Office of Indian Energy Overview of Geothermal Energy Development Webcast (text version)

Below is the text version of the webcast titled "Overview of Geothermal Energy Development," originally presented on January 10, 2012. In addition to this text version of the audio, you can access the recorded webcast and a PDF of the slides at www.energy.gov/indianenergy/resources/education-and-training.

Alex Dane:
All right, folks. We're going to go ahead and get started right now. It's my pleasure to introduce to you the Deputy Director of the Office of Indian Energy, Pilar Thomas, who's going to have a couple minutes here to introduce some background of the office of what they do and Pilar, I've un-muted your line so feel free to jump on in. I think we can hear you.

Pilar Thomas:
Hi. Good morning everybody. How many folks do we have on the line, Alex?

Alex Dane:
Right now we have about 48 and slowly climbing.

Pilar Thomas:
And climbing. Very good. First of all, good morning everyone. Thank you for attending I guess what I will characterize is the Office of Indian Energy Policy and Programs inaugural webinar on geothermal technology and energy development. Thank you for taking some time out of your busy schedule and at the beginning of this New Year to learn a little bit more about geothermal energy development. One of the goals that the Office of Indian Energy Policy and Programs has, both a statutory goal but also a strategic goal, is to help educate and build capacity in Indian country on the various renewable energy resources that they have, to provide information to Indian country whether it's elected tribal leaders, other tribal officials or tribal executives or folks doing business in Indian country and working with tribes on how to best develop based on the tribe's own goals and objectives, how to best develop renewable energy resources that the tribe may have.

The Department of Energy over the last 10 to 15 years has invested through grant funding a substantial amount of money in helping tribes do resource assessments, feasibility studies on the various types of renewable energy resources that those tribes may have, be it solar, wind, in some cases geothermal. For example in geothermal under the Recovery Act we actually invested about $5 million in two tribes to help those tribes determine what type of geothermal resources they may have available to them. So our goal for the Office of Indian Energy Policy and Programs is to help tribes leverage what they've learned through those resource assessments and through the visibility studies and actually see, as we like to say here, see some steel in the ground.

We'd like to see some projects up and running whether the tribe is the host or in other words leasing their land to an outside developer, or whether the tribe is going to take advantage of the resources for their own use. So this is the first in a series of webinars

that we will be sponsoring or co-sponsoring to help tribes better understand all aspects of energy development. A couple of things to note in that area, we do have right now an open request for applications for our newly announced START program. START stands for Strategic Technical Assistance and Response Teams where we've put together a group of experts from the Department of Energy and our National Renewable Energy Labs to assist tribes, selected tribes, on helping them actually see some steel in the ground, and that request for applications was announced back in December at the White House Tribal Nations Conference.

The program was announced then and the application period ends on January 15. The application itself is available on our website, which is energy.gov/IndianEnergy, and if you go to services and the start program there's one application for Alaska and then there's a separate application for what the Alaskans like to call the lower 48. So if you are a tribe in the lower 48 that's the application for you, and if you're an Alaska tribe or native corporation then the Alaska application is for you. It's a relatively simple application. Hopefully we're not asking for too much information, but we're encouraging tribes that are looking to actually get some projects developed and have pretty well developed ideas and/or are working with somebody that if you need the technical assistance to help kind of push you over the edge that's what this program is designed to do right now.

Certainly any questions about the START program feel free to call me separately or email me or send a question to IndianEnergy@hq.doe.gov, which is our email address, and we'll be happy to answer any questions. We're really encouraging folks to apply for the START application and work to get selected for strategic technical assistance on renewable energy projects. Another program note that I would make, I said this at the beginning of the webinar, we are also co-sponsoring a series of webinars that are actually being conducted by the Western Area Power Administration sometimes known as Western, sometimes known as WAPA, and they have monthly webinars and we have information up on our website about the upcoming webinar that's scheduled for two weeks from now on transmission and WAPA will be doing a series of webinars on the transmission system, regulatory issues, interconnect issues, understanding transmission and the grid.

So we encourage the folks on this call to also either go to the WAPA website or go to our website for more information on the WAPA webinar. So that's kind of what we're hoping these webinars will do. Again we thank you for your time. Let me just tell you a little bit about the two folks who are going to be presenting here at the webinar. The first speaker is a gentleman by the name of Kermit Witherbee. Kermit is currently at the National Renewable Energy Lab, is an energy geologist and analyst in the Strategic Energy Analysis Center. His work currently includes geothermal analysis and various areas including resource assessment, processing timelines, geothermal leasing, permitting, development, and policy analysis.

Prior to joining NREL, Kermit served as the BLM national geothermal program manager, so he has a lot of familiarity with how the federal government permits and processes

geothermal. His career with BLM has included staff and supervisory responsibilities in oil and gas, leasing and management, reservoir management, evaluations, as well as national level policy development, strategic planning and budget. He has both a bachelors and a master's degree in geology from State University of New York at Oneonta. He is a registered professional geologist in Wyoming and a member of the Geothermal Resource Council, American Institute of Professional Geologists, American Association of Petroleum Geologists, and a Geological Society of America.

Our second speaker is a gentleman by the name of Paul Schwab. Paul researches renewable energy finance and related policies at NREL. He's authored several studies on the economic drivers of wind and geothermal energy projects, and investigated the effects of the financial crisis on renewable energy deployment. He's contributed to the design and review of the *Guidebook to Geothermal Power Finance*, which I highly recommend for those of you who are interested in reading something. The document is on NREL's website. His diverse professional experience includes over nine years in the electricity, natural gas, and financial sectors. He holds a Master of Science in applied economics and finance and a Bachelor of Arts in Economics from the University of California at Santa Cruz.

Wow, he went to Santa Cruz? I won't say anything about Santa Cruz. I'm from California. So those are our two speakers and a little bit on what we hope the goals of this webinar are and the upcoming webinar series that we'll be rolling out for education and capacity building. Thanks again to NREL for pulling together this forum for us and getting these two great speakers to present to Indian country on geothermal development. If there aren't any questions, Alex, I'll turn it back over to you.

Alex Dane:
That's fantastic. Thank you, Pilar. A big thank you to the deputy director of the Office of Indian Energy there for the introductions. Thanks. We're going to go ahead and get started with Kermit in just a couple minutes here, but just a few housekeeping notes. Kermit is going to present for about a half-hour. Then we're going to do a brief Q&A. Then after that Paul is going to present and we'll do a Q&A after that. So if you want to hold your questions until then that would be the most appropriate time to ask them.

