DOE Office of Indian Energy Foundational Course Renewable Energy Technologies: Geothermal Webinar (text version)

Below is the text version of the Webinar titled "DOE Office of Indian Energy Foundational Course: Geothermal Energy as a Renewable Energy."

Amy Hollander:

Hello. I'm Amy Hollander with the National Renewable Energy Laboratory. Welcome to today's webinar on Geothermal Energy as a Renewable Energy, sponsored by the U.S. Department of Energy Office of Indian Energy Policy and Programs. This webinar is being recorded from DOE's National Renewable Energy Laboratory's brand new, state of the art net-zero energy research support facility in Golden, Colorado. Our Geothermal presentation today is one of nine foundational webinars in this series from the DOE Office of Indian Energy Education Initiative designed to assist tribes with energy planning and development.

The course outline for this and all DOE Indian Energy Foundational webinars will cover: who the DOE Office of Indian Energy Education is and what is its initiative; the course overview, resource, maps and project scales; technology overviews with siting and cost information; successful project examples, policies relevant to project development; and some additional information resources.

The Office of Indian Energy is responsible for assisting tribes with energy planning and development, infrastructure, energy cost and electrification of Indian lands and homes. As part of this commitment, and on behalf of the U.S. Department of Energy, Indian Energy is leading education and capacity building efforts in Indian country. The foundational courses were created to give tribal leaders and professionals background information in renewable energy development that presents foundational information on strategic energy planning, grid basics and renewable energy technologies, that breaks down the components of the project development process on the commercial and community scale and then explains how the various financing structures can be practical for projects on tribal lands.

And with that, I'd like to introduce today's speaker, Mr. Kermit Witherbee. Mr. Witherbee is with the National Renewable Energy Laboratory, working as a geothermal energy geologist and analyst in the Geothermal Technologies Program. He is involved in a variety of projects, including geothermal resource assessment, geothermal regulatory roadmapping, policy analysis and development of Web-based geothermal data and analysis applications. Prior to joining NREL, he served as the Bureau of Land Management's National Geothermal Program manager, where he was engaged in national-level policy development, strategic planning and budget. He has both a bachelors and masters degree in geology from the State University of New York at Oneonta and is a registered professional geologist.

And with that, I will turn it over to Mr. Witherbee.

Kermit Witherbee:
Thank you, Amy. It is a pleasure to participate in this foundation course on geothermal energy. I will be discussing the following topics today. One important aspect of geothermal is that it is base load; that is, it is available 24 hours a day, seven days a week. Generally, geothermal is defined on its use. Commercial scale is large-scale electrical generation. The community scale is direct heating, hot water or agricultural applications sometimes known as district heating.

This slide illustrates examples of commercial and community scale productions. There are many potential uses of geothermal energy, both on a passive and active basis. We'll discuss further on the next slide.

This graph illustrates the many uses of geothermal resources. As you can see, the current uses and potential for future applications is left to the imagination. The graph shows geothermal applications classified by temperature and uses broken up into electricity, red; foods, yellow; heating, medium gray; and other uses, light gray. Geothermal heat pump systems do not create heat energy; they move the heat between the building and the ground while the conventional furnace converts oil, gas, wood or electricity to heat. Actually, a geothermal heat pump utilizes the natural heat of the earth for cooling in the summer and heating in the winter months. In most applications, a backup heating unit to supplement the heat pump in cold weather may be necessary.

The EPA has data that geothermal heat pump systems are the most energy efficient, environmentally clean and cost-effective space conditioning systems available. Additional information of geothermal resources and technology can be found on these referenced websites.

This map illustrates the geothermal resource potential for the United States. It shows locations of identified hydrothermal sites, which are shown in black dots, and the favorability of deep Enhanced Geothermal Systems, also referred to as EGS. The map does not include EGS resources located near hydrothermal sites or US Geological Survey assessment of undiscovered hydrothermal resources. The map was created by NREL using data provided by the Southern Methodist University Geothermal Laboratory and NREL analysts for regions with temperatures equal to or greater than 150 degrees Centigrade.

Source data for identified hydrothermal sites is from the US Geological Survey's "Assessment of Moderate- and High-Temperature Geothermal Resources of the United States," which was published in October of 2008. This map illustrates the results of the United States Geological Survey's USGS "Assessment of Moderate- and High-Temperature Geothermal Resources of the United States." The favorability map is overlain with geothermal exploration districts, which were developed from the physiographic regions of the conterminous United States.

