Building a Geothermal Future on a Sedimentary Foundation*

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Abstract

Geothermal energy from sedimentary basins has emerging possibilities that speak to both a new future for sedimentary sciences and a new and important role for sediments in the emerging market for renewable energy. These opportunities, however, are not necessarily linked or limited to conventional views of geothermal energy extraction. This is the primary finding of the SedHeat initiative. The SedHeat initiative is a Research Coordination Network funded by the National Science Foundation to explore the potential for sustainable geothermal energy from sedimentary basins. The network includes over 300 members from academia and industry dedicated to identifying and overcoming the challenges for economic extraction of geothermal energy from sedimentary basins. The group spans the fields of geology, engineering, economics, social sciences, and education.

The group has come to some conclusions over the span of its current six years. First, conventional geothermal power extraction is now possible from sedimentary basins because of new technologies in heat-to-electric conversion. Most conventional geothermal energy depends on flash steam power, which depends on very high heat levels that are rare in sedimentary basins. The newer Rankin-cycle generators are able to run fluids with temperatures below 200 degrees Celsius, temperatures more common in sedimentary basins. They can do so at the current margins of economic viability, and are becoming increasingly competitive. Second, much of the domestic and commercial energy consumed is used to heat spaces and fluids. Upscaling of direct heating systems to manage large infrastructure from large-flow and deep-basin wells is already initiating and has promise for future expansion. Third, the Earth is a good battery. Growth of renewables like solar and wind energy are severely hampered by their intermittent nature. Their future use depends on megawatt-scale energy storage systems that thus far have not emerged. Coupling of geothermal and solar systems is an encouraging solution. Solar energy is stored in deep sedimentary basins through injection of water superheated by thermal solar systems. The heat is later retrieved as stored base-load geothermal energy. The marginal lower heat of most sedimentary-basin geothermal systems is spiked for maximum output. The solar lost to non-demand periods is smoothed into peak demand times. Two problems with two renewables are solved by linking them together. Each of these options can be applied by expanding existing technologies. Each addresses the push for carbon-neutral energy and gives sedimentary science a large space to occupy in the emerging global renewables market. These speaks to a deep relevance of sedimentary basins and sedimentary science in a currently emerging future.
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Geothermal energy from sedimentary basins has emerging possibilities that speak to both a new future for sedimentary sciences and a new and important role for sediments in the emerging market for renewable energy. These opportunities however are not necessarily linked or limited to conventional views of geothermal energy extraction. This is the primary finding of the SedHeat initiative. The SedHeat initiative is a Research Coordination Network funded by the National Science Foundation to explore the potential for sustainable geothermal energy from sedimentary basins. The network includes over 300 members from academia and industry dedicated to identifying and overcoming the challenges for economic extraction of geothermal energy from sedimentary basins. The group spans the fields of geology, engineering, economics, social sciences, and education. The group has come to some conclusions over the span of its current six years. First, conventional geothermal power extraction is now possible from sedimentary basins because of new technologies in heat to electric conversion. Most conventional geothermal energy depends on flash steam power, which depends on very high heat levels that are rare in sedimentary basins. The newer Rankine-cycle generators are able to run fluids with temperatures below 200 degrees Celsius, temperatures more common in sedimentary basins. They can do so at the current margins of economic viability, and are becoming increasingly competitive. Second, much of the domestic and commercial energy consumed is used to heat spaces and fluids. Upscaling of direct heating systems to manage large infrastructure from large-flow and deep-basin wells is already initiating and has promise for future expansion. Third, the Earth is a good battery. Growth of renewables like solar and wind energy are severely hampered by their intermittent nature. Their future use depends on megawatt-scale energy storage systems that thusfar have not emerged. Coupling of geothermal and solar systems is an encouraging solution. Solar energy is stored in deep sedimentary basins through injection of water superheated by thermal solar systems. The heat is later retrieved as stored base-load geothermal energy. The marginal lower heat of most sedimentary-basin geothermal systems is spiked for maximum output. The solar lost to non-demand periods is smoothed into peak demand times. Two problems with two renewables are solved by linking them together. Each of these options can be applied by expanding existing technologies. Each addresses the push for carbon-neutral energy and gives sedimentary science a large space to occupy in the emerging global renewables market. These speaks to a deep relevance of sedimentary basins and sedimentary science in a currently emerging future.

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Take a Flyer!
Read more about the Challenge

The Resource
How Much Power is there in SEDHEAT?

The Need
How Much Power do we use?

The Future
Geothermal as Power Storage?

