Geothermal Insights II: View from the hotwell pit

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This is the second in a three-part series discussing the trajectory of the geothermal industry: past, present and future. It is written from my perspective working at POWER Engineers, and draws on our company's history of engagements in the surface facility aspects of geothermal projects. It spans conceptual design and feasibility studies, detailed flash and binary plant design, monitoring of projects as an owner's engineer, and performing independent engineering for lenders.

The first installment was a retrospective: how have things changed from 1997 to 2017? What major trends are evident?

This second installment addresses the life of people engaged in this industry. What are geothermal projects like? Why do we enjoy this work? It is a bit more qualitative than the first article, but nevertheless discusses topics central to our efforts.

The third installment will be speculation about the future of the industry. How does geothermal stack up against other conventional or renewable power generation options? How can our industry continue to contribute and be competitive in the coming years?

Now, what perspective are we writing this from, and what is the appeal of geothermal?

Perspectives and priorities

Place yourself in the shoes of an emerging technician, engineer or scientist. Consider their employment opportunities. Ideally, we would all be able to engage our talents in ways that are challenging and enjoyable. As someone said: "find something you love to do and you'll never have to work a day in your life." For me, the characteristics of that kind of engagement would be that it:

1. Matches but also requires constant expansion of your skill sets.
2. Provides some latitude to demonstrate uniqueness/craftsmanship.
3. Contributes to the betterment of society.

Would work in the geothermal field qualify? I say yes. But let us explore in further detail.

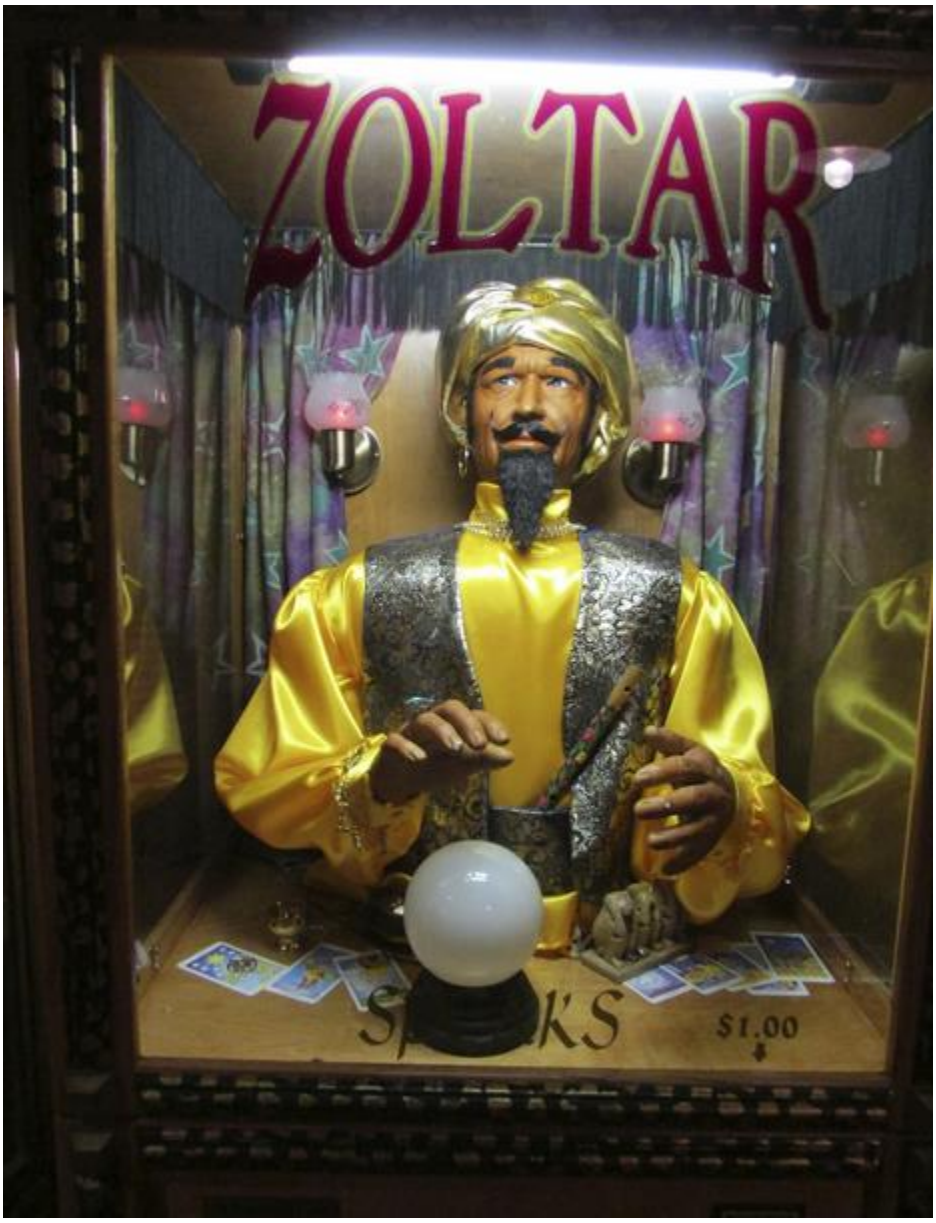
Geothermal projects are complex undertakings

