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Technical Report

Evaluation of the Geothermal Public Power Utility Workshops in California

Barbara C. Farhar, Ph.D.

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Contents

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Preface

Two workshops were held in California for municipal utilities interested in knowing more about the status of geothermal. The first workshop was held in Pasadena on December 16, 2003 and the second in Sacramento on December 18, 2003. The sponsors were the U.S. Department of Energy's (DOE's) GeoPowering the West (GPW) Program and the Western Area Power Administration (WAPA). The work was based on the California Energy Commission (CEC)-sponsored project to evaluate geothermal and transmission resources in California and Nevada. Ray Dracker of the Center for Resource Solutions was the Project Manager of the task. Jim Lovekin of Geothermex was the contractor and the primary presenter at the geothermal workshop. GPW team members in attendance were Randy Manion (WAPA), Curtis Framel (DOE-Seattle Regional Office, Barbara Farhar (National Renewable Energy Laboratory), Jon Wellinghoff (Beckley, Singleton, Jemison, Cobeaga and List), and Roger Hill (Sandia National Laboratories).

A key conclusion of the CEC work is that perhaps 4,000 MW of geothermal (hydrothermal) resource is the likely incremental capacity expansion supported by resource evaluations. The presentations to the participants of the workshops included a comprehensive treatment of geothermal development, operating, economics, risks, and other utility issues.

Several "geothermal" utilities were present at the Northern California Power Agency—one of the operators at the Geysers—as well as the city of Riverside and the Imperial Irrigation District, both of whom are buyers of significant amounts of geothermal energy. Other attendees came from the public utilities in the state. A list of attendees for each workshop is appended to this report.

Abstract

The federal government devotes significant resources to educating consumers and businesses about geothermal energy. Yet little evidence exists for defining the kinds of information needed by the various audiences with specialized needs. This paper presents the results of an evaluation of the Geothermal Municipal Utility Workshops that presented information on geothermal energy to utility resource planners at customer-owned utilities in California. The workshops were sponsored by the Western Area Power Administration and the U.S. Department of Energy's GeoPowering the West Program and were intended to qualitatively assess the information needs of municipal utilities relative to geothermal energy and get feedback for future workshops.

The utility workshop participants found the geothermal workshops to be useful and effective for their purposes. An important insight from the workshops is that utilities need considerable lead-time to plan a geothermal project. They need to know whether it is better to own a project or to purchase geothermal electricity from another nonutility owner. California customer-owned utilities say they do not need to generate more electricity to meet demand, but they do need to provide more electricity from renewable resources to meet the requirements of the state's Renewable Portfolio Standard.

Introduction

This section provides background on the purpose of evaluating the workshops and summarizes the material presented at the workshops.

Purpose of Evaluating the Workshops

The Western Area Power Administration (WAPA)—one of the key sponsors of the utility geothermal workshops—decided that the workshops could serve as opportunities to qualitatively assess the information needs of municipal utilities relative to geothermal energy. Because WAPA plans additional workshops in other important geothermal states, it also wanted to get feedback from participants about each workshop structure and content, significant utility geothermal information needs, and the best ways to meet them. The GeoPowering the West (GPW) team supported this effort.

The Geothermal Utility Workshops

The information was primarily presented by Jim Lovekin, an earth scientist from Geothermex, Inc., with commentary from Ray Dracker, Center for Resource Solutions. The purpose of the Geothermal Utility Workshops was to present information on geothermal energy for utility resource planners at customer-owned utilities in California. The workshops were structured to encourage audience participation, and a large percentage of time was spent in answering the questions of utility participants and hearing their comments. A PowerPoint presentation comprised of 85 slides covered six key areas (see Appendix G). These were:

- Nature of geothermal resources from a utility perspective: 41 slides
- Development and operational issues: 14 slides
- Economics: 10 slides
- Emerging technology: 13 slides
- Risks: 5 slides
- Utility experience and perspectives: 2 slides.

