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The Development Process of a Greenfield Geothermal Plant—
Key Issues in Moving the Industry Forward
to Development of New Resources

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Abstract

Development of any power plant; be it fossil-fueled, wind, solar, hydro, biomass, or geothermal, goes through its own unique development process. Even for tasks similar across energy technologies (land acquisition, financing, construction permits, power-sales agreements, interconnection to the grid) timelines differ for critical milestones.

Geothermal energy projects are often developed on a longer timeline than other renewable technologies. Specifically, they require exploration drilling to confirm the resource. Resource confirmation incurs significant upfront costs and geologic expertise to define, delineate, and target potential resources.

The purpose of this paper is to explain how the geothermal development process is different than other renewable energy technologies (wind and solar specifically). This paper describes the development process, and provides suggestions on how critical milestones within the process can be addressed by government policies. What may work for solar or wind might not work for geothermal and vice-versa.

Most of the new geothermal energy projects brought online in the last decade involved expansion of existing well fields or development of fields that were drilled and/or had a resource confirmed many years earlier. However, the next wave of projects under development includes many greenfield sites with little to no prior exploration drilling. The development process for greenfield sites requires specific attention in order for these projects to succeed and the industry to maintain strong growth in the years ahead.

This paper draws from the expertise of Ormat Technologies, Inc. which owns and operates 367 MW of geothermal power plants in the United States, and has produced or supplied roughly 1200 MW of geothermal plants globally in 19 countries.

Different Technologies Require Different Solutions

While policymakers have many disagreements, there is almost universal support for technologies that utilize clean, renewable sources of energy. Support for these technologies has continually gained strength over the past several years. This support has come from local and state governments as well as the U.S. Congress and the White House; from Republicans, Democrats, and Independents. Federal policies (including investment tax credits, production tax credits, and proposed climate change regulations) are broad in scope, as are state renewable portfolio standards (RPS), sales tax exemptions, etc. While these policies certainly help create a market for renewable energy, they don’t address specific issues that impact development for each specific technology. Wind, solar, and geothermal technologies all have different development profiles, and require support from multiple government agencies at different project stages in order to achieve success. Geothermal projects need support that is unique to geothermal, and not necessarily relevant to other technologies.

This is especially the case when considering so many geothermal projects currently under development are greenfields (as discussed above). Greenfields are areas where the productivity of a geothermal field is unknown. The development timeline for a greenfield project is generally longer than for a project that expands an existing well field, or where the resource has been confirmed through a discovery well (i.e. a producing geothermal well with commercial temperatures – usually greater than 300 degrees Fahrenheit).

While there are differing definitions of a greenfield (some consider a greenfield any site where a utility scale power plant has not operated in the past), for the purposes of this paper, a greenfield is a site that does not have a discovery well as described above.

Below are examples of how developments of geothermal projects, particularly greenfields are unique, and how policies may address these characteristics to maximize geothermal development in the U.S.

Project Financing

Before a company can consider development of a geothermal energy project, they must craft a strategy for financing or have the equity to cover a part or all of the exploration and development phases. Significant expense may be incurred early on in the process, when land and mineral rights need to be acquired. However, even if land is purchased with seed money (i.e. private equity,
etc.), little more can be done without spending in excess of seven figures ($1 million) to move a project forward. Exploration studies (geochemistry, geophysics, etc.) can range from tens of thousands of dollars to hundreds of thousands of dollars. Even permitting for exploration wells may cost several hundred thousand dollars; particularly for a project on public lands requiring environmental review under the National Environmental Policy Act of 1969 (NEPA). Achieving financing is difficult prior to drilling, because the investment risk is much higher. Even a successful geothermal well does not pay off immediately (like an oil or gas well). So, investors are wary to provide financing.