Coming out of university, I served for a time in the navy. As a mechanical engineer, this exposed me to a wealth of complex systems I had to become familiar with such as propulsion, power generation and distribution, atmosphere manipulation, navigation, weapons, steering/hydraulics and discretion. Sure, one relies a lot on one's in-degree background (e.g. thermodynamics, fluids, mechanisms). However, you inevitably must absorb knowledge from other fields to deal with electric motors, batteries, controls, communications and management. Being placed in a more sterile, single-discipline environment would not test and grow one as well as immersion in and exposure to a host of challenges in a richer soup. Similar to ship systems or other large-scale industrial facilities, a geothermal project provides access to challenges across a wide spectrum of engineering and scientific disciplines. It's basically a space program going the opposite way.

If we look at a typical cast of characters engaged in the detailed design of a geothermal project, consider these sorts of issues:

- Geologist/Geophysicist: how do we minimize exploration costs while also maximizing the confidence of successful results?
- Geochemist: let's mix us up some geofluid cocktails…and each well has their own, constantly changing one!
- Reservoir Engineer: let's calibrate our 30 km3 reservoir model with a couple million years of geologic history. That shouldn't take long.
- Architect: can we design this plant as a "showcase" in the local setting?
- Civil/Structural: you are asking us to build this plant on top of a volcano, basically?
- Mechanical: what would it take to eke another tenth of a degree from this heat exchanger economically?

- Electrical: what are the grid code requirements in this beautiful, spider-filled country?
- Controls: shall we approach this with 1960s valves and instrumentation suitable to survive an electromagnetic pulse, or how much more sophisticated would the owner like to get?
- Procurement: how close are the container ships carrying our equipment going to get to the pirates?



My view of geoscientists (Source: Flickr).

Embedded in a geothermal team, you cross paths with these sorts of people/issues and more. And whether directly or through osmosis, you are going to pick up a host of secondary skills (in some cases at the "know enough to be dangerous" level). Solar PV, hydropower or wind turbine projects have their own sets of intricate and intensive challenges. It's just that those associated with geothermal—in essence a massive liquids, gases and solids processing facility that, oh by the way, can generate heat and

power—require a larger, more interdisciplinary team to manage. If working in that sort of environment attracts you, as a way to accelerate your skill building within your own discipline and across others, then you might find geothermal especially appealing.

Bespoke projects

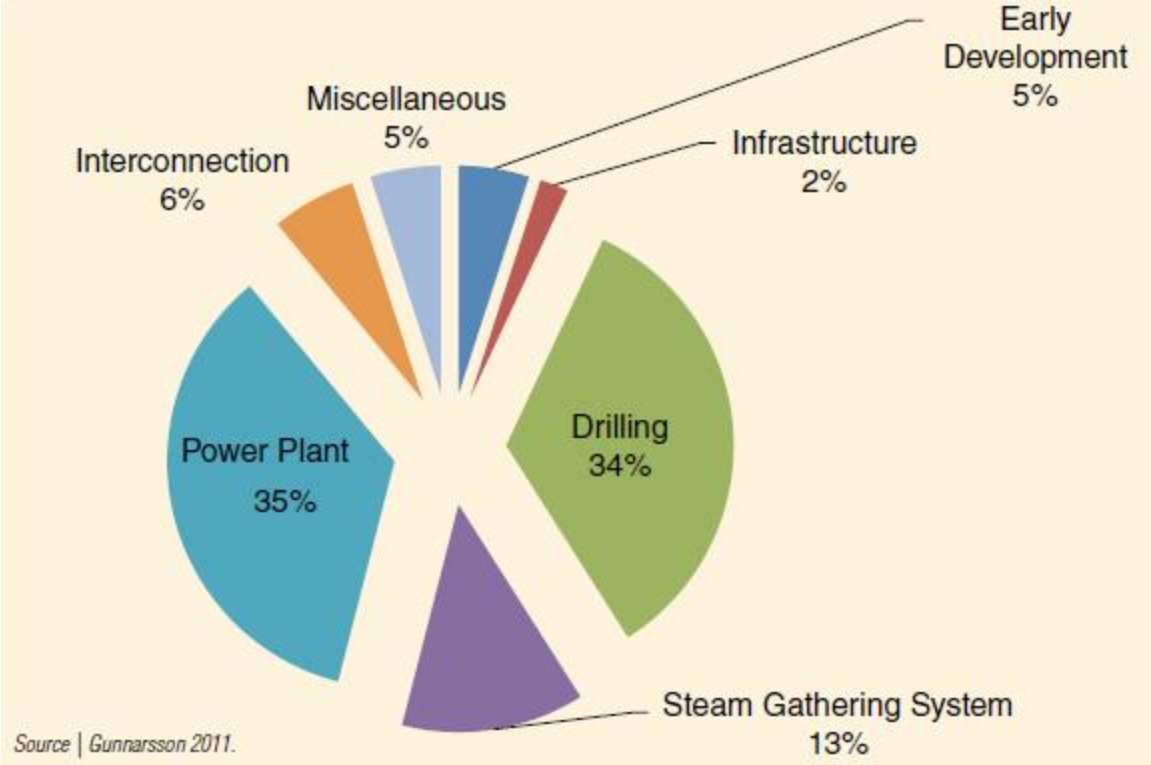
The theme of this section is going to sound a bit elitist, but the strategy is ultimately practical and of service to the client, which is what matters. So let's get this out of the way early. How do you feel about "bespoke"?