Nature of geothermal resources. The workshop began with a "Geothermal 101" type of presentation, including basic information on the characterization of the geothermal resource potential in California and Nevada. This map elicited a good deal of utility interest. Utility participants were particularly interested in the generating capacities of major geothermal resource areas in California and Nevada. A map characterizing the geothermal potential over a 10- to 15-year time horizon catalyzed considerable discussion. The map showed data on estimated generating capacities of major geothermal resources areas, such as Dixie Corridor, Medicine Lake, The Geysers, Imperial Valley, and the Greater Reno area. The California total was 1,800 MW minimally, but 3000 MW is the most likely estimated resource. The map showed that in California, approximately 3000 MW of geothermal energy is available, and in Nevada, between 800 and 1200 MW of geothermal resources are available for development over a 10- to 15-year time frame. The incremental geothermal power available in California and Nevada is, at a minimum, 2,600 gross MW and most likely (modal value) 4,250 gross MW.

Resource types discussed include hydrothermal, hot dry rock, geopressured, and magma energy. Attributes discussed were rock types (volcanic, sedimentary, and basement), depth (13,000 to 14,000 feet), temperatures (more than 600°F), and fluid availability. From the plant operator's perspective, the fluids are dry steam at wellhead, two-phase at wellhead (steam and liquid), and hot water at wellhead.

The presentation included a schematic of the conversion technologies: a dry steam plant, a flash plant, a binary plant, and a hybrid combined cycle plant. Photos included the historic and current plants in Larderello, Italy; The Geysers, California; Dixie Valley, Nevada; Salton Sea, California; Mammoth-Pacific, California; Soda Lake, Nevada; Wendel-Amedee, California; and Puna, Hawaii. In addition, the amount of electricity generated from facilities was characterized.

Characteristic outputs of air-cooled plants were discussed, including a scatterplot of the power output of a dual-flash plant over time. Various problems in air-cooled plants—such as parasitic loads in daily oscillation output and seasonal variation in output—were also discussed.

The presentation addressed the Salton Sea development, with 350 MW online and a 90% probability of 1350 MW of heat reserves—a huge resource in California. Heat is not a limiting factor; the question would be whether mass and pressure support can be maintained.

Development and operational issues. Information was also presented at the workshops on certain issues related to geothermal development. Grid stability can be an issue with small plants at decentralized locations. Many geothermal sites are located in remote areas far from the transmission system. The positive contribution to grid stability should be taken into account in determining the value of geothermal power. In this regard, the Mammoth Lakes site was discussed.

Further development of large project sites offers economies of scale, according to the presentation. Such development allows for use of existing infrastructure and the local workforce. A few sites account for most of the incremental potential, including, in California, the Salton Sea, Geysers, Medicine Lake, the Brawley areas, and Dixie Valley, Nevada.

The presentations stated that environmental benefits of geothermal development include the fact that geothermal is a sustainable resource; it adds to resource diversity; it is indigenous; a relatively small area is affected by development; and it has especially low greenhouse gas emissions when compared with natural gas, oil, and coal. Potential environmental challenges can include hydrogen sulfide emissions that are odoriferous and must be abated; solid waste disposal issues; pollutants in cooling tower drift; hydrocarbon releases; and subsidence. Seismicity is not a major concern.

Siting issues identified in the workshop presentations included an industrial presence in potentially pristine areas; visibility issues (including steam plumes and pipelines); noise (when drilling); endangered species that must be considered; impacts on archaeological sites; effects on natural hot springs; and potential cultural sensitivities.

The presentations emphasized that the Renewable Portfolio Standards (RPS) in California and Nevada provide impetus to geothermal development. In California, SO 1078 (September 2002) states that utilities must increase total renewable energy sales by 1% annually until they reach 20%. Renewable resources must be at 20% by 2017. In Nevada, SO 372 (PUC Order May 2002) states that 5% of electrical sales to retail customers must occur by 2003, and must grow 2% biannually to 15% in 2013. The possibility of a federal RPS was also discussed.