Solar Base Load!!

The Resource
How Much Heat is there?

The Types of Geothermal Production

The Resource
How Much Power is there in SEDHEAT?

US Power usage is ~100 EJ/~100 quad BTU

Learn More
Slide 2
-The SEDHEAT Challenges
Slide 3
-How Much Power Do We Use?
Slide 4 & 5 Profit from Wastewater
- Co-Producing From Your Well?
-Geothermal as Power Storage and the Way Forward

Sediment Thickness (m)

Earth Battery

Typical Injection well at about 100C

Power From the battery

Economic Sedheat
0.5 barrels/sec at 150C

1000 years of heat in sedimentary basins
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The SEDHEAT Challenges

The Seismic Hazard Challenge

Where are the MegaWatt Geothermal Plants?

The Water Challenge

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The Cost Challenge

Costs vs return means wells must rarely miss and pay off over long periods.

The Resource Challenge

There is enough heat but it is a little low for production in most places. About 100-150°C is optimal for traditional geothermal but well temps at high porosity are usually about 80-100°C.

The Geothermal Difference? Extraction During Injection

Got Alotta Sedimentary Basins

Hurdles!

We commonly inject and often extract the needed flow rates of ~0.5 barrels per second already.

Wise County, The Birthplace of the Shale Gas Revolution!
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How Much Power Do We Use?

U.S. energy consumption by energy source, 2016

- Total = 97.4 quadrillion
- British thermal units (Btu)
- Total = 10.2 quadrillion Btu
- Natural gas: 37%
- Petroleum: 26%
- Nuclear-electric: 17.5%
- Solar: 0%
- Wind: 9%
- Biomass: 3%
- Hydropower: 24%
- Other: 6.5%

Note: Sum of components may not equal 100% because of independent rounding.
Source: U.S. Energy Information Administration, Annual Energy Review, Table 1.3 and Table 10.1, April 2017, preliminary data.

Where Does it go?

Global Consumption: Sector Breakout

- World energy is used predominantly for transport, industry, and buildings.
- Total World Energy Consumption, 2008
  - 334.5 quads (12.0 BTCE)

- Transportation: 27%
- Residential: 24%
- Industry: 28%
- Commercial and Public Services: 9%
- Non-Energy Use: 8%
- Other: 4%

Note: Chart presents total final energy consumption. Other sectors include agriculture, forestry, fishing, and non-specified.

World Renewable Use and Projections

World Energy by Use and Change

Space Heating
An Electron Saved is and Electron Earned

Up to ~0.08 of Electric is Electric Energy

~0.25 of Geothermal Energy

~12% of Electric

~14% of Electric

~46% of Electric
Co-Producing From Your Well?

Rankin cycle turbines can produce heat economically from wast heat from wells. There are a lot of wells.

Low Heat Power

Electricity from Heat

Turbines - The Reigning Champs

The Opportunity

Co-Produced Water from Existing Wells

823,000 active oil & gas wells in the U.S.
3 million GPM of hot water in top 8 states
36W power at 217°F

Sources: The Price of Geothermal Energy - Zeno MIT Report

California Energy Commission (CEC) 2007 estimates
SedHeat: Gone from Maybe for Dollars to Surely for Pennies

What do We Pay for Power?

The Green Machine Example
(You can Buy This)

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Rankine Cycle for Geothermal Power Plant
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**The Sustainable Energy Problem Solved?**
A bold new direction for geothermal is using intermittent solar energy to spike heat in any of the many sedimentary with marginal heat resources by spiking heat of injectors with intermittent solar energy. The stored heat is then used to generate power from geothermal pumping. This ultimately turns intermittent solar energy into more usable baseload energy.

**So Why Does Storage Matter?**

**California Power**
A Solar Wind With no Sign of Slowing

The “Duck” Dilemma

**The Hybrid Plant Model**
Stillwater Plant, Fallon, NV

**The Opportunity**
Co-Produced Water From Existing Wells

**150 F Solar Spike**
7.5 X Increase!

**Coupled Geothermal Systems?**

**EGL, University of Utah**

**Who’s Working on This?**

**Ohio University and JPL**
Earth Battery Incubator Workshop 2016

**Convert your Wastewater to a Power Plant?**

**Earth Battery Incubator Workshop 2016**

**Typical Injection well at about 100C**

**Economic Sedheat**
0.5 barrels/sec at 150C
(40 l/sec at 150C for 5MWe; MIT Panel, 2005)

**Solar Base Load!!**

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