These maps illustrate the location of the identified geothermal systems located on lands managed by federal agencies: The National Park Service, shown in green; the United

States Forest Service, shown in blue; the Bureau of Land Management, shown in teal; and Other Agencies, shown in yellow. Wilderness areas managed by either US Forest Service or the Bureau of Land Management is illustrated in brown. The Bureau of Land Management is responsible for managing the federal mineral estate, about 700 million acres, where the service is managed by the US Forest Service, the Bureau of Reclamation, the US Fish and Wildlife Service, and public lands managed by the Bureau of Land management.

The mineral estate on tribal lands is managed by the Bureau of Indian Affairs as a trust asset. This table illustrates states evaluated by the United States Geological Survey Geothermal Resource Assessment. The first column contains the number of existing geothermal systems. The second column contains the resource estimate for the identified geothermal systems, approximately 9,000 megawatts. This can be compared with the 3,000 megawatts that are currently in production. The third column is the undiscovered resources, just over 30,000 megawatts, while the fourth column is the estimate for enhanced geothermal systems, to be discussed later.

We'll next be discussing geothermal technology, types of commercial projects for electrical generation and community projects, including exploration and development, environmental benefits and cost.

Hydrothermal resources are found in a variety of geologic environments. This diagram illustrates two of the major geologic environments. Hydrothermal systems associated with magmatic systems represented in the Western United States by the Cascade Range for active and dormant volcanoes. The second are extensional systems developed along rift systems like the basin and range that includes most of Nevada. One of the geothermal classifications for hydrothermal systems is based on temperature of the resource: high temperatures greater than 302 degrees Fahrenheit, and moderate temperatures varying from 194 to 302 degrees Fahrenheit, and low temperatures, which are less than 194 degrees Fahrenheit.

Hot dry rock, which I briefly mentioned earlier, is a developing technology that requires creating or engineering a geothermal reservoir by drilling into a potential reservoir having sufficient heat and then through "sharing," or micro-fracturing, the rock to develop a connection between adjacent wells, which is followed by pumping a fluid into the reservoir to be heated and circulated to the surface to generate electricity.

Cold generation, as the name applies, is capturing the heat or energy from existing oil and gas wells to generate electricity that can be used to run the well field equipment or supplied to the grid. Tribes with oil and gas operations could potentially benefit from this technology. There are three primary types of geothermal power plants. Dry steam power plant is the first type. The second is a flash power plant, and the third is a binary power plant.

A dry steam flash plant is illustrated in this slide, shows how dry steam is trapped by the wells and transported to a turbine through a series of pipelines to generate electricity.

Condensed steam as water is reinjected into the reservoir. Excess steam is vented, as shown in the photo of the Geysers geothermal area in Northwestern California. The Geysers is the largest dry steam plant in the world, with a total capacity of about 750 megawatts from 22 producing power plants.

The second type of geothermal power plant is a flash plant. The plant illustrated in this slide is the 23-megawatt Blundell Power Plant located at Roosevelt Hot Springs near Milford, Utah. The technology for this plant is similar to dry steam, except the geothermal waters are produced under high pressure that is produced in a vessel at a much lower pressure, called a separator, than the fluid. This causes the fluid to flash, or vaporize. The vapor, under high pressure, drives the turbine and generator to generate electricity. The separated water is either then: (1) reinjected into the reservoir or, (2) directed to a bottom cycling system and then reinjected into the reservoir. The bottom cycling system is actually a binary power system, which will be discussed with the next slide.

Binary power plants are the most common types of geothermal plant in the United States. Recent advances in geothermal technology have made possible the economic production of electricity from geothermal resources lower than 150 degrees Centigrade, or 302 degrees Fahrenheit. Known as binary geothermal plants, the facilities that make this possible reduce geothermal energy's already low emission rate to zero. The geothermal water heats another liquid, a refrigerant such isobutene or other organic fluids, which boils at a much lower temperature than water. The two liquids are kept separate through the use of a heat exchanger, which transfers the heat energy from the geothermal water to the working fluid. The secondary fluid, or working fluid, expands into gaseous vapor. The force of the expanding vapor like steam turns the turbines that power the generators. All of the produced geothermal water is injected back into the reservoir.

An example of a small commercial project that has potential applications for many community based projects is shown on this slide. The Chena Hot Springs Resort in Alaska is located about 60 miles north of Fairbanks and has harnessed geothermal resources for a variety of uses, including the generation of electricity, space heating for the resort, heating greenhouses for growing fresh fruits and vegetables for the resort's restaurant, and the hot springs themselves. The resort is essentially self-contained and off the grid.

Engineered, or Enhanced Geothermal Systems, commonly referred to as EGS or hot dry rock, is an emerging technology. Very simply, it is the process of creating a commercial geothermal reservoir by creating a fracture network, which is the plumbing system, and then connecting that to an injection well and a production well. The fluid, water or other liquid – CO_2 is currently being investigated as one of those liquids – is injected into the newly created reservoir to be heated and pumped to the surface where it is then piped through a heat exchanger to heat a working fluid that will flash and turn a turbine to generate electricity. Essentially, it's created a binary geothermal system.