Economics. The presentations stated that capital costs vary widely, ranging from $1,200 to $3,200 per kw installed. Exploration and drilling typically account for 30% to 40% of the total. Costs have declined significantly over the past 25 years. "Make-up drilling" was also discussed. Individual production and injection wells could decline in capacity over time, requiring remedial drilling. Operations and maintenance (O&M) costs also vary significantly, ranging from 1.2 cents to 2.8 cents per kwh. Binary plants may have more expensive O&M costs, but some sites require a binary plant to use the resource. Municipal utilities can benefit from tax-exempt financing.

The presentations reported that bids in response to recent solicitations by U.S. utilities have ranged in busbar cost from 5.5 cents to 6.5 cents per kWh. Negotiations have included such values of grid stabilization, dispatchability versus base load, and the structure of energy versus capacity prices.

As of November 2003, a 10% federal investment tax credit was available for geothermal. The discussion on pending legislation included a possible production tax credit (PTC) (1.2 cents to 1.8 cents per kWh) available for an unknown number of years of production. If a PTC were passed, this would have significant positive economic impact for geothermal development.

The presentations also focused on transmission issues. The cost of transmission lines has significant economic implications for development of geothermal plants, particularly those at small, remote locations. Aggregation of smaller projects could result in overall transmission cost savings.

Emerging technology. The presentations focused on a fairly technical discussion of six emerging geothermal technologies. These included minerals recovery (zinc and silica); enhanced geothermal systems on the margin of existing fields; injection supplementation to maintain reservoir pressure; electric submersible pumps; Kalina cycles for improving heat recovery from lower-temperature resources; and evaporative pre-cooling to improve the efficiency of air-cooled binary plants.

Risks. The presentation included a brief discussion of risks. The risks identified were oversizing plant capacity with respect to resource available; insufficient capital for developers to follow through with projects; competing leaseholds on a single project; and project delays because of environmental or land-use constraints. Environmental approvals take lead time, but recent federal policy has increased the commitment of government agencies to process leases more quickly and give weight to the environmental benefits of geothermal electricity.

Utility experience and perspectives. The presentations concluded with an argument for the value of geothermal power development: that geothermal power is already cost-competitive in some markets; that RPS's are stimulating increased interest in geothermal power; that resource inventories are being updated; and finally, that geothermal deserves serious consideration as part of an electricity supply portfolio.

Summary. The presentations given at the two workshops emphasized description of the geothermal resource, where it is located, how much of it there is, and how it can be accessed. Other topics—such as economics, emerging technologies, risks, environmental effects, and utility experiences—received a much briefer treatment. The workshop presentations appeared to be balanced in that they identified both opportunities for and challenges to geothermal development.

Perspectives of Participants

Various data sources were used to gather the utility participants views of the workshops, the costs and benefits of geothermal energy, risks, integration issues, and policy issues.[1] These included notes taken during the workshop discussions, flipchart notes, and participants written responses on evaluation forms. Appendix A describes the method and data sources in more detail. Appendix B summarizes the notes on utility comments during the workshops. Appendix C summarizes utility comments on the most useful aspects of the workshops, geothermal topics they would like to know more about, and best methods for them to receive information. Appendix D presents findings from the Workshop Evaluation forms.

Success of the Workshops

The participants were quite satisfied with the workshops. All of the utility participants said it met (60%) or exceeded (40%) their expectations. On a 1 to 10 scale with 10 being "extremely valuable, " the mean participant rating was 8.3. All presentation topics tended to receive high marks from the utility participants. The presentation topic with the highest ranking in usefulness was the nature of geothermal resources (mean = 9.1) and the lowest ranked was risks (mean = 7.8).

The presentations on geothermal resources, largely made by Jim Lovekin but with substantial informal commentary by Ray Dracker, were viewed as credible and comprehensive. Participants particularly appreciated the discussion of the California and Nevada geothermal resources. They remarked that they were grateful that the presentations included both positive aspects of geothermal energy and potential drawbacks, and that it was not a "sales pitch."