Based on these initial challenges, it is a wonder that any geothermal exploration gets done. However, it does, and for a few good reasons:

One – extensive geothermal exploration was performed during the 1970s and early 1980s when the oil crisis encouraged oil and gas companies to explore for geothermal energy. Many of the existing geothermal power plants operating in the U.S. today were discovered by well-funded oil and gas companies, who were able to quickly drill and identify resources with their own equity.

Two – geothermal wells and springs have been mapped extensively by the U.S. Geological Survey and by state and local entities. Significant federal funding was provided during the late 1970’s to state geological surveys to estimate geothermal potential and survey areas at and around hot springs and/or geologic anomalies of interest. Additionally, because precious minerals and geothermal resources are often found in similar geologic areas, many geothermal prospects have been identified by mining companies. So, it is rare that a company will be completely blind when approaching a geothermal project in its early stages.

Finally, not all companies today are limited by financing. Larger companies, like Ormat, as well as companies backed by major investors, can finance early stage exploration, permitting, and initial drilling themselves.

So, there is a light at the end of the tunnel that companies will explore greenfield geothermal sites. However, the level of exploration going forward depends in large measure on support from external sources of funding. In November 2009, the U.S. Department of Energy awarded over $98 million specifically for geothermal exploration, at 24 separate sites, as part of a $338 million allocation for geothermal research. While nearly all of these sites have exploration history, most do not have discovery wells.

**Land Acquisition**

Geothermal projects require mineral rights in order to access the geothermal resource below the soil. This is not required for wind and solar energy. Geothermal projects need access to very specific geologic targets. Move a solar project over a few miles, and odds are the solar radiation will be just as strong. Move a geothermal project over a few miles and it’s like moving a solar project from the Mohave Desert to the North Pole!

Thus, when acquiring land for a geothermal project, the quality of the land is directly related to specific land parcels, without which a project is no longer viable. On private land, surface and mineral rights may have numerous owners, requiring many deals to be brokered to ensure access to the resource. Further, because geothermal resources are located primarily in the Western U.S., many geothermal projects involve working with the Bureau of Land Management (BLM) and/or other federal agencies with significant land acreage, such as the Department of Defense and the U.S. Forest Service. While a large tract of BLM land has the advantage of only having to work with one land and mineral owner; that is probably the only advantage. As will be explained in more detail in the permitting section, the development process for geothermal projects on federal lands is often far more complex.

While wind projects have proliferated throughout the U.S. in the past decade, less than 1% of the 35 GW of wind power installed by year-end 2009 was located on federal lands (Source BLM). As one can see in Figure 1, this is not the case for geothermal energy projects; which are built almost exclusively in the West. While the majority of operating geothermal power plants are actually located on private lands, many of those power plants utilize geothermal wells on BLM land and require acquisition of substantial federal leases.

Land acquisition on federal lands could be very difficult, sometimes impossible, prior to 2007. Since the 1970s, geothermal leasing on federal land was done non-competitively, with a lease set at a price of $1 per acre. It was up to the discretion of the federal agency whether or not to process a lease application; and as such, some applications sat for decades without so much as a glance. That is why 2007 was a marquee year because it was then that new regulations (passed in the Energy Policy Act of 2005) took effect, changing the process to a competitive system similar to oil and gas. In doing so, the new regulations brought significant new funding to the BLM, as well as states and individual county governments. Parcels are nominated by private parties or companies and put up for auction. The proceeds are now divided up with 50% to the State where the leases are located, 25% to the county government*, and 25% to the BLM. The first two sales held during the summer of 2007 raised roughly $28 million; and subsequent sales have raised over $45 million more. The time to process applications decreased significantly; reducing to months a process that once took years. Besides the BLM, which benefited in its ability to fund the NEPA review required to release lands for sale, the county governments benefited tremendously when revenues from the lease sales helped fund local programs that might otherwise be left unfunded during the latest recession.