Probably the most effective way to ask the questions will be type it into the chat box that you have in the lower right hand corner and you can send that to the meeting organizer or you can send that to the audience as a whole and see if we can get some conversation going. Otherwise when we get to the Q&A time, everyone's phone line is muted right now, but we have the option of clicking on your phone if you're entered the audio PIN. We can un-mute your line. So when we get to the Q&A you'll see a little icon for a raised hand. If you have a question during that Q&A period, raise your hand and then we can un-mute your line and hopefully we can answer the questions that you have. So without further adieu, I'm going to go ahead and turn the presentation over to Kermit who's going to jump right on in.

Kermit Witherbee:

Okay. Thank you, Alex and thank you, Pilar. It's a pleasure to be presenting here. Planning on doing a very quick, down and dirty general view of geothermal resources, geology, technology transfer, some environmental impacts, and then leasing and permitting in general on federally managed lands and also discussing –

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A little housekeeping here. There we go. So anyway, the outline to reiterate, talking about geology and environmental impact, technology and energy conversion, and leasing and development.

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Geology and resources.

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For the worldwide view, plate tectonics is the driver for the location of the majority of geothermal resources that have been explored and developed worldwide. You can see on this map the various places that affect us in North America is the Pacific plate and the North American plate. The little red triangles in there are locations of volcanoes for the most part. The string of vertical volcanoes in northwestern America is the Cascade Range.

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Taking a closer look at a cartoon of the processes: As you can see, there are two main types of geothermal systems: a magmatic system, which is characterized by the Cascade Range. At present there's no electrical generation from the Cascade Range. Unfortunately or fortunately depending on your perspective, geothermal never made it up to the northwest because of having to compete with the low electrical prices for hydroelectric generation. As you can see the hotspots are the Cascade Range in northwestern United States or any other subduction zones associated with volcanism and magnetic systems, and then you have the extensional systems. If you look at the top of the diagram up there you'll see there's rifting, an area of extension, a down dropping with associated volcanic activity. These are the extensional systems, the rifting characterized by the basin and range and the central western U.S. The Rio Grande rift, which runs from Mexico all the way up into central Colorado, Imperial Valley and extreme southern Colorado, northern New Mexico and the East African rift valley.

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Geothermal potential can be divided up into exploration districts of favorability. This map was generated by the U.S. Geological Survey as a result of the Energy Policy Act of 2005 and in September of 2008 the USGS published this map as well as resource estimates for indicated undiscovered hydrothermal and EGS, which is enhanced geothermal systems, which is the development of geothermal resources at great depths in areas that don't have an hydrothermal (hot water and sufficient fractures) systems. So as you can see in this map the Cascade Range runs from northern California up into Washington. The majority of hydrothermal systems are in the basin and range province, which is for the most part Nevada, western Utah, southern Idaho and Oregon and extreme

eastern California and then down in the southern part of California you see the Gulf of California rift zone, and eastern side of the map there you see the Rio Grande rift system, which incorporates portions of the southern Rocky Mountains.

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This table is the resource assessment, the identified means in megawatts of equipment electricity for the various states, and you see that from the identified California has over 5 gigawatts capacity that were identified, and also has 11,000 gigawatts of undiscovered and has a fair amount of enhanced geothermal systems, and we'll look at a diagram of that in a few minutes. You see there's a lot of potential, 30 gigawatts of undiscovered hydrothermal resources, still out there to be discovered.

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This is just a map of Alaska, Hawaii, and the western U.S., the geothermal systems on the public lands, and you can see most of them are scattered around the basin and range geologic province. There's I recall about 253 different systems that are actually used within the evaluation, and these are hot springs and other geothermal features. They could actually make estimates in terms of the volume, the temperature, and come up with an estimate for capacity in megawatts for each one of those locations.

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A brief overview of environmental impacts: Geothermal is extremely environmentally I guess I could say conscious of the environment in terms of land use and technology, and these are just averages. Geothermal uses about 47 acres per gigawatt hour produced over 30 years. Solar VP of course you have to have a lot of land available for capturing the sunlight. The other aspect is water use for technology. As you can see down at the bottom geothermal binary is a closed loop system, consumes zero water. What comes up through the wells and through the heat exchangers is reinjected back into the reservoirs. Geothermal flash with reinjection is about five gallons per megawatt hour. Most of that is lost through the cooling powers of steam. The coal fired power plants and nuclear in particular, are big water hogs; they use a lot of it.

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Power plant comparisons and air emissions: This came from the Geothermal Energy Association a couple years ago. The Cherokee station is a comparison between '97 and 2003 in terms of the nitrogen dioxide, sulfur dioxide and CO2 emissions and you'll see that they actually were able to lower their nitrogen dioxide and sulfur dioxide emissions while increasing production. The CO2 emission rates went up a little bit, but if you look at the Sonoma County emissions from the geysers, those emissions are from the water loss essentially from the cooling towers. Those are flash plants. They generate electricity directly from the pressure of the steam coming up and turning the generators. The Mammoth Pacific plant is on the eastern Sierra near Mammoth Lakes. It's a binary plant that is a closed system and has zero emissions and you can see that they have zero nitrous oxide, sulfur dioxide, and CO2 emissions.

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In terms of technologies and capacity factors: These data shown are very general averages and basically it's the percentage of time that these generating plants are actually in operation. I'll be talking about this in more detail later, and covering investment cost. Geothermal binary and flash plants, I think the cost has gone down, but they're in the middle of the pack.

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In terms of energy conversion the types of power plants, the world's first geothermal power plant was in 1904 in Larderello, Italy, with Prince Piero Ginori Conti standing next to his generator. Basically it was a separating tank there, pressure tank that ran the steam generator. As I understand it generated enough electricity for several incandescent light bulbs, and today the area has expanded from that one little plant up to 473 megawatts of electricity production.

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Geothermal environments are divided into the types of systems, the hydrothermal systems, meaning hot water is being circulated, and they run from high temperatures about 150 degrees C or over 300 degrees F. They are liquid and vapor dominated. Hot steam comes up and it might even be dry steam for that matter, and then the moderate temperature environments are primarily liquid dominated, the brines that are circulated throughout the binary systems, the flash systems, and they range from about 190 degrees F to over 300. Then the lower temperatures are for liquid dominated and they are generated less than 194, 190 degrees.