The Maurice Sedwell Experience (Source: YouTube)

The nature of the "fuel," or geothermal fluid produced from a reservoir, varies in quantity and quality: its enthalpy, noncondensable gas and solids compositions. Thus, each geothermal resource and project varies significantly from one another to a greater degree than any other power generation technology fueled by hydrocarbons, irradiation, Aeolian or hydraulic fuels. Admittedly biomass might be analogous, with its varieties of species and moisture contents.

There is a natural tendency in many technologies, in order to capitalize on economies of scale and manufacturing, to try to develop standardized designs or "cookie cutter" approaches. In those settings, the engineering and end-manufactured products become more like commodities.

In geothermal, we do try to standardize aspects of the surface facilities when appropriate to reduce owner costs and execution times. However, the nature of geothermal currently is that a significant fraction of the cost (say half) is in exploration and drilling. The other half is in the power plant and some other tidbits, as illustrated below by Gunnarson (2011) and as cited in the splendid ESMAP (2012) report.



Typical capital cost breakdown of a geothermal plant (ESMAP 2012).

If the wells are a significant proportion of the project cost, and capable of delivering a relatively set quantity of geofluid, then there is a naturally strong motivation for investing more engineering and capital cost into improving the power plant performance. Improvements in the surface facilities can usually be done with a higher degree of confidence, versus additional drilling, given there can be considerable uncertainties in the resource extent and well productivity. Paradoxically, a more costly and efficient customized power plant can make for a more economical project overall.

Another factor which lends geothermal projects more to customization than other power generation technologies is what we call a division of responsibility. This is the consideration in the project management stage regarding which parties will design, supply, construct and commission different aspects of the project. Are all aspects of the project known sufficiently well up front that someone can turnkey it all? Or do you need to divide up the "known, can start on this" and the "let's hold off on that until some more drilling" aspects? Does your project country have a healthy supply of a specific type of laborer or materials? Or is there a dearth? Are there many or just a few contractors who are motivated to pursue this or that slice of the project? Considering not just what the plant design should be, but also how it should be executed, is an important planning stage task which merits a high degree of customization. Importantly, your decisions on how to approach the project can spur the growth of industry in your project country.

Want to know more? Check out Hometown Values: Cooperative Models for Engineering Geothermal Projects

The intellectual demands are also high on the reservoir monitoring and plant operations staff. The operations staff at a PV, wind or fossil plant less frequently wake up and ask, "What's changed in the fuel source and how can I adapt my plant today, this month or this year to improve the revenue

stream?" For a geothermal project, the potentially continuing evolution of the reservoir conditions calls for more constant monitoring and tuning of plant parameters to recognize the maximum benefit. This rewards the curious, vigilant and diligent.

Geothermal projects certainly form a smaller generation pool compared to the tens of thousands of MW of solar PV and wind installed annually around the world. Our company just passed the 1,000 MW threshold in terms of our detailed designs being realized in installed geothermal projects, equating to about 25 projects of an average size of 40 MW over the past two decades. This could be considered small potatoes compared to the over 1,000 MW of installed capacity from one combined cycle gas turbine project.

