Petty, 2016, Transitioning Coal to Geothermal, *Proceedings of 41st Workshop on Geothermal Reservoir Engineering*.

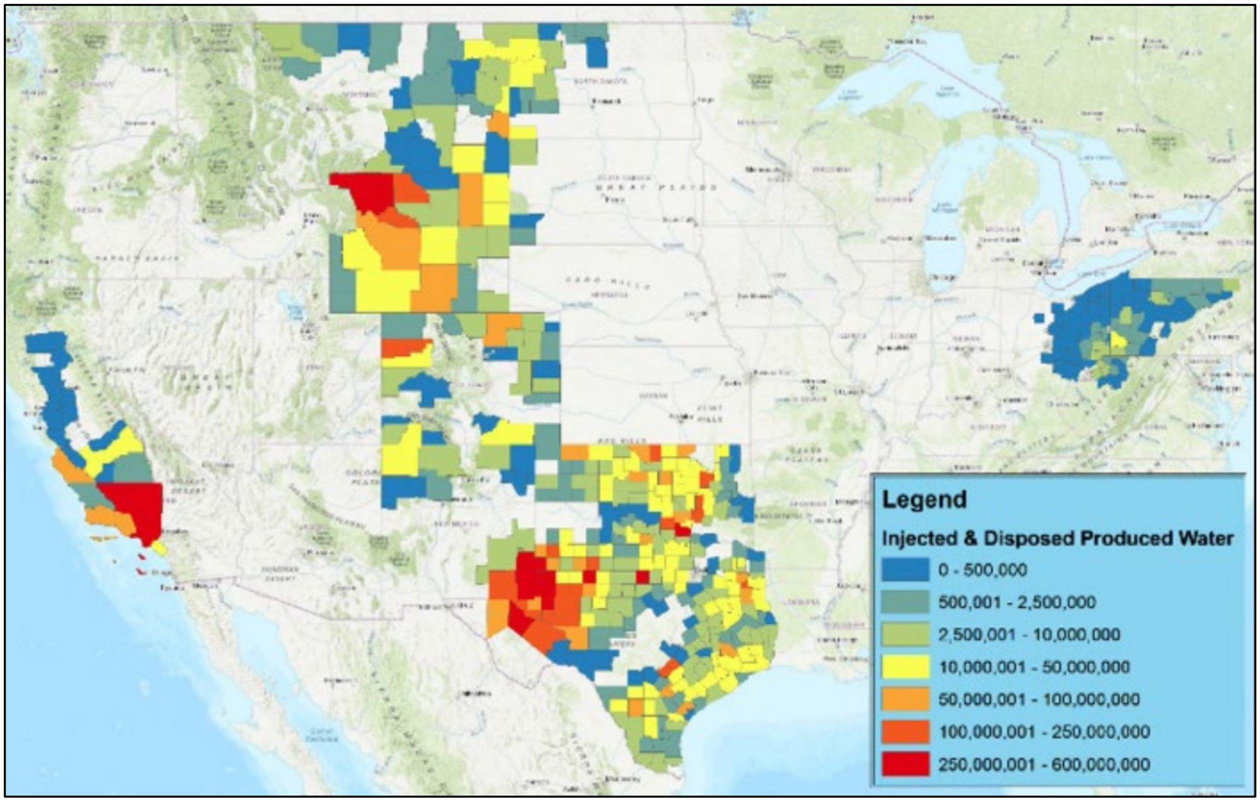

Figure 1. Injected Produced Water by County (bbl.) in 2017. Counties with high water disposal volumes, a proxy for high water production, are highlighted in red, orange, and yellow and are mostly concentrated in Texas and Oklahoma. This figure shows the estimated volume of injected produced water in barrels (42 gallons per barrel) generated at a county level in 2017, where available. These volumes are a proxy for water production, but do not account for reuse or water crossing county lines.[12]

Over the past 15 years it has been exciting for me to participate as new geothermal technologies enter the market, only then to become disappointed as I learn the company is out out of funds before a proper demonstration occurs. Technology breakthroughs for geothermal energy typically request funding in the range of less than $10 M, rather than the finance firms' preference of $100 M+. Technology companies need funding for small-scale low-temperature demonstrations in our sedimentary basins to prove both their technology and the resource long-term availability. An example: Dr. Will Gosnold of the University of North Dakota worked

[12] Produced Water Report: Regulations, Current Practices, and Research Needs, Module 2. http://www.gwpc.org/sites/default/files/files/Module%202.pdf

with a start-up technology firm to install two 125 kW binary-turbine using Continental Resources wells and pad in a Southern North Dakota oil field. Today the system is sitting idle because of repairs needed to successfully demonstrate the technology and field. The technology company does not have financing, nor does the University, and it's outside of Continental Resources' expertise/focus.