An important and somewhat surprising comment from the utility participants was that the municipal utilities in California do not need to generate more electricity. However, they are responsible for meeting California state RPS goals of 20% of electricity from renewable resources by 2017. Some municipal utilities in California voluntarily complied with a 20% by 2010 RPS goal. If the state RPS goal changes to 2010, utilities would have to have geothermal projects in place by 2007.[2] In general, the utility representatives felt that the time to consider geothermal energy for meeting RPS goals is very short.

A key issue that utility participants identified in both workshops was whether California municipal utilities should own geothermal plants themselves or purchase geothermal power from someone else. The workshops did not provide an answer to that question.

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[1]Nonutility participants also commented on the workshops. They appreciated being able to witness the utility experiences and perspectives. They agreed with utility participants that the workshops were successful, but they were a bit more critical of the workshops than the utility participants were. They agreed with the utility participants that risks were not as fully covered as they might have been.

[2] At the time of this writing, the California legislature had passed legislation to change the date by which the 20% RPS goal would have to be reached from 2017 to 2010. The bill is on Governor Arnold Schwarzenegger's desk for signature.

Information Needs

The utility participants spoke of the various topics on which they need information relative to geothermal energy. Their comments can be organized into six categories: (1) resources, (2) costs and benefits, (3) risks, (4) technology issues, (5) integration issues, and (6) policy issues.

1. Resources. Utility participants particularly appreciated the information on geothermal resources. They said they would like to receive additional information on local area resources and updates on resource developments. One or two comments mentioned a need for site-specific geothermal resource evaluations.

2. Costs and benefits.

- Economics
- Tax credits
- Financial information involving real examples of cost breakdowns for plants and O&M costs
- Cost-saving opportunities for municipal utilities
- Economies of scale and size limits
- Costs of transmission
- Grid stabilization
- Public relations benefits.

3. Risks.

- Technological problems and their resolution
- Constraints on resource
- Environmental compliance and public response process
- Streamline permitting processes
- Drilling risks
- Risk of future natural gas price spikes.

4. Technology issues.

- Operating characteristics of actual plants
- Updates on technology developments
- Transmission and reliability issues.

5. Integration issues.

- Geothermal as it fits in with other renewables in utility resource planning (the California RPS calls for 20% renewables by 2017; certain municipal utilities have their own RPS's)
- Transmission issues; integrating geothermal into existing transmission lines; substations
- Water availability
- Integrating geothermal into the utility load profile (baseload versus peaking)
- Issues in relating investor-owned utility and customer-owned utility efforts on geothermal.

6. Policy issues.

- Current policies, political issues, and legislative activities (including the federal Energy bill)
- Investment tax credits
- RPS
- Federal funding sources
- Green tickets.

Preferred Means of Receiving Information

The utility participants liked the idea of having webcasts combined with conference calls, particularly if these could be limited to one hour. This approach was perceived as particularly helpful because it is less costly than travel to meetings and workshops.

Websites and e-mails were also preferred sources of geothermal information.

The participants called for geothermal presentations designed for utility staff and tailored to specific utility situations. They wanted geothermal speakers, and possibly even a geothermal SWAT team that could respond as analysts to specific utility needs.

In addition, workshop participants promoted the idea of informing utility decision makers, city officials, and the public about geothermal energy.

Conclusions

The municipal utility workshops on geothermal energy were evaluated at the request of the Western Area Power Administration. The evaluation has fostered a better understanding of municipal utility issues relative to utility decision-making about geothermal power. It has shown that municipal utilities need an increased amount of both general and specific information about geothermal energy.

The kinds of information customer-owned utilities say they need include the following:

- Geothermal resources—location relative to transmission lines and MW potential
- Economic—capital cost reduction data; real examples of cost breakdowns; more detail about costs of plants and O&M; cost-saving opportunities; and help with purchase power versus own power plant decision
- Technological—training; geothermal evolution, including solving of technical problems; plant size limits; and more information about future technological issues that could affect cost
- Public policy—information on features of the Energy Bill relative to geothermal energy; production tax credits; green tickets; and help with public permitting processes
- Risk—a great deal more information about risks and mitigation strategies, especially drilling risks; barriers to geothermal power; lessons learned; and myths about geothermal that need to be addressed.