Geothermal resources use, whether for the generation of electricity or direct uses, is environmentally friendly. As these two graphs illustrate, geothermal has the smallest footprint – that is, surface disturbance – of any other renewable energy resources, as well as coal. Consumptive water use is nonexistent in geothermal binary power plants and minor in flash plants when compared to the other energy resources used for electrical generation. I should also point out that water use is minor but required for solar and wind generation for routine maintenance operations, such as cleaning wind turbine blades and solar PV panels and solar reflectors.

In terms of air emissions from geothermal power plants, there is essentially zero emissions of nitrous oxides, sulfur dioxide and carbon dioxide when compared to a typical Western coal-fired power plant. This chart illustrates the relationship of the cost of geothermal dual-flash and binary plant cost over the life of the project or levelized cost, as can be seen only when biomass and landfill gas, methane, are competitive with geothermal.

This chart illustrates some general costs associated with electrical generation projects and geoexchange applications, including residential, commercial and schools. The cost for developing a power plant can vary widely and are highly dependent on the type of the project, plant size – larger plant, lower cost per megawatt – site accessibility and location, well performance, time delays and other factors.

The geoexchange data came from case studies published online at geoexchange.org, referenced at the bottom of the page. These are average costs and can vary widely, depending on the local market, ground temperatures and the size of buildings, to name just a few. As would be expected, the larger the project, square footage or ton, the lower the cost. Know this is a very cost-effective technology for heating and cooling.

As you can see in this slide, a commercial project from concept to electric generation can take up to several years under ideal conditions. Geothermal resources are like oil and gas; they must be discovered through drilling and testing, unlike solar and wind, which has about 50 percent of its cost in exploration and confirmation of the resource. Solar and wind do require resource evaluations. They are much more straightforward and less costly to demonstrate the resource potential and design of the generation facility. Total geothermal costs may vary from $2-$3 million per megawatt capacity.

This chart simply illustrates the number and phase of development of commercial geothermal projects in the U.S. As you can see, when this was published, there were 146 projects in development. Plan capacity additions, within the third column, represents projects that have confirmed additional generating capacity to existing generation facilities, or new power plants. The fourth column represents estimates of potential development in the early stages of exploration and confirmation.

We will now move on to a discussion of geothermal's current policies. As you can see, the Department of Energy's geothermal technology program is key in assisting the geothermal community and the public in assessing information and implementation of programs to increase the use of geothermal resources on both commercial and community scale. Congress has supported geothermal resource development and deployment through a variety of legislative measures, including tax credits and other incentives.

This slide details the process of developing a geothermal resource. Actually, with minor variation, the process is similar whether the project is for direct use, community based or for electrical generation.

The following slide illustrates the type of activities necessary for development. As we've previously discussed, the process of bringing geothermal power plant on line is a lengthy process that involves exploration and drilling of exploration temperature gradient wells to determine whether a reservoir exists. If the results from the exploration are favorable, the decision may be made to drill a full-diameter well in the potential reservoir to test its commercial viability and ultimately to develop a geothermal power plant.

These photos are examples of the various stages of geothermal development. Although this slide was developed in 2006, the flow chart was included in the Final Summary 2006 California Tribal Geothermal Workshop held in Susanville, California in June 2006. The workshop was sponsored by the California Geothermal Energy Collaborative. As you can see, it is a relatively complex process that directly involves the tribe, the Bureau of Indian Affairs, the Bureau of Land Management and the Office of Natural Resource Revenue, which was formerly the Minerals Management Service.

As you see, we have come to the end of our presentation, but I want to leave you with a few resources, shown on the next slide. This slide shows where to access information on geothermal resources, technology and policy.

Thank you for your attention during this webinar. If you have questions, feel free to e-mail me, or, for a faster response, e-mail the tab selection the Technical Assistance website at IndianEnergy@hq.doe.gov.

Amy Hollander:
Thank you, Mr. Witherbee, for that excellent overview of geothermal energy technology.

There are three series in the program, the Leadership Series, the Professional Series and the Foundational Courses. The two columns here demonstrate how both the leadership and professional series have project development and project financing modules, delivered in person, and some through webinars. The foundational courses offer energy basics in renewable energy technologies, as listed on the next slide.

All of these webinars can be found at the DOE Office of Indian Energy website. With that, I want to thank you for your attendance. Thank you, and be sure to visit the DOE Office of Indian Energy webpage for future postings of webinars and other tools.

[End of Audio]