While competitive leasing has been one solution to encourage more exploration and fund federal agencies to process permits, more is needed from policymakers to encourage geothermal development. For example, environmental regulations need to be more flexible for geothermal resources as compared with solar and wind. In particular, the exploration process requires identifying a specific geologic target, much like oil and gas resources. Thus, when processing land nominations for geothermal prospects, access to these targets must be valued by the BLM and the Forest Service to enable project viability. Although a large area must be leased in order to properly explore a geothermal prospect (usually 5,000-10,000 acres), a 30-50 megawatt geothermal project will only impact about 100 acres, and a power plant itself will usually encompass no more than 10-15 acres. Because geothermal projects impact a much smaller land footprint compared with wind and solar technologies, mitigation measures are generally less complex. Transmission lines remain a common issue for geothermal, wind,
and solar; given that most of the land impacted by geothermal projects is generally dedicated to connecting to the main power grid. This issue is discussed in more detail in the interconnection and transmission section.

**Exploration**

Before a drill bit enters the soil, surface exploration is necessary to identify the best targets for drilling. While a substantive description of various exploration techniques is beyond the scope of this paper, essentially these studies are needed to identify geologic structures where a geothermal reservoir can best be accessed for production. For small properties (covering a few square miles), exploration costs can be minimal overall. However, for large lease tracts, which can cover dozens of square miles, exploration costs can be significant. Thus, the U.S. Department of Energy grants discussed earlier are helping companies in their exploration activities so they can reach the next step to identify new resources.

**Project Permitting**

Project permitting involves both exploration drilling and the power plant and associated infrastructure. Permitting offers a multitude of challenges, and there are critical policies that can help make the process run smoother and faster.

As discussed above, a primary issue of importance to the geothermal industry is project permitting on federal lands. Typically these lands are managed by the BLM or U.S. Forest Service (for which the mineral rights are managed by the BLM). Critical decisions are made by the U.S. Department of Interior (DOI) which oversees the BLM. This is something geothermal projects share with large scale solar projects, which typically require many acres of open land in desert regions. Most Americans are probably unaware that the DOI is one of the most important agencies affecting the future development of large scale solar and geothermal resources. Yet, it is often the DOI, and not financiers, utilities, or legislators, that will determine whether a project gets built or not.
Even if a geothermal developer is able to lease the lands necessary to develop a viable resource, permitting geothermal wells can be delayed significantly on federal lands vs. private lands. In Nevada, for example, permitting a geothermal well on private land takes an average of 45 days. Permitting a geothermal well on BLM land can take anywhere from 6 months to 1.5 years, with similar timelines for permitting a geothermal power plant. The primary reason for this is NEPA, as mentioned above, which covers, among other things, energy and minerals development on federal lands. In order to comply with NEPA, numerous studies are required to ensure the project’s impact on cultural, biological, and ecological resources; for exploration drilling, plant construction, and interconnection. A geothermal project generally requires an Environmental Assessment (EA) or an Environmental Impact Statement (EIS), depending on the level of impacts anticipated to the local environment. It is precisely NEPA compliance that creates the disparity in time for permitting on federal land versus private; particularly in Nevada.

This disparity between permitting on private lands and federal lands is further complicated by the fact that some BLM offices have limited experience with permitting geothermal projects. In fact, the permitting of geothermal, wind, and solar projects is a relatively new phenomenon for much of the BLM. Applications for these types of projects has grown exponentially over the past decade, forcing the agency to change with it.

For most of its history subsurface exploration governed by the BLM involved mostly mining and fossil fuels, such as oil, gas, and coal. Although geothermal exploration on federal lands was robust during the mid-to late 1970s through the early 1980s, some of the staff familiar with geothermal projects has now retired. New staff unfamiliar with these types of projects has been forced to adapt quickly. Public involvement has grown due to the internet, and the ability to share information about a project and its potential impacts to a broader audience. Native American tribes have become more engaged as well, and tribal consultation has become a very important part of the permitting process for geothermal development as well as for solar and wind.

So, What are the Solutions?