The ways in which customer-owned utilities prefer to receive geothermal information are:

- Electronic—email with information in text (no attachments); Website (i.e., geobiz.com's newsletter); and Webcast with conference call that saves travel money and allows more interested parties to participate
- Print—Factsheets
- Workshops and presentations—designed for different audiences, public forums, and brown-bag lunches.

The California workshops made clear that the staffs of customer-owned utilities are hungry for credible, timely technical and policy-relevant information on the development of geothermal resources. The workshop format appeared to work well in meeting several of the utility staffs' information needs. Based on the experiences of the California workshops, it seems likely that similar geothermal utility workshops will be effective for meeting many of important geothermal information needs of the customer-owned utility staffs in other states as well.

Appendix A. Methods and Data Sources

Methods and Data Sources

Three sources of data form the basis for this qualitative assessment of the information needs of the customer-owned utility staff regarding geothermal energy:

1. Notes taken during the presentations on utility questions and comments
2. Flipchart notes of the facilitated discussion toward the end of each workshop
3. Written responses from the evaluation forms completed at the end of each workshop.

Notes Taken during Presentations

These notes are included in Appendix B. They include the comments and questions raised by the utility participants, but not the answers provided by the presenters. These are included as one indication of the types of information utilities would like to have and the concerns and perceptions they expressed concerning geothermal energy in open exchanges between the presenters and the attendees of the workshops. Because the presentations were not couched as "sales pitches," utility participants reported being comfortable with the quality of information provided. This no doubt aided in the transparency of utility commentary and questions, thus making them valuable qualitative data points for the analysis.

Facilitated Discussion

For the final 20 to 30 minutes of each workshop, the group focused on three key open-ended questions:

- What were the most useful aspects of today's workshop?
- What more would you like to know?
- How would municipal utilities like to receive information?

Each participant was given an opportunity to comment on these questions in the group format, and the resulting contributions were recorded on flipcharts. These notes are presented in Appendix B.

Evaluation Forms

A one-page double-sided form for evaluating the workshop was handed out to the participants toward the end of each workshop, and each person attending completed the form. Although the forms were designed for the utility participants, both utility and nonutility[3] participants completed them. The evaluation form itself is shown in Appendix D. Results from the forms are presented in two parts: (1) findings from the utility participants, and (2) findings from the nonutility participants. Because of the small number of respondents, (10 in each category), the findings from both workshops are analyzed together.

[3]Nonutility participants included members of the GPW team and a representative from the U.S. Department of Energy.

Appendix B. Notes Taken during Presentations at the Workshops

Notes from Discussions
Excerpted to Reflect Utility Questions and Comments

Questions and comments from utility participants in the 12/16/03 Workshop:

- Is there any opposition from environmental groups? How does this affect development?
- Is there specific access at a specific line? Is there a substation at this line?
- Intertie in middle: Do you have to upgrade the ends?
- Where would east-west AC line flow?
- Why do we need a 500 kV line? (Can carry 1300 MW)
- If there is a situation where you need to tap, do you need a very large project to make it worthwhile? 800 MW geothermal project?
- What is the temperature at Mammoth?
- Why have air cooled plants? Is there not enough water?
- Why are the seasonal variations in output of an air-cooled binary plant opposite from seasonal variation in parasitic load at an air-cooled binary plant? (Ref. to top two slides on page 10 of handout.)
- Siting issues are not unique to geothermal.
- How locked up is the Salton Sea?
- Is there opportunity to do municipal utility financing and shared ownership at the Salton Sea?
- What is driving the cost of geothermal down?
- What do the capital costs include?
- What is the weighted cost of capital?
- How are costs computed?
- We haven't seen 5.5 in geothermal yet.
- You may have baseload set up and only need peakers.
- Hydro is a more dispatchable resource because you can store it.
- We have concentrated service areas that don't have such issues as the value of grid stabilization.
- Loss savings are not shown.
- Renewables premium is not shown.
- If we must develop by 2007 there is not enough time to develop a geothermal project.
- In the energy bill, geothermal would give up the investment tax credit, but there is a higher benefit from the production tax credit.
- Can municipal utilities claim REPI?
- We have the energy there is no problem with needing more energy.
- Wind completed by 12/31/03 gets PTC for 10 years; after that, no PTC.
- Green tickets are not mandated by anyone. CalEnergy can sell green tickets.
- We have decided to develop a wind project because it makes economic sense to us. For a 120-MW wind plant, build is better than buy. REPI would be gravy. Cost of capital is less.
- If we are building our own transmission grid, we will have hydro, etc.—we are leveraging existing assets.
- SCAPPA built Magnolia for 1% per year growth. LA has significant reserve margin, and they don't need plain energy capacity. They passed RPS s on their own.
- Prudent practice means diversity in sources; there is added cost to access geothermal.
- Will it change the whole structure of the transmission system?
- Problem is cost of geothermal and transmission upgrade.
- Municipal utilities are in the city; we have no land to expand.
- Changing all towers is not practical.
- Energy used to go North to South; now it goes South to North in peaking.

- IPP3 is LA the only investor?
- We would be buyers, rather than sellers, of green tags.

Questions and comments from utility participants in the 12/18/03 Workshop:

- Monte Carlo: what are the major drivers leading uncertainty? Need sensitivity analysis.
- What geothermal exists in Oregon?
- We weren't looking to build a large geothermal power plant. We need to buy little pieces, then aggregate to put power together. We have our own RPS independent of the state. The issue is scale. A 30- to 80-MW power plant is a big chunk of our load.
- We don't know the market long-term; there are congestion issues and not knowing what the regulations will be keeps us from making 25-year commitments.
- Landfill gas sites in the Bay Area—gives public relations benefits.
- Desire for local control will last a long time.
- Dispatchability issue is a big issue.
- The foremost issue is ownership versus purchased geothermal power.
- Are there REPI payments for new geothermal?
- LADWP owns a large wind facility, which provides 100% tax-exempt, debt-financed benefits.
- Natural gas price spikes are a big risk in the future; gas production is on a decline.
- CEC is providing $2 million to Calpine for Glass Mountain. Look to the federal and state government to help out with funding resource.
- It's hard to justify doing more exploration when we can't market the resource we already have.
- What are IOUs doing about geothermal?
- Battle over use of public benefits funds for renewables versus energy efficiency; this has become an issue.
- We are adversaries with PG&E.
- Better to work with Edison; PG&E is too adversarial.
- Pyramid Lake Paiutes wanted to become a member of NCPA and to do a renewable energy park. At the same time a coal developer above Pyramid Lake wanted to ship power to California. How big a resource—what is the potential for Pyramid Lake?
- IOUs and municipal utilities are so different philosophically, it would be difficult to work out.
- SMUD divested itself of geothermal plants it owned when restructuring occurred, and may not want to go and get it back or build more because it would seem to be admitting that they'd made a mistake.
- We don't need to add a whole lot of geothermal.
- We possibly could work with IOUs in other states.
- It will cost a fortune to put in transmission; we need to know how to combine renewables to get the most benefit from transmission.
- Optimization of existing resources is Phase 2 of the PRP research.
- Re NEPA and public participation processes: Too many are feeding on the same carcass!
- Two reasons to look at the near-term: (1) PTC and (2) gains are incremental.
- Considering price, cost of capital, and risk mitigation, which is best purchased power or ownership? This is a hard decision.
- Advantage of municipal utilities: tax-free debt to build the power plant, so the weighted cost of capital is 5%.
- Municipal utilities avoid taxes, so is it better than private developers?
- It's a matter of which risks you want to take on.