Oil and gas companies may be excellent at drilling their resources, yet they are *not* in geothermal resource plays nor in the electrical power industry and vice versa. The new AGILE initiative for DOE Offices of Fossil Energy and Geothermal Energy to transfer and adapt key technologies is an important next step. Funding is still necessary for both sides to work together on demonstration projects and to find synergies between industries for extraction and finances if the United States is going to achieve low-temperature (and high temperature) geothermal power from sedimentary sources.

**University Importance in Training the Next Generation**

The AGILE Act highlights a 5-yr consistent $150 M budget for competitive R&D, and $20 M for a mineral extraction competition. These funds are arriving at a critical juncture for universities. The AGILE Act also includes a specific resource assessment allocation for solely U.S.G.S., yet universities are the lead component in collecting and assessing these data for decades. Thus a broader initiative will provide critical funding for keeping faculty and researchers in geothermal exploration and training students, rather than changing to other fields. As an example, the SMU Geothermal Lab as a leader has received no upcoming funding for research in developing geothermal resource assessment techniques (details in section below). Therefore, we switched to researching methane hydrates and climate studies as a way to maintain our expertise in heat flow research, directing students to these new fields. Whether it is SMU, Cornell University, University of North Dakota, University of Utah, or University of Michigan, those founding researchers in heat flow and geothermal resources are either already retired or at retirement age. A geothermal fellowship program, similar to the Department of Energy Computational Science Graduate Fellowship, is another next step as part of training the next generation. Funding universities now is of most importance to preserve the greater knowledge transfer and keeping us as a world leader in geothermal energy.

The funding for resource assessments is also significant in growing the geothermal industry. SMU Geothermal Laboratory is just one example, yet look at the impact possible. Each new SMU geothermal map (1992, 2004, 2011, 2016)[13] developed new techniques from computer programing to inclusion of new data, e.g., oil and gas data, which highlighted the available resources of the midcontinent sediments from North Dakota to the Gulf Coast. Working with Google.org we developed nation-wide temperature-at depth maps to 10 km (2011) that led to working in Alaska (Figure 2) and with Cornell University and University of West Virginia to improve site-specific methods of temperature calculations and incorporate mapping of risk levels.[14] More recently our re-evaluation of the Oregon Cascades,[15] East Texas,[16] and the Snake River Plain, Idaho[17] examined geothermal potential on a 1 km x 1 km x 1 km resolution.

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[13] Blackwell, D.D., and Steele, J.L., 1992, Geothermal Map of North America, *Geological Society of America* DNAG Map No. 006, scale 1:5,000,000.
Blackwell D.D., and Richards, M.C., 2004, Geothermal Map of North America, *AAPG* Map, scale 1:6,500,000.
Blackwell, D., Richards, M., Frone, Z., Batir, J., Ruzo, A., Dingwall, R., and Williams, M., 2011, Temperature-at-depth maps for the conterminous US & geothermal resource estimates, *Geothermal Resources Council Transactions*.
Batir, J.F., Blackwell, D.D., and Richards, M.C., 2016, Heat flow and temperature-depth curves throughout Alaska: finding regions for future geothermal exploration *Journal of Geophysics and Engineering*.

[14] Jordan, T., et al., 2016, Low Temperature Geothermal Play Fairway Analysis For the Appalachian Basin: Phase 1 Revised Report. Principal Investigator Teresa E. Jordan. Technical report DEE0006726.

[15] Frone Z., Richards, M., Blackwell, D. and Augustine, C., 2015, Shallow EGS Resource Potential Maps of the Cascades, *Stanford Geothermal Workshop*, Stanford University.

[16] Richards, M., Batir, J., Schumann, H., 2018, Resource Analysis for Deep Direct-Use Feasibility Study in East Texas, Geothermal Data Repository, https://gdr.openei.org/submissions/1073.

[17] SMU Geothermal Laboratory and Nat Renewable Energy Lab Subcontract No. XEJ-9-92239-01 under Prime Contract DE-AC36-08G028308. Shallow EGS Regional Resource Potential Map – Snake River Plain, 2019-2020.

At this level of detail, SMU determines total land surface area and location for future project development based on the different types of geothermal resource. Each of these projects involves students and successfully trains the next generation of professionals, which then positively impacted programs in other universities and organizations such as the Geothermal Resources Council.

