Geothermal Energy in Perspective

by William H. Clark II, P.E.

Introduction

Thank you for the opportunity to speak to this gathering today about geothermal resource use. In addition to having a chance to speak about a topic for which I have a great passion, it is an honor and privilege to address such a distinguished group of scientists and engineers.

Geothermal energy. What does that term bring to mind? Geysers perhaps, or steam fields or large power plants? Or maybe heated pools, bathhouses or fish farms? Geothermal energy is than and much more.

Worldwide, geothermal resources account for 6300 MW of electricity generated, with twice that attributed to direct use technologies: for space conditioning, predominantly. Electric generation costs are four cents/kwh while direct use costs are half of that - two cents/kwh. (slide 1)

The technology is proven and time tested, mostly in the industrialized nations, the United States, Italy, Japan, Mexico and Iceland. However, the machines and techniques are "ready for export," so to speak; in fact that process has already begun.

Four third world nations produce over ten percent of their electricity from geothermal resources. The Philippines produces 21% of its power that way, Nicaragua 18%, El Salvador 18% and Kenya 11%. This trend is expected to continue, well into the 21st Century.

When people remark that the growth of geothermal power usage is diminishing since the boom of the 70's and early 80's, following the oil embargoes and the boost in fossil fuel prices that suddenly made geothermal competitive, don't believe them. In the short term, sure, geothermal production has remained relatively flat over the last three years. Still, in the next seven years geothermal production is expected to double. Just as it has done every seven years since 1980 - and just like it will continue to do in the years ahead. (slide 2)

If anyone remarks that scientific interest in geothermal power is waning, ask them to consider the six hundred abstracts received to date for the World Geothermal Congress in 1995. And when someone says geothermal is too high tech that its use is only concentrated in America, you can say that only one sixth of the World Congress papers came from U.S. authors or organizations.

In fact, one authority in the field, the ASHRAE Ground Source Heat Pump Committee chairman expressed concern that direct use applications might grow too rapidly! Indeed, according to some projections I will mention later, this may very well be the case - no matter what the geothermal communities do or desire. If so, as the demand escalates our mission must be to meet that demand, and to ensure it is achieved with technical competence and professionalism.

Geothermal energy, then, is here to stay. It's a well integrated, highly organized industry. It has a long history of steady growth and steady progress. Without a doubt this will continue for the foreseeable future.

OK, now that I have convinced you geothermal power is a force to contend with, I will delve into some of the specifics. Though geothermics is a diverse and complex science, I will try to discuss briefly each aspect and - in the process - invite you to either read some of our papers on each topic or attend our session to hear our reports and to visit with the presenters and with the officers from the ASME Geothermal Technical Committee in attendance.

Direct Use

The largest geothermal pipeline in the world is a 63 km line in Iceland. It's also interesting to note that 85% of the Icelanders live in homes heated by geothermal water. There are many other important uses of this technology that do not require any technology to access. (slide 3)

Two of the most important applications use the geothermal fluid at relatively low temperatures, cooler than that needed for space heating. These are for greenhouse heating and for raising freshwater fish - these uses are quite common in China, the second largest user of geothermal power for direct use.

The Geoheat Center in Klamath Falls Oregon is researching these and other direct uses of geothermal energy. One of the more sophisticated applications they are investigating is using ground water - or water from a surface lake or river - for space cooling. Instead of using a cooling tower to reject heat from the chiller in a facility, the heat is absorbed by water circulating from a natural resource. Several such installations are currently in operation in the U.S.A.

Another direct use application is ground source heat pumps. A conventional heat pump rejects building heat to the atmosphere; a ground source system rejects it to the ground by way of a piping loop buried in the ground. An estimated 90,000 closed loop ground source heat pump systems are installed to date. The systems have been increasing at the annual rate of ten percent for the past ten years; there will be 800,000 in use by the year 2000, according to the International Geothermal Association. An authoritative report on the current state of the art of these sturdy systems will be presented in our session by Sandia Labs, a leader in geothermal research.