But given the large degree of variability in the fuel sources, the disproportionate value of plant performance customization, and the many country-specific aspects that deserve consideration for projects, I like to think of the geothermal projects as being more suitably "bespoke" than those for other technologies. As a result, much like a selected clan of tailors would, people in the geothermal field have a deserved sense of élan regarding their satisfaction in crafting the designs and operations of their projects.

Everyone should exert craftsmanship and feel pride in any field they enter, but geothermal has especially strong motivations and opportunities to do so.

Contributing to a sustainable world

As an undergraduate, I remember going to a recruiting workshop for a soap manufacturer where, in the middle of the session, the presenter proudly showed a slide of the first bar of soap produced. I confess I yawned a bit; suppose that wasn't the industry for me at that time. Now soap is important (people remind me of that often enough). However, my personal objectives currently center on investing effort into infrastructure projects that have more "green power" attributes, given the enduring, resilient and widespread benefits of sustainable development. And I am not alone. Projects of this type appear to appeal to the millennial population as well; they often seek out and are willing to exert strong and enthusiastic effort on socially beneficial causes that appeal to them, and that can be a factor in recruiting the best. Since energy production and use impact so many aspects of a society (e.g. health and agriculture via refrigeration, education and gender equity via lighting and cooking options, industry and per capita GDP, waste and pollution), then working on projects that transform the landscape of a country's energy lifeblood really leverage these personal drives and have impacts well beyond the plant fence.

Miravalles III is around 30 MW of geothermal. Can you spot the other two renewable contributors?

There was a good quote from a project long ago that keeps things in perspective for those of us in the U.S. The project had its rough spots, as all projects do, and at one time, the exasperated construction manager exclaimed, “I’ve worked on projects that had bigger megawatt pumps than this entire plant!” Sure, geothermal plants often have double-digit megawatts instead of some four-digit fossil or nuclear projects. Still, +25-50 MW in some regions can add hours of baseload power to the day in an entire country that otherwise suffers blackouts, brownouts or other disruptions to grid reliability—which can negatively impact everyone’s livelihood. Every increment of renewable power you add counts in the Great Ledger. As Ahab exclaimed (with some selective editing):

*If money's to be the measurer, man, and the accountants have computed their great counting-house the globe, by girdling it with guineas, one to every three parts of an inch; then, let me tell thee, that [geothermal project or whale] will fetch a great premium **here**!" [smiting his chest]*

We all consider, in the projects we undertake, whether the completion of them will fetch us the sort of premium and satisfaction, monetary or non-monetary, that we should be maximizing. For those of us in the close-knit geothermal industry, I can state with confidence that there is a definite satisfaction in knowing that a finished project will make positive contributions to its community for scores of decades. As a corollary, I don’t view other firms worldwide doing the kind of work we do as competitors per se. Since the true opponents are poverty, disease, lack of economic opportunity, climate-induced disruptions and the Night King, the work everyone does to improve access to renewable energy puts us within the same global alliance.

Summary

One can get bogged down in the hotwell pit of the complexity, difficulty and frustrations in executing geothermal projects. Those periods of trial are when it is good to step back from the immediate demands and think about the larger and sustained impacts of your projects, such as:

- The growth of your broad technical and project management expertise.
- The opportunity to exercise your craftsmanship.
- The decades of positive impacts from that facility to millions of citizens.

While there is a wealth of opportunities in many fields of renewable energy and sustainable development, it certainly is true that for those that have had the opportunity to do geothermal work (be they developers, engineers, contractors, operators, etc.), all share these sorts of common experiences and consequent bonds that make the work particularly rewarding. Perhaps you will join us.

In the next installment we'll then consider: the future.

About the Author

William Harvey, P.E. is a project engineer and a Ph.D. in Mechanical Engineering specializing in renewable energy projects, principally geothermal. His background includes design, commissioning and operating experience in mechanical, nuclear, chemical, and electrical power plant aspects. With POWER Engineers, he has served in all project phases for flash and binary geothermal plants, including projects commissioned in the Americas, Africa, Turkey and Asia. His roles span detailed design, owner's engineering and independent engineering. Dr. Harvey has delivered training for industrial clients and organizations such as the Electric Power Research Institute, the Geothermal Resources Council, Kenya Electricity Generating Company, Costa Rica's Instituto Costarricense de Electricidad, the Iceland School of Energy at Reykjavik University, and the International Finance Corporation, among many others. He writes and lectures extensively on geothermal and renewable energy topics. He tries to maintain a personal blog on semi-random engineering and renewable energy career topics at www.badgercrossroads.com. He is a contributing author for the textbook Geothermal Power Generation: Developments and Innovation (2016).

Please note that the opinions expressed in these posts are my own and not necessarily those of my employer.

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