Then there's a hot, dry rock which I'd previously mentioned that engineered geothermal systems and I'll touch on that briefly later on. Then co-production generation is usually the geothermal resources from oil and gas production, and this can be from utilizing the hot water produced from oil and gas wells to generate electricity to a binary geothermal system. Next is Geo-pressured, which is using the kinetic energy of the pressure from oil and gas well that's produced as co-generation with oil and gas production that can be utilized to generate electricity.

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Dry steam plants: This picture shows the geyser geothermal area in northern California. It's a magmatic system; wells produce dry steam at depths down to about 8,000 feet with temperatures up to 480 degrees F. Go to the diagram on the right, little cartoon, that illustrates the sequence of the power generation, there's a producing well, in that case lots of wells in the area, and the dry steam produced under pressure, turns the turbine which in turn generates the electricity. Then that steam is cooled. Steam is emitted to the atmosphere in a cooling tower. Condensed water is re-circulated and then re-injected. There's a little bit of emissions in steam as you can see in the plant, so that's just hot water and steam being emitted into the atmosphere.

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The next type of plant is the flash plant, and these can vary from 300 to 700 degrees F. If you look at the diagram on the bottom right, the brine comes up under pressure and it a

portion of it flashes into steam when the pressure is reduced, and then the steam directly turns the turbine and the water, the brine drops out and condenses, is then reinjected. The steam goes through a cooling power. Some steam is given off. You don't see very much in this one, that's the Blundell power plant in southwestern Utah. This plant over the last two years has added a bottom cycling (binary) unit so they capture heat from the brine, the heat from the hot brine is then piped to a binary system that uses a heat exchanger to generate additional electricity so they're not losing that additional heat, and then that's re-injected back down into the reservoir.

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And last is the binary power plant for electrical generation. These are lower temperature, up to 360 degrees F. The example shown here is the Mammoth Pacific Power Plant at Mammoth Lakes, California. You can see they use fans for cooling, large rectangular areas; the working fluid is pumped to the cooling fans (working flluid is what goes through the heat exchanger), cools it off, and then is recycled to the heat exchanger where the process is repeated. The process is using the hot water, the brine through a heat exchanger to heat up a working fluid, which boils off at a lower temperature and then that goes through the turbine and then goes through the process. It's a closed loop system on both ends.

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Low temperature works very well in areas where you have a great difference in temperature of the geothermal fluids and the surface. This is the Chena Hot Springs resort in Alaska. It's a hot springs resort. The local proprietor is Bernie Karl. Through DOE grants, investments and a lot of research and development, commissioned a 250 kilowatt binary plant in July of 2006 a second system was added later that year. It's the lowest geothermal temperature plant. It's less than 165 degrees F. The system is off grid. He's got a sustainable system up there and he uses the waste heat and the heat from the hot springs for growing vegetables in the greenhouse and he's added all sorts of other things, growing additional crops for animals like beef and pork that he also raises there, and he's also capturing and recycling CO2 into the greenhouses to enhance their growth cycles.

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Oil and gas, well co-production and geo pressure: Bernie Karl, Chena Power, has a mobile unit that was partially funded by DOE to showcase and demonstrate low temperature and co-produced geothermal technology. The picture in the upper right is at the Pepper Mill Resort and Casino in Las Vegas and they are actually operating it there on some of the Pepper Mill' geothermal wells. The geothermal heat is used for space heating and the mobile unit was hooked up to their wells and used them as a demonstration project for low temperature electrical generation. Then the Rocky Mountain Oil Field testing center is an oil and gas co-production project with DOE and Ormat Technologies up in Wyoming. It's located at the Salt Creek, Tea Pot Dome area north of Casper and that's been working on research and development on binary systems from oil and gas fields.

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Engineered geothermal systems energy: Basically, this is artificially creating a geothermal reservoir by hydro fracturing or hydro sharing the rock. Then the process is to introduce a fluid into that rock, where it is heated, and then pump it up and run it through heat exchangers to generate electrical power. The fluid is then re-injected into the reservoir to be re-circulated. This example came from AltraRock west and the east and supporting this for quite some time.

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Current development projects: I'll go through this pretty quickly. As you can see the capacity is added quite significantly since 2005 from 2,700 megawatt capacity to 3,100 and it's still growing.

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Power in the top countries: As you can see on the graph, the U.S. is still the largest producer of electricity from geothermal. Philippines and Indonesia are coming on strong, with a lot of new capacity being developed. The expected rate or amount of growth and generated capacity up to 2015 and beyond is shown on the graph.

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In terms of the U.S. there are 78 power plants, about 3.1 gigawatts capacity that generated about 15,000 gigawatt hours in 2009. As you can see, California has the greatest generating capacity, followed by Nevada and Utah. Other states, Oregon and Idaho will be coming online. Utah has two other major projects in development.

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In development by state, we'll look at these visually later, but as you can see there is phases one through four development. Stage four development is when they're starting to build the power plant. There's an additional almost up to 5,000 gigawatts coming online in addition to almost 6,000 gigawatts of overall total.

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Growth in Geothermal Projects: This is a little pie chart and a bar graph showing the number of projects from co-production to geo pressure to hydro thermal un-produced, produced, and what's being expanded.

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Leasing and development: I'll probably concentrate on this more than anything else. Policy drivers and incentive programs slide. Paul is going to talk more in detail on these. This is just an overview. He's got more detail in his presentation coming up, but DOE's geothermal technologies program is instrumental in implementing many of these incentives and subsidies. Production tax credits are on again, off again, but it's eligible for power plants that are placed in the service by 12/31/2013, and that's a tax credit write-off, which is quite an incentive. The Energy Policy Act of 2005, accelerated BLM's geothermal leasing program.

- The Bureau of Land Management (BLM) conducted a programmatic geothermal leasing EIS with the US Forest Service and has since completed a major revision of the geothermal regulations. Since 2007 BLM has conducted several sales that have more than doubled the number of geothermal leases that are available and in industries inventory. Also, under provisions of the Energy Policy Act of 2005, revenue from federal geothermal leases is shared with the states and counties in which the leases are located. All the revenues from geothermal from federal leases, which includes bonus bids from the competitive lease sales, royalties paid on production, and lease rentals: 50 percent goes to the state, 25 percent goes to the county in which the leases are located, and 25 percent goes to the treasury. There's also loan guarantees available for qualified projects and a production tax credit. Also the, American Recovery Investment Act and renewable energy portfolio standards has facilitated geothermal development.