Ground water systems are a variation of the ground source technology, in which ground water is circulated directly through the device. Presently 60,000 such systems are installed worldwide, and escalating. A report on a unique application of this system will be published in the proceedings, to complete our coverage of direct use applications.

Electric Power Generation

The next major segment of geothermal power is electric power generation. This is a significant energy source in the Western United States: Here in California 8% of the power is from geothermal sources. Nevada generates 12% of its power from geothermal, Utah 2% and Hawaii 3%. Worldwide, 21 nations take advantage of geothermal energy sources. At present North America is the world leader, but this will soon change.

By the year 2000 Asia will triple its geothermal capacity, and eclipse North America. The Philippines and Indonesia will be responsible for most of this growth, though Japan, China and New Zealand will also contribute.

To put this global vantage in perspective, consider that the present world wide use of geothermal is about 6000 MW. Over ten times that capacity has been identified to date in the developing countries. This bounteous resource is untapped. There is great hope that geothermal power will be the cornerstone of rural electrification programs in the future, perhaps with the use of small packaged geothermal plants already in production and in use around the globe.

A big advantage of geothermal power is that it reduces the carbon dioxide burden - at present by the amount of 20 million tons a year. This will double by the turn of the century, and double again in ten more years. This will become more and more important as time goes on, and as environmental issues predominate the world political landscape.

As for the mechanics of electricity production from geothermal sources, a plethora of applications exist throughout the United States, of every size and shape. An authoritative report on these undertakings will be featured in our session by one of the ASME committee officers. When that paper is complete, there will be nothing further to know about the application and use of geothermal electric power generation.

Another paper delves into the peculiar problems associated with geothermal power, which must remove gasses from the pressured fluid before using it in the steam power cycle. The paper will investigate the use of turbine driven compressors for the removal of non-condensible gasses. This report tackles an issue at the heart of geothermal power production and will be an informative talk indeed.

A final paper will be published proposing a computer based analysis of geopressured drilling - which has problems unique to the industry. This will complete our coverage of electric power generated from geopressured reservoirs.

Hot Dry Rock

The final frontier of geothermal power is referred to as hot dry rock drilling, or heat mining. This experimental field targets the thermal energy of the earth's crust. For the simple reason that the heat available from cooling just one cubic kilometer of rock one degree Centigrade is equal to the energy content of 70,000 tons of coal!

Now that's a goal worthy of any endeavor. It is also the topic of a provocative paper in our session, describing the drilling of many wells to pump water into hot dry rock, then to extract the heated fluid by another centrally located bore hole. This exciting new field is the topic of much research, and promises to be a major geothermal resource.

A final report published discusses a novel use of geothermal drill wells, with thermal output enhanced by the disposal of spent nuclear fuel rods. A controversial topic in anyone's book, and perhaps not even feasible; but certainly a thought provoking enterprise!

Conclusion

In closing, I want to leave you with the conviction that geothermal energy is a force to contend with. Perhaps the best way to drive this point home is to state that $17.6 billion has been invested in geothermal research over the ~~pst~~ past two decades in the industrialized nations. Another $3.5 billion was devoted to the developing nations, and almost $1 billion in Eastern European nations.

This huge investment has created a whole generation of technology that is only now being applied in the third world; with great success, I dare say, in Central America, Indonesia and the other nations framing the Pacific Rim and its high level of seismic activity. In the years ahead this trend will erupt into the scientific spotlight, and escalate as ambitions nations around the world build their economies to competitive levels in the global marketplace, using the cheapest energy source available: Geothermal, of course!

Electricity Costs

1. Fossil fuel : 8¢ /kwH

2. Geothermal electric : 4¢ /kwH

3. Direct use Geothermal : 2¢ /kwH

Installed geothermal electric capacity

1980	1960 MW
1985	3700
1990	5800
1993	5900
2000	10,200

Source: Geothermal Electric Power in the World
by Mary Dickson and Mario Fanelli