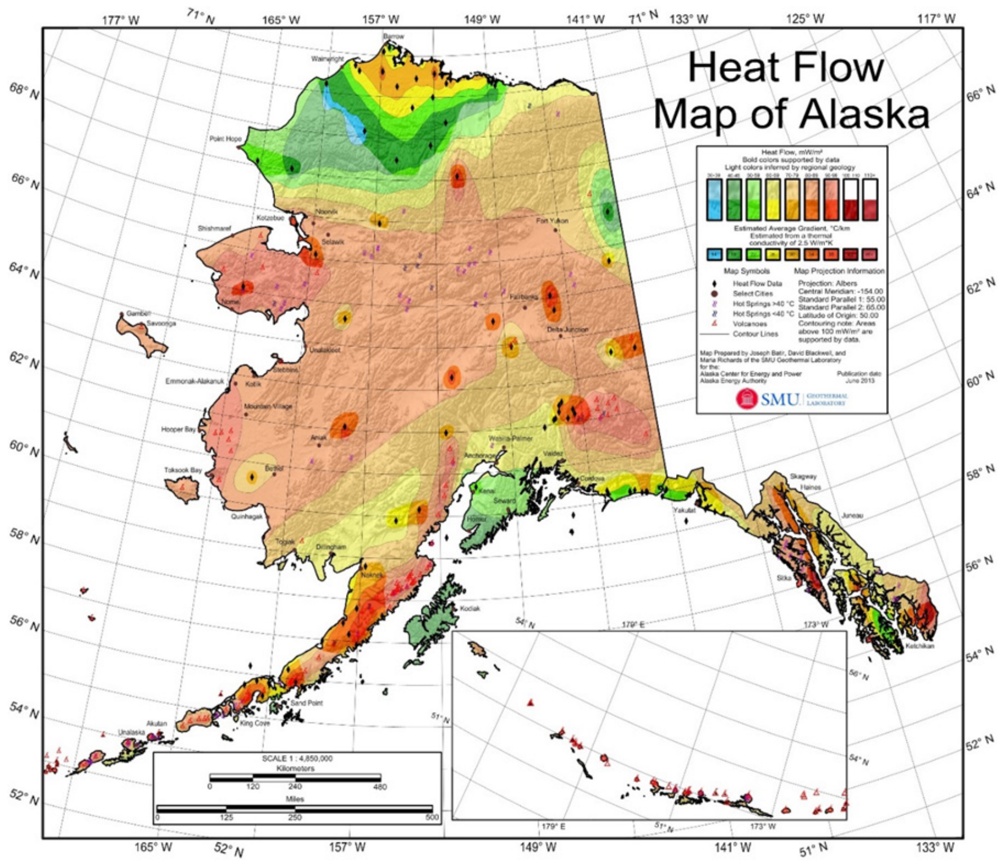


Figure 4. Subset of U.S Geothermal Map 2011 updated for the Geothermal Resources of Alaska, Batir et al., 2016.

Universities and their faculty are America's powerhouses for training the next generation of science, technology, and engineering workers. Their research drives the ability for the national labs to achieve excellence, and entrepreneurs' ability to drive technological innovation.

Your support for DOE's funding for universities, national labs, and companies will allow us to work together to find the innovations that will shift the United States from a fossil fuel dependent country to one with partnerships between industries; this is a win-win-win for the geothermal and other renewable industries, fossil fuel industries, and the public -one that will allow us to achieve the GeoVision roadmap to 2050, with more diverse, efficient, safe, secure, and sustainable energy solutions.

Today I've highlighted 1) why we need to increase our usage of the geothermal resources: it will provide a diversified and thus more secure, power grid, 2) why we need to build projects connecting industries: it leverages our strengths and provides a path forward, and 3) why it is important to fund university research and outreach: it preserves our current knowledge base while preparing the next generation of innovators.

Thank you for the opportunity to testify today. I welcome any questions you may have for me.

**Brief Biography**

Maria Richards is a researcher, project coordinator, and fundraiser for the SMU Geothermal Laboratory. She works directly with faculty and students overseeing related research as an Investigator on grants/contracts from initial application, management of budget, to final report with primary funding from companies, State Agencies (e.g., TXSECO), and Federal Agencies (e.g., Dept. of Energy; National Laboratories). She coordinates outreach programs on geothermal energy, speaks locally to internationally, developed and oversees the lab website, facilitates operations and training of oil/gas software, and develops learning activities between SMU and community programs. Research projects vary from temperature-depth maps for Google.org to on-site geothermal exploration in the Northern Mariana Islands, Peru, and Montana. Current concentration is on use of temperature well logs for understanding climate change, the transition of oil fields into geothermal production, and low temperature geothermal applications such as district heating for commercial buildings. She coordinated ten conferences focused on developing geothermal energy in oil and gas fields, building a network of individuals, companies, and government agencies from all aspects of development with cross-over between many related industries. Sponsorships from the conference help fund the lab outreach and student projects. Through the SMU Geothermal Lab outreach efforts Maria assists numerous companies and students world-wide to disseminate information on geothermal energy and resources. With colleagues, she coordinated the design, population, and ongoing dissemination of data for the SMU Node of the National Geothermal Database System. Highlights of research with Dr. David Blackwell include the Geothermal Map of North America, Dixie Valley Synthesis, Eastern Texas Geothermal Assessment, and the Report on the Future of Geothermal Energy; with Dr. Matthew Hornbach the Climate Impact of Northern Rocky Mountains. Maria holds a Master of Science degree in Physical Geography from the University of Tennessee, Knoxville and a B.S. in Environmental Geography from Michigan State University.