The development process, first you've got to have a lease, whether it's a federal lease, a lease from a private party, private mineral owner, or from a state agency, as well as on tribal lands or individual mineral owners on the Indian lands. There are two primary regulations in effect for Indian Country: one is 25 CFR 211, which is Leasing on Tribal Lands, and the other is The Indian Minerals Development Act, 25 CFR 225, Oil and Gas, Geothermal, and Mineral Agreements. Once leases are acquired, exploration activities take place to locate and identify the resources. Generally, prior to that time and the acquisition of a lease the lessees or development parties have a pretty good idea that there may in fact be commercial deposits available and a lease is necessary to determine whether or not a commercial resource exists.

Next would be the drilling of production and injection wells once a commercial geothermal reservoir identified. That's followed by the utilization process, which is the construction of the power plants and/or production facilities and commercial generation; utilization of the resource. Finally, once the resource has been exhausted or no longer commercial, and it's quite a ways down the line, for instance, the geysers have been producing since the early 60's, late 50's I believe. In the example in Italy, the Larderello geothermal field has been producing since 1904. Then finally once all the production is done wells are plugged, facilities removed and the surface is reclaimed.

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This is just a simple little matrix that illustrates responsibilities in Indian Country for tribal and allotted lands both in terms of leases and IMDA's. BIA's role is as advisor and for approval, BLM when requested, under their 43 CFR's, cover evaluations, mineral appraisals in terms of the leasing. For geothermal exploration operations; BLM when requested by a tribe will do permitting for geothermal exploration such as temperature gradient wells, seismic and other geophysical activities. For the actual drilling operations, BLM will approve the drilling permits and sundry notices for subsequent operations. BLM will also work with the tribes and their reality/energy offices on plant construction and development. Resource assessments, appraisals, agreements, approval, and this is all done in conjunction with working with the tribes and the BIA offices.

Then ONRR, which is the Office of Natural Resources Revenue, still having trouble with their name change. I still think of them as Minerals Management Service (MMS). In terms of accounting and auditing, they do the actual physical auditing and the collection of revenues and then disperse the revenues to the tribes or the allotment owner. BLM monitors production as verifies what was reported in terms of the electricity that was generated and was sold in any particular month and they keep track of that and check it against the production reports that go from the operator to ONRR.

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This is the flow chart of the IMBA process, and I found this in a California Geothermal Energy Collaborative, California Tribal Workshop that was conducted, in Davis in 2006.

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Permitting exploration: Any activity that requires physical presence on the land that may cause damage to those lands requires a permit. Permitting requirements: all activities require evidence of bond coverage. The filing of a Notice of Intent to Conduct (NOI) exploration that will involve surface disturbance requires measures to protect the environment, reclamation methods, as well as other methods that may be required in the execution of that expiration activity. For the drilling of a temperature gradient well, under BLM regulations there are 12 items required as part of the NOI. If it's other than a temperature gradient well, a seismic operation or a gravity or magnetic survey requires a description of the operation, the starting and ending dates, and reclamation plan. Exploration filed under a NOI does not include the direct testing of the geothermal resource, so temperature gradient wells cannot drill into the reservoir. Testing of the reservoir requires that a Geothermal Drill Permit (GDP) be approved to test a potential geothermal reservoir through the drilling of production and injection wells.

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That's covered under the geothermal drilling permit, the actual drilling operations into the reservoir. In terms of operations and bonding, it is necessary prior to initiating any surface disturbance too have a bond in place. The amounts, which are minimums, are $5,000.00 for single operations, $25,000.00 for operations within a single state, and $50,000.00 for operations nationwide, and it's released after requested not automatic, after all the wells have been plugged and abandoned and the surface has been reclaimed, and met all requirements for reclamation (both within the lease terms and regulations). Final determination is made after consulting with the tribe and BIA before a bond is released.

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Geothermal drilling permits. These are the deep wells, wide diameter bore hole, initially, may be up to 28 inches or greater in diameter. Sometimes an operator may choose to drill a slim hole to confirm the existence of a commercial reservoir, prior to drilling a full diameter well. As you can see in the slide the well permit requires a drilling plan and a surface plan that covers all aspects of the drilling in terms of health, safety, casing, cementing, drilling fluids, surveys etc and the layout of the drill location and access to the location. Abandonment may be required when the well is no longer needed or if the well

is not mechanically sound. During the drilling of the well and subsequent operations any changes to the drilling plan and completions plans would be submitted on a sundry notice, which is submitted to BLM and/or the tribal energy office.

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Bonding for drilling operations is also higher than those required for exploration operations. Cash bonds are not accepted, only a letter of credit or surety bonds. Again these amounts are minimums and are: $10,000.00 for an individual lease, $50,000.00 statewide, and $150,000.00 nationwide. Again they're released only after requested, the wells have been plugged and abandoned, and the site has been reclaimed.

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Miscellaneous geothermal drilling permit: a drilling permit and surface operations plan/program can be submitted together, or they can be submitted separately. In this case the operations plan would be submitted prior to submitting the actual drilling plan. This is required because of the environmental studies that have to be done prior to approval of the permit and requires the environmental documentation that has to be done and approved prior to approving any operations. Subsequent changes to the drilling plan, which I just mentioned are by a sundry notice for approval for site operations.

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This is just a picture of a big rig drilling out in Nevada. I don't know exactly where. You can see the steam coming out; it looks like they are at reservoir depth and may be doing initial production testing. It takes a fair amount of surface disturbance for a drill rig of this size. These wells are typically started and cased at greater than 28 inches diameter at the top. The volume of the well bore that they're drilling is greater than oil and gas, because you need to have the greater volume in the well to bring up the capacity (volume of fluid) and the heat for generating electricity through the binary, heat exchangers or flash plants.

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Well testing. This slide shows a couple examples of well testing and I don't remember where these game from. I've had these pictures for quite a while. The picture on the left is testing a well that had previously been completed is flowing from the wall head, called a Christmas tree, and is discharging into a holding pond or reserve pit where the steam condenses. The other one is a vertical test where the steam is vented into the atmosphere.

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Exploration operations: Just a few general notes on abandonment. When the generation facility or power plant is no longer needed, when BLM or the tribe comes in and says, "We want that cleaned up" before there's a sundry notice filed by the operator. They are required to file a sundry notice to begin reclamation and they're not to start working on abandonment until they're approved. On reports the lessee submits all the data for the operator. Confidential information is held confidential indefinitely, or until release is

authorized by the operator, or Tribal authorities. These provisions, details for 43 CFR and the 25 CFR.