Geothermal energy projects, in particular, will benefit from investment into the BLM, to boost the human resources necessary to process permits in a timely manner and to hire and train qualified staff to manage the rapid increase in project applications.

A more comprehensive approach in recent years has been to issue Programmatic Environmental Impact Statements (PEIS). A PEIS addresses resource issues common to the entire Western U.S. instead of a single area. A PEIS was completed for wind, geothermal, and transmission pathways, and is ongoing for solar energy. The PEIS for geothermal was helpful in addressing common environmental issues across the West, and also in amending numerous Resource Management Plans in BLM Districts which did not include geothermal development. However, the PEIS was focused on leasing, and unable to impact permitting in any meaningful way. Further, it was unable to achieve full agency coordination with the Forest Service, where many potential geothermal resource areas have been identified.

Other methods can be implemented to help streamline permitting. A full description of these goes beyond the scope of this paper. Overall, however, it is important to emphasize that while every geothermal site is different, there are tremendous similarities as well. Thus, successful strategies employed on one project need to be replicated elsewhere. The goal should be to streamline as much as possible, while still addressing core environmental issues. Further emphasis must be made on the environmental attributes of these projects, which serve to offset fossil fuel consumption and pollution that would otherwise be produced; an issue documented effectively by the National Geothermal Collaborative in their January 2005 publication, “Geothermal Outreach Principles and Comment Analysis Report” (link provided below).

Not that permitting projects on private lands isn’t complicated. Permitting a geothermal power plant on private land involves local and state jurisdiction, and can involve many of the same cultural and biological studies required by federal permitting agencies. Of course this varies depending on the location. Permitting a geothermal project on private land in Nevada or Utah is generally less complicated than a project in California.

Another critical issue is water. This has not been a problem for wind, but has been a large sticking point for solar thermal projects, and can be a major issue for a geothermal project depending on the technology used. While geothermal projects in some locations may opt for dry cooling, this is not an option everywhere, in particular, geothermal resources in the Imperial Valley of California.

The Imperial Valley, in southeastern California near the Mexican border, encompasses one of the largest geographical areas of concentrated geothermal potential anywhere in the world. Multi-gigawatt potential has been identified in this region, although only about 550 MW of geothermal capacity is currently in operation. The Imperial Valley includes the Salton Sea resource, as well as numerous other geothermal fields, including Brawley, Heber, and East Mesa (for which Ormat owns and operates approximately 200 MW of generating capacity). Due to its location and surface elevation (typically below sea level), it has some of the highest average ambient temperatures on earth, also making this a prime location for solar energy projects.

Air cooling is not a viable option for geothermal power plants here, and water use is always an issue of contention. This provides a dilemma, where water is valuable for both agriculture and industrial uses. Innovative concepts such as use of reclaimed or “recycled” water for cooling are one method for addressing this issue. Historically, water issues have been addressed on a project by project basis. However, it is clear that a more comprehensive water strategy is needed.

Drilling

Solar projects are based on the average solar radiation in a given area. Wind projects are based on average wind velocities in a given area. Both of these measurements can be obtained rather inexpensively, and without significant lead time. In order to confirm a geothermal resource, drilling exploration wells is required. Drilling and testing a full-size geothermal exploration well can sometimes cost in excess of $5 million.

Drilling geothermal wells can be risky even in producing fields, or fields already identified. Drilling in a greenfield is even riskier. Subsurface temperatures are often predicted from tests of mineral composition and chemistry from surface springs and
shallow wells. Additional geophysical techniques are used in exploration to help identify geological structures to target in the drilling program. While these methods can be effective at ruling out a certain prospect, they cannot predict the quantities of fluid and permeability in a geothermal reservoir, and still leave developers with only about a 20-25% chance that they will find a commercial resource. Before confirming the resource with a full-size exploration well, shallow temperature gradient holes, core holes, and/or slim holes are usually drilled to test a geologic model and confirm the extent of the thermal anomaly and the expected resource temperature. These test holes greatly reduce the risks associated with full-size wells, but increase project timelines and incur substantial costs (hundreds of thousands of dollars for shallow temperature gradient holes and typically over a million dollars for core holes and slim holes). Because each exploration hole reveals more about the resource, new sites often need to be located, or relocated, which may create additional permitting delays, particularly on federal lands.