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Abandonment: Wells when they're plugged and abandoned, if there's a dry hole or they're no longer needed or they're an observation well and no longer needed. You file a notice of intent, a sundry notice to abandon the well. If the operator didn't previously submit the information it includes all required data. There are five items required for abandoning wells that are listed in the code of federal regulations. Oral approval can be granted, but the request must be subsequently filed. The surface has to be reclaimed before the bond can be released. Again abandonment may be required when the well or the facilities are no longer needed or they're not mechanically sound.

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Monthly reporting: Newly completed wells. File a completion report within 30 days after the well is completed. Subsequent work-overs (maintenance) are required to be reported on sundry notices. Confidential information, as previously mentioned, is covered under the Freedom of Information Act (FOIA) provisions and also under the provisions for holding all Indian minerals data as confidential. Items that are typically not held confidential is the surface location, surface elevation and well status. There is a dual regulatory provision with state regulatory agencies for regulating geothermal drilling and production. Sometimes they handle confidential information differently and vary from state to state.

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Utilization of the actual building of the power plants, and there's basically two types of utilization. One is direct, which is – at least this is going to be non-competitively, and state, tribal, and local governments can use geothermal resources directly and secure a noncompetitive lease and for public purposes other than commercial generation of electricity. Indirect utilization is where you're converting the heat to generate electricity from it. There's also a provision for mining claimants that they can secure geothermal leases on federal lands non-competitively if they meet certain requirements, which is basically having an approved plan of operations. The photo on the right is if of an alligator farm using geothermal waters. This alligator farm is located the San Luis Valley in Colorado, just north of Alamosa. The power plant with the red turbines in the middle I think that's located in the Imperial Valley of California near the Salton Sea, and then the lower picture is a minerals drilling rig in Nevada, probably drilling for gold.

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The National Renewable Energy Lab, with DOE support and funding has developed a Developer's Permitting Checklist. The link for this checklist is located in the upper right hand corner of the slide; please take a look at it. It's got a lot of information on permitting both on the state, the federal, both on BLM and National Forest Service Lands, and private lands and also has information there on leasing and development on tribal lands. It's a good place to get other information. It's currently being expanded and

put into OpenEI, a kind of a Wiki format, which will be available sometime this next spring or early summer. That's the end of my presentation.

Alex:
Great. Thanks, Kermit. Just to answer some questions that I saw popping up right now, we will be posting the slides after the presentation on the Office of Indian Energy's website, and if not there a direct to where those slides will be. We're going to put a hold on actually raising hands and doing a live questions right now in favor of the chat right now. We're recording this and we want to push the questions to the end so we can have all the presentations together for further use. We're going to move on to Paul Schwab next. I'm going to go ahead and bring up his presentation, and a big thanks to Kermit for that really insightful presentation. Just one second, folks.

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Great. With that I'm going to turn this over to Paul Schwab. Paul, if you just want to give a couple sentences on your background to give a little framing and just jump on into it.

Paul Schwab:
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Great. Thank you, Alex. Hello everyone. Yes, I'm Paul Schwabe. I'm an energy analyst here at NREL as Pilar also described, also proud alumni of Fighting Banana Slugs of UC Santa Cruz. I'm going to give you a quick introduction and overview of geothermal financing. NREL has done a number of analyses for geothermal financing with support from DOE. We don't have the time really to get into the depth of other products that we've put out, but I'm going to pepper in this presentation different areas to go for more information following the webinar.

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So with that, here's a quick overview of some of the ideas that I'd like to cover today. First is just a geothermal U.S. market snapshot. Kermit covered this briefly, but I want to just reemphasize a couple points. I think it's especially important in the context of why the geothermal financing market is as it is, which I'll describe. I will also get into a quick discussion on the key federal incentives for geothermal energy power production and the impact on the economics of a geothermal energy plant. Also I'm going to spend the bulk of the time on describing the geothermal project development process and the financing process as well, and then cover a few areas of challenges that typically arise in terms of developing a geothermal power plant. As I mentioned previously I'm also going to give a few areas where we can go following the webinar for more information.

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So as Kermit described there's nearly 3,000 megawatts of cumulative geothermal installed capacity in the U.S. that's shown in the graph on the left. As Kermit described these projects are primarily concentrated in California and Nevada. What's interesting going forward is if you look at the chart on the right, U.S. capacity that's underway especially in the drilling or construction phase, that is projects that are likely to come

online, have a much more regional representation in states where there's limited development thus far but expect to be several projects going online in the next few years.

In terms of the bullet points down below what I want to emphasize here is that it's been a relatively couple of lean years the last two years for geothermal energy development. In 2010 about one project came online, at 15-megawatt project. In 2011 continuing that trend, really just one project was refurbish for a couple of additional megawatts and then one new project that reached mechanical completion and that is essentially not commercially online but expect to be online in the next month, so for all intents and purposes developed in 2011. So as I mentioned a relatively lean couple of years the last few years.

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In terms of why this is I think there's a number of reasons why we've seen this slowdown the last couple of years for geothermal industry development. One of the key reasons for that is often cited is lingering impacts from the 2008-2009 financial crisis. I know that seems at this point a couple years ago, but what I'll get into is that the development for geothermal plants timeline is longer than typically other renewable energy projects, and so you're really just – it's taken a few years for those impacts to play themselves out in the geothermal sector specifically. As the headlines indicate here, several investors for renewable energy projects generally and geothermal energy developers specifically investors for those projects have actually left the market or been restructured in a way that limited the supplies and investment coming to the geothermal industry.

Not only does it limit the supply, but it also shifted downward the risk tolerances for many geothermal investors. The good news however is that many analysts including Bloomberg New Energy Finance, predict that 2011 will really be the bottom of the trough and that we'll start to see significant up-ticks in development in the next few years. It's just simply taken a couple years for the investment community and the market to recover and for that to trickle down to the geothermal industry with the longer development times. Many of the projects that were developed in 2010 and 2011 were actually seeking financing right around the crest of the impact of the financial crisis.

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That gives you a snapshot of where the market is and where it's about to be headed in terms of federal incentives.

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What I want to point out is we're just really scratching the surface or the tip of the iceberg for all of the different policy considerations for geothermal development. Kermit covered the leasing policies. I'm going to spend a few minutes on federal tax incentives, and there's a lot of different policy and regulatory considerations for geothermal development and essentially making a project pencil out and the economics work.