Geothermal projects, thus, need incentives to perform exploration drilling at greenfield sites in order to justify the expense and help reduce the upfront risk. If the risks/rewards of geothermal drilling lack sufficient support, odds are few wells will be drilled at these sites. Evidence in the field demonstrates this point further. Nevada has seen the most drilling at greenfield sites, with a number of prospects being drilled in places where only shallow drilling has occurred in the past. However, most new drilling outside Nevada has taken place typically in areas with discovery wells (i.e. Cove Fort and Thermo in Utah, Crump, Neal Hot Springs, and Newberry in Oregon, Lightning Dock in New Mexico, etc.) In California, for example, almost all geothermal drilling over the past several years has taken place adjacent to existing facilities at Coso, The Geysers, and adjacent to existing facilities and discovery wells in the Imperial Valley.

Finally, geothermal drilling is not complete until sufficient production and injection wells have been drilled. Even highly productive fields like Brawley in California and Blue Mountain in Nevada have faced injection issues that limited production after the facilities were constructed, and required additional wells. Quite simply, a geothermal project is a highly capital intensive and risky endeavor, and more than anything else, it is the drilling of geothermal wells that separates geothermal projects from other types of renewable energy projects. Thus, in order to encourage more geothermal development, government policy must pay specific attention to the financing, permitting, and technological challenges of drilling geothermal wells.

**Transmission and Interconnection**

As a base-load energy source, geothermal power works well with the electric grid. Its supply curve is generally predictable unlike intermittent energy resources like solar and wind. However, geothermal fields vary greatly in their location and are often remote, in locations where building a transmission line can be challenging. Solar projects cluster where it is hot; and wind projects cluster where it is windy. Hundreds or even thousands of megawatts can be developed in one area or region (i.e. wind in the Columbia River Gorge in Oregon/Washington State, solar in the Mohave Desert). However, geothermal sites tend not to be as evenly clustered and simply building a large transmission line will not automatically lead to new geothermal capacity.

This “chicken and egg” scenario for geothermal projects remains a quandary as geothermal resources are considered in regional planning. Typically, a geothermal project in Nevada will involve anywhere from 5-30 miles of new transmission lines to tie into the main grid. This can significantly raise costs of projects that are relatively small (10-30 MW). However, due to Nevada’s wide open valleys, permitting of these lines is not usually a major issue, because existing rights-of-way can be utilized along roadsides. What is a primary challenge in Nevada, and California, as well as emerging markets in Idaho, Oregon, and Utah, is sending the power to major population centers. Thus, geothermal projects are better served by strengthening the capacity of existing grids, and expanding transfer capacity into larger markets. The existing transmission system in Northern Nevada was not built with the intention of exporting significant electric generation west into California population centers. The transmission system in Northern Nevada is not connected directly to the system in Southern Nevada, although NV Energy has proposed connecting both grids within the next three years.**

The Imperial Valley is another area where transmission is a critical issue. While the regional renewable energy resource potential is well known, the construction of new transmission lines has met considerable resistance due in part to the broad geographical area impacted by such projects, and the political and regulatory complexity involved. Thus, a great amount of outreach and leadership is needed to make such projects happen. One such project, the Sunrise Powerlink, is intended to bring renewable resources from the Imperial Valley to San Diego. San Diego Gas & Electric (SDG&E), has the lowest RPS compliance rate of all California RPS eligible utilities.

Initially, SDG&E wanted to build the line through Anza De Borrego State Park along an existing transmission line corridor. This was fought bitterly, and the route was moved. However, there are serious geographical limitations given that the park covers over 600,000 acres and is roughly 50 miles north-south, bounded on the south by Interstate 8. Efforts to build a new line “Green Path North” that would send power from the Imperial Valley to Los Angeles Department of Water and Power (LADWP) was recently abandoned after significant opposition. The Imperial Irrigation District, who would wheel power to these entities, has internal transmission constraints that they must address with additional transmission and upgrades.

Since these projects involve permitting through state and federal agencies, and need mitigation and significant cultural and biological studies, the complexity simply creates a political barrier, although the projects are economically and technically feasible. Complex and nuanced matters such as these are often avoided in the political arena, however, only through leadership and common cause, can such matters be resolved. Thus, one possible solution is to create legislation that ties permitting benchmarks to renewable energy standards, so that the ground rules for lawmakers, regulators, communities, and utilities are clearly laid out before passing mandates without complementary policies to enable those mandates to be met. Efforts to evaluate primary transmission routes for renewable energy have been taken up across the West, through regional studies, like the Western Renewable Energy
that recognize resource uncertainty.
utilities to sign long-term contracts with geothermal developers
then these regulatory agencies can help create incentives for
when establishing guidelines for renewable energy compliance.
State Public Utility Commissions when approving contracts and
produce on average three or four times as much as one installed
technology given that one installed MW of geothermal power will
cost-competitive on a MW by MW basis with wind and solar
criteria than wind or solar projects. Geothermal is highly
extended, there are no incentives for production of the geothermal
the currently available Investment Tax Credit cash grant has long
since expired, and so has the production tax credit. If these are not
extended, there are no incentives for production of the geothermal
resource. The project may no longer be economically viable. The
developer may not be able to acquire financing, and the project
may cease. This is the scenario facing the geothermal industry
if current policies stay in place**. If greenfield sites are to be
developed, longer timelines are needed for such incentives.
Because the rate of growth for geothermal projects is not the
same as for wind projects; as well as for solar projects, longer
timelines won’t score too high in budgeting for tax
incentive legislation. Thus it is in the best interest of legislators
to support extended timelines.
It is not that geothermal projects deserve special treatment than
other clean renewable energy technologies. It’s just that crafting
the same policies to encourage geothermal development and solar
and wind development is like crafting the same policies to encourage
growers of apples, oranges, and bananas. These technologies
are all clean, renewable energy, just like those commodities are
all types of fruit. But the methods for developing them are all
different, and must be treated as such.

**Conclusion**
As green energy incentives grew during the last decade,
policymakers made a point not to single out one technology over
another. This is why timelines and incentive levels have been
generally similar. This was fine in order to spur initial growth,
but as markets have matured so to must the policies. Geother-
mal energy is not a small contributor to electric generation. In
California, the eighth largest economy in the world, roughly
4.5% of electric load was served by geothermal in 2009 (Source: CEC).
Geothermal energy development has grown substantially
in the last decade both in the U.S. and worldwide. While this
new development is encouraging, it is only the tip of the ice-
berg. Development of geothermal resources has the potential
to grow even faster if the right policies are implemented and
implemented quickly. These policies must be comprehensive and
must address every hurdle or barrier to geothermal development
that unnecessarily slows down or discourages the development
process, in order to maintain industry growth, create jobs, and
benefit the environment.

**Notes**
*25% to County Governments was temporarily rescinded, but
then later restored through federal legislation in May of 2010. However, due to uncertainty over final passage by the time of submission, the 25% may not be the current structure as of the date of publication.*
**The status of the One Nevada Line may have changed by date of publication. The Public Utilities Commission of Nevada is expected to make a decision on July 28, 2010.***
***The ITC and PTC had not been extended by the time of submission. However, Congress has been attempting to extend them, and the status may have changed by the date of publication.***

**References**
CEC Source: [http://energyalmanac.ca.gov/electricity/total_system_power.html](http://energyalmanac.ca.gov/electricity/total_system_power.html)