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As I mentioned, I'm going to focus quickly on some of the key federal financial incentives for geothermal. This is specifically a table showing what I've identified as the two key primary financial incentives for geothermal. This list is not exhausted, but they're the ones that provide the bulk of the economic value of federal incentives. On the top row you have an election between a couple of tax credits, I'm pointing to the production tax credit or the investment tax credit. These are one or the other; you don't get both.

The production tax credit is based on actual kilowatt hours that is produced by a geothermal system. It's worth approximately 2.2 cents per kilowatt hour. It's adjusted for inflation annually and it's available for ten years. Alternatively a developer can also elect the investment tax credit. This is essentially worth 30 percent of the cost of the system and it's a one-time payment as opposed to being available for the first ten years of project The investment tax credit is a one-time payment at the end of the first year after the project was brought online.

It is important to point out that both of these tax credits have a sunset expiration date of December 31, 2013, so projects need to be in the ground and commercially online by that date in order to qualify unless otherwise extended. The other benefit is what's called modified accelerated cost recovery system. That's really a long-worded way of saying essentially it's a tax deduction of the cost of the geothermal plant. It's increasing or accelerating the depreciation of the plant from typically around six years. That's more economically beneficial than depleting it or depreciating it over 20 years, which is the alternative incentive option.

The point at the bottom what I really want to emphasize is that both of these federal incentives in combination provide a tremendous amount of economic value to the system. In combination they represent somewhere around half the cost of this system. One thing that's important to point out though, the federal government has chosen to incentivize these based on the tax code, and that primarily means that, one, you have to be a taxpaying entity in order to utilize these incentives, and two, you have to have expectations of a tax bill. There are considerations to be made for ownership considerations on whether or not a developer would want to own the project in order to take advantage of these credits. Again you have to be a taxpaying entity in order to take advantage of this. There could be some ways to develop some pass through entities potentially to utilize these, but it is a key driver for the economics of a geothermal system, and it's important to keep in consideration.

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In terms of the geothermal development process, everything that I'm going to be talking about in the next few minutes comes from a project that NREL partnered with Navigating Consulting with support from DOE to develop a guidebook to geothermal power finance. That's the report that's shown on the left. This was published in late spring 2011, so it's relatively recent. As I mentioned I'm only going to be covering some high level information, but NREL has also developed a dedicated website that distills much of this

information that's shown here at nrel.gov/geothermal/financing that you can go to following the webinar.

It's important to point out what we are and what we are not talking about. This is principally focused on geothermal electric power, so it's not talking about the direct use of geothermal or the alligator farms or the greenhouse applications that Kermit mentioned. It's geothermal power production. It's also for conventional technologies. For all intents and purposes what we're going to be talking about is for binary cycle and flash technologies, which is what primarily the market is developing at this point, and it's also on the utility side of the meter. What I mean by that is it's not distributed generation.

They're also not small projects. They're on the order of several megawatts. There's not a definitive size of what constitutes utility size but keep in mind that they're several megawatts, which costs on the order of tens of millions of dollars. The reasons why you need these large project sizes is simply the projects have to be large enough to attract capital investment. There's a significant amount of due diligence and financing and cost that goes into supporting and investing in geothermal projects, and there has to be a sizable incentive in order to really spend the time and investment in a project. So again, we will be talking about large projects not on the distributed scale.

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So this is a slide that shows what the 2008 geothermal technology's market report defined as the stages of geothermal development. Geothermal typically takes somewhere from around four to seven years for development of a geothermal plant. This is not a hard and fast rule. We've heard some estimates up to ten years, but it's not an operation that is going to be from completion in the same year. We've classified these five stages of development also shown kind of some of the activity that's involved with each stage and a rough approximation of the percentage of costs under each stage, which is shown in the graphics.

The first two stages, resource identification evaluation, I don't think this is necessarily unique to geothermal. This is something that all renewable technologies essentially other than the steam gathering that we listed there will go through essentially identifying a site, doing some virtual reconnaissance, perhaps focusing in on a few development areas, gathering necessary permits as Kermit discussed, these types of activities. Unique things perhaps for geothermal is it could include a temperature gradient well, but it's not the actual drilling phases, which I'll talk about in a second. On the order this is somewhere around 10 percent of costs.

In terms of what I really think is the unique feature of geothermal for the development process is the drilling aspects. These are shown in stages three and four. What's unique about these is they're a high percentage of systems cost, somewhere around 40, 45, 50 percent of the systems cost is found within the drilling phases. It's unique also because there's no certainty of project development at these stages. You're incurring these certain amount of cost without necessarily knowing full well if a project will proceed to

commercial operations or not. Finally a plant construction, which is about the remainder 50 percent of the cost. This is similar to a construction of any sort of power gen technology. At this point I'll get into that financing becomes much more similar to what you would see for other technologies. It's simply building the plants, construction, and infrastructure to get the plant online.

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So one of the key concepts for financing geothermal is that it's a staged investment process just like it's a stage development process. You're going to have different investment types that correspond with each stage development. What I want to introduce here is this concept of the risk spectrum within the development process that is represented by the red arrow at the top of the graphic. What this represents really is that in the initial stages of development it's considered a moderate level of risk. In the very early stages the project is probably not likely in terms of the probability of coming online. You have a low level of probability.

With each successful stage of succession to the next stage of development that probability goes up, however you also have increasing some costs at that point. There's a certain amount of investment necessary to progress to the next stage, so you have what's really an increasing risk profile from the initial moderate stages of resource identification, increasing through the test and production well drilling phases when the project is at the highest risk. The reason why it's at the highest risk at this stages is because one, you still do not have a definitive answer if the project is going to come online or not, and two, you've sunk a considerable amount of costs, perhaps as much as 50 percent of the overall cost of the system up to this point.

Now once you have adequate production wells drilled, and one geothermal plant may require several production wells as well as re-injection wells, there's enough certainty about the resource that it's likely to have a decreasing risk profile at that point where you can attract kind of more moderate risk investors who are more comfortable once the resource has been proven investing into a geothermal project. As I mentioned multiple investors will be required typically, not always, and I'll get into a couple exceptions, but most of the time multiple investors that are aligned with the type of risk and return that matches that stage of development.

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So this slide really I tried to match up the stages of development and the decreasing risk profile that was shown in the previous slide. It also gives some examples of sources of funds that have been used for each stage of development. As I mentioned the report goes into more detail than I will be able to on each of these and provides some examples. In terms of the early stage equity this is primarily equity driven and that's because the project is really too risky to get a loan against at this point for really the drilling phases, the initial exploration phases. The probability is low enough for completing a project that a bank isn't really going to want to lend to that project.

Some sources that I've used for past funding is exchange traded equity. What I mean here is simply partnering with a developer who is traded on a public exchange, simply a stock market. There's examples of firms, developers partnering with firms who are on both the U.S. and international stock exchanges, and there's different mechanisms in the stock exchanges that they can use to raise funds for a particular project or the company as a whole. Private equity is a similar type of investment except it's not publicly traded, it's privately held, and it's partnering with a cash rich company that is willing to invest in either your particular project or your particular company with some ownership concessions going to the private equity investor.

There's also corporate balance sheets. This is working with a developer who has a portfolio of projects and that they're large enough and cash strong enough to be able to invest in one particular project that is supported by the company as a whole. It's basically financed on their balance sheet. As the risk profile is reduced, some of the resource is proven, you might be able to attract what's known as mezzanine finance. This is sort of a combination or a happy medium between early stage financing and late stage financing. The examples here, this is kind of the first introduction of when debt might be available for a project.

This is where a corporate level company might come in and be able to take out a loan against the company level, so that is it's not just supported by your one particular project but a suite of development projects and that the company could be able to take on a corporate level loan at this point, or similarly a line of credit where they draw down the funds as necessary. Now as I mentioned once enough of the project has been proven you get to what's defined as construction and project operating finance. This is really kind of plain vanilla long-term debt financing for the project. These are often bundled together as one product from a traditional lender, that is a bank or other type of lending institution, and this really corresponds to the construction and operation of the plant.

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So turning back to this slide, I added here a box. What I really wanted to emphasize is that there are certain milestones that need to be met in order to proceed from each stage of development. Some are present along the entire spectrum of development such as an experienced and qualified management team. That probably should go without saying, but of course there are other milestones that are unique to the stage of development.

One interesting aspect I think is approaching the level of where you might get financing for the production wells, so sort of this high risk phase. You'll see if you look down there's a line there, PPA with a credit worthy counterparty. PPA is a power purchase agreement, and what I'm trying to emphasize there is that oftentimes although not maybe 100 percent of the time, more often than not I should say, you will need to secure someone to buy the power of your system, and that buyer power has to be a credit worthy entity that is likely to be around for the entire length of the contract. Without that PPA it's difficult to secure even financing for the production well phase of drilling.

Another interesting aspect is under the plant construction phase. You'll see there's some red text of at least 50-80 percent of production wells drilled. This is a really interesting effect from the financial crisis is that in order to get that more traditional construction financing of a plant you need to have proven and financed somewhere between 50 and 80 percent of your production wells. This is a significantly higher percentage than it was before the financial crisis. That number may have been somewhere around 25 percent of your production, 35 percent, something like that, but now you'll see the lion's share of production wells have to have been financed, drilled, and successfully proven in order to get that more traditional and cheaper financing of construction and operating finance.

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Here's some examples of recent financing strategies that I've listed with the various strategies for financing. What I think is really interesting about this table is as you'll see there are a lot of approaches. There's no prescriptive one-size-fits-all financing strategy for geothermal. There's case studies for each of these projects in that report, but each of these types of financing have different characteristics of both cost and availability that are described, and really I think it's important that it's kind of a diverse approach to financing each of these phases of development. There's not a one-size fits all strategy.

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In terms of the last few things I'd like to get to is to some challenges facing geothermal development.

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There's a number of challenges that are often reported in our conversations with developers and financiers. Some of these I feel also should go without saying but are important to point out that are kind of common barriers that can impact the likelihood of project development. The first is simply risk is not adequately accounted for. I think a developer have to be optimistic by nature, but for planning purposes conservative is best. You need to plan for the unexpected. Often a challenge is that people may not fully plan for all the expected cost overruns or have adequate contingency funds setup for when something doesn't come as expected. I think the process was nicely summed up as the process takes longer and costs more than typically anticipated.

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Another example is just seeking funding from improper source. It's important to as I mentioned, geothermal financing is characterized by stages of development and different types of investors. It's important to make sure to appropriately match the type of investor with the stage of development. The best consequence would be that you're just delaying your project timeline, but at worst it puts a bad reputation on the developer and can jeopardize project development. Also in terms of milestones it's really important to understand what are banks' requirements, what sort of milestones do they expect and require in order to finance a project. As I mentioned a PPA could be one, a certain or that percentage of holes have been drilled. These types of metrics must be met in order to realistically have a chance for developing and securing financing for the project.

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A couple key takeaways. I think one of the main things in our research that we've found and seen elsewhere is there really is no magic bullet for financing geothermal power projects. Part of this is due to just the deal volume. There's only been a couple projects developed in the last few years, but there's been certainly more projects that I described that were financed, but you don't have enough of liquidity essentially in order to make these kind of boiler plate financing agreements. They tend to be unique arrangements specific to that type of development opportunity. It's important always to consider the value of all available incentive options, not just the federal incentives, which are a sizable economic contributor but also local and state level policies such as greenhouse gas regulations regionally or state RPS requirements that will offer additional value streams through renewable energy credits.

Also of course as I mentioned staging of the characteristics of the investment profile. It's important to think on both sides of the equation, how the financiers are doing the project versus the development community. So there's a host of information available first on tribal specific questions. There's DOE's Office of Indian Energy program website including various development options. There's also more technology specific information at the geothermal technologies program, GTP at DOE, and as I mentioned there's NREL's financing specific information both for geothermal power projects and then financing kind of broadly for renewables.

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So with that, I will leave my contact information. I'm happy to answer any questions. I think Alex is going to moderate some questions.

Alex:
Paul Schwab and Kermit Witherbee, two of NREL's finest. Thank you gentlemen for doing this. At this point we're going to merge into some questions and answers and we're going to be stopping our recording here in a second, so the Q&A will be off the record so to speak. Feel free to ask questions. I think the best method for this will be to use the chat box in the lower right hand corner you have and type in any questions you have whether they deal with Kermit's presentation or Paul's and we'll work through those. Then I just want to reiterate in addition to the resources that Paul shared, the Office of Indian Energy's website is in the process of developing a material library at this point really aiming at getting some hands on useful resources relating to project development and finance generally and then for different technologies as well.

So feel free to check that out. That'll be coming out soon and the geothermal finance guide that NREL has and the developers permitting checklist I'm sure will be posted on that upcoming material library as well. Then to echo what deputy director Pilar Thomas said earlier, there's the open START application period, which ends toward the end of this week here. It's a very easy to use application and it's aimed for the tribes in the lower 48 the opportunities to provide technical assistance and overcoming different barriers in the project development and financing efforts that are being made locally. So at that point we're going to end the presentation. Thank you everyone. You're free to

sign off if you want, but for those who want to have a back-and-forth with some questions, feel free to stay on. Thanks everyone. It looks like we have one question being asked, "Is there an average return on investment for a geothermal plant? Does that depend on scale and how long is that usually?"

Paul Schwab:
That's a good question. That's probably a difficult question to answer. One thing I didn't point out was each of those stages of investments, it really depends on what you're talking about. Are you talking about the individual aspect? Initial stages of return are quite high given that the risk of drilling and expiration, you may see several orders or several multiples of investment, 2x to 4x times for the very initial kind of high risk stages. With each successful stage that is reduced. So kind of in the middle stages you might see somewhere 20 to 40 percent return. We have these metrics in the guidebook, 20 percent to 40 percent return requirement from investors.

Then in the later stages it's kind of typical equity and construction return rates, anywhere from 7 to kind of 12, 15 percent return, so you have to kind of take a mix of all those in terms of you're just saying a typical geothermal development you're going to have to think of a metric that kind of incorporates all of those. It's going to be – I don't want to really pin down one number, but it's somewhere close towards those latter stages of returns for the project as a whole. You can pay of these high risk investors and still get a return kind of in the teens to somewhere around that percent, 10-20 percent, something like that.

Alex:
Great. Thanks, Paul. Looks like we have a technical question coming in for Kermit, and the question deals with "Why aren't there more surface anomalies showing geothermal resource potential in the Cascade arch?"

Kermit Witherbee:
I think a lot of that has to do with the vegetation cover and the geology of the areas, that there aren't as many hot springs and thermal anomalies up and down the Cascade Range. I think there's plenty of hot springs up and down there, but there's very little expiration to identify a lot of those anomalies. A lot of it has to do with the climate, the vegetation, access to some areas. Most of them are on the east side of the Cascade Range all the way up through. Of course there's hot springs on Mt. Hood and Rainier area and others.

I think also in some of the streams themselves are flowing pretty warm water as I've seen recently in an article and a TV clip on *National Geographic Explorer* or something like that. It hasn't been really explored primarily because of the low energy costs from hydro power. A lot of the municipalities and the electrical suppliers up in there like Snohomish County in Washington up in Everett area are actively looking at geothermal.

Alex:

Great. Thanks, Kermit. Looks like we have a question coming in on the permitting process. The question is, does BIA require different lease documents for the different phases of development?

Kermit Witherbee:
No. That's typically under one lease document. The lease covers all aspects of the rights that are given to the lessee under a standard lease, so in IMDA type lease, which is more freeform, which would be more of a contract between the tribe and the potential developer, the potential lessee would have a lot of different stages of performance for the lessee in terms of expiration and then drilling certain wells on a timetable on a schedule. That can be individually structured so that it meets the needs and requirements and best interest of a tribal government in the expirations. In terms of the permitting, BLM's involvement is primarily regulatory. BIA's is primarily advisory and approval, but under the IMDA's they can be structured to meet your needs. So it can be different phases, kind of like a joint venture. You reach a certain milestone and then you're able to move on to another milestone.

Alex:
Thanks, Kermit. Looks like we have another question on leasing and maybe too detailed, just let us know and we'll direct you to other resources as well. The question is, "Does BIA have or are there existing projects leased on reservations, which real estate services could use a leasing template?"

Kermit Witherbee:
From what I've seen in the past, currently there are no active as far as I know geothermal leases on tribal lands. There are geothermal lease templates that are available that are very similar to oil and gas. The model that could be used would be a BLM type lease for strictly leasing in terms of lease terms and rentals and royalty payments. The rentals and royalty payments are all negotiated through the process, but we certainly locate existing templates that can be utilized to meet your needs.

Alex:
Great. Thanks, Kermit. Looks like I have a question for me here coming in. The question deals with, "Another START question. In addition to the applications being due on Sunday, can these teams get help at any stage in the process or is START targeted at certain phases in a bid's development process, i.e. exploration, drilling construction?" So the START program right now is for the lower 48 offering a pretty wide assistance. We're primarily looking within the development continuum though. Paul was showing that process of going through the permitting, to finding a purchaser, to financing options.

Those are all types of technical assistance within the development itself that START is looking to offer. Feel free for all the folks out there who haven't had a chance to look at the Office of Indian Energy's website and there's some more detailed descriptions on what the Start program is and what it's aiming to achieve. So I think we have time for one more question or so. This is probably the most penetrating one so far. So Kermit, what's the deal with the alligator farm?

Kermit Witherbee:
The alligator farm? That's a pretty lucrative business in terms of there are quite a few alligator farms around the west, hot springs. One interesting one that I heard was that a proprietor of a fish-rearing unit in Idaho had mortality with the fish he was growing. He was cascading through his fish-rearing pools for different species of fish and during the process some fish he showed live to the market, others he processed and then sold them as the meat, and he had all that waste meat plus morality and had the idea that he could bring in alligators and keep them at a certain temperature and they would be able to eat the waste from the fish processing and the mortality, and also discovered the alligators are a good economic source for food as well as the leather, the skin for alligator bags and cowboy boots and all sorts of other things. Matter of fact the skin is worth as much as the meat I understand. Pretty lucrative business and one direct use aqua in Idaho has also been working with the Idaho State University on rearing sturgeon and producing caviar and that's been rather successful too. Alligators, they're kind of strange to see around snow-covered mountains.

Alex:
Well it looks like we have time for just one final question and a return to the serious here. After Kermit takes this question we'll close up shop and once again thanks everyone for joining. "Kermit, how does IRA section 17 corporations authorization to execute a lease without BIA involvement impact leases for geothermal?" That seems like a pretty detailed question, but do you have any thoughts on that?

Kermit Witherbee:
I am not really familiar with that. I do know that the tribe can have a consultant developing tribal resources and BLM's involvement is only if requested under the regulatory scheme. I don't know whether that answers your question or not, but I'd be happy to look into it further if you'd like.

Alex:
Feel free to follow up with Paul or Kermit on some of these more detailed questions if you have any and in the chat box we have some good insights coming in as well at the very end there, so feel free to read those, but for now on behalf of NREL and the Office of Indian Energy thank you for joining today. It's been great and we'll get these slides up on to the Office of Indian Energy's website as soon as we can and thank you for your participation today.

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