Appendix C. Notes from Facilitated Discussions

Notes from Facilitated Discussions
Part One: Pasadena Workshop, 12/16/03

Most useful aspects of the workshop

- Learn real-life experiences with geothermal and related issues
- Educational, not a sales pitch
- Technologies
- Salton Sea—highest potential geothermal
- Eye opener about geothermal as a real opportunity and a real alternative
- Everything—the comprehensiveness
- Regional locations on geothermal resources with actual numbers/estimates
- Answered all questions.

Would like to know more

- More on economics and operational aspects
- Not generic, but *real* data
- Factsheet would be good
- How capital costs will be reduced
- Green tickets
- Training for the future
- Tax credits
- How the Energy Bill will come out
- How geothermal has evolved over time; how technological problems have been resolved over time
- Financials—real examples of cost breakdowns, historical aspects and change
- Future outlook: key technological issues that will affect costs
- More detail about costs of plants and O&M—breakdowns rather than one number
- Pinpoint cost-saving opportunities for municipal utilities.

How municipal utilities would like to receive information

- E-mail with information in the text (not in an attachment)
- Webcast with conference call (1 hour in length)
- Website (e.g., geobiz.com is a good newsletter)
- Workshop (more information can be delivered).

Notes from Facilitated Discussion
Part Two: Sacramento Workshop, 12/18/03

Most useful aspects of the workshop

- Stayed on topic and on time—that is important
- High quality information—no fluff—lots of preparation and it showed
- Learned new things, including from the audience
- Resource assessment
- Constraints on the resource
- It was all valuable
- Format of well-prepared talks interspersed with discussion
- Valuable presentation.

Would like to know more

- Economies of scale with plants aggregated/bigger—what are the size limits?
- Is there something municipal utilities can do to streamline the permitting process? (Municipal utilities are routinely involved in public/stakeholder processes.)
- Technological development—what is in the pipeline? What are the impacts on costs/risk?
- Economic potential at different costs.
- Where there might be reliability, transmission benefits—where and what kind? Can we avoid building a line?
- Detailed information on risk and mitigation strategies.
- Risks—need to discuss fully (horror stories out there) —geothermal not a good technology for municipal utilities because of drilling risks
- Utilities need to know what it's really going to cost (Nevada and California numbers are different)
- Because there is history with geothermal, and myths abound from the early development in the United States, GPW/WAPA could offer utilities the opportunity to do a myth exercise—to investigate what the perceptions and myths might be and bring factual evidence to bear on those—the utility staff and the public both need to know.
- Unbundling has done damage to marginal resources—municipal utilities should contract out because of high overhead; gave up their plants; hard wires, maintenance response. The issue of whether municipal utilities should purchase geothermal power versus own geothermal power plants should be highlighted.
- Investigate what municipal utilities see as the impediments and barriers to geothermal power—things no one dreamed would happen have come to pass—there are lots of lessons to be learned.
- Current examples/practices on impacts of projects in the United States could counter myths and errors. (For example, see comment on the Geysers and air quality on page 16 under "Other comments.")
- Think about covering all of the important work done by the labs, etc., relative to the RPS goal in California.
- Developers attending workshops would help answer questions
- Bring knowledge from elsewhere to California so it can be run with here. DOE often thinks California is ahead of the curve, so focuses its efforts elsewhere. This may not be the correct view.
- Speaker's list/topics so that municipal utilities could contact them directly.

How municipal utilities would like to receive information

- Webcast: we are strapped for cash so a webcast that doesn't involve travel would really help. Also, others, such as directors, could participate, too. Have an agenda at the beginning.
- Set up custom presentations for different audiences, such as financial planners. If this were offered at SMUD, the management would direct the financial planners to attend. The presentation could be one hour of presentation, one hour of Qs and As, and could possibly involve food.
- Council? SMUD Board doesn't know whom to invite. Who should come in? Outside experts needed at SMUD to present on geothermal. How do we get on the SMUD Board's agenda? Network to Board members; call the General Manager.
- Public forum: educating the public. The City Manager likes to control the agenda of the City Council, and there is too much on their plates. Perhaps the City Council could be invited to a presentation on geothermal.
- Fund a deliberative poll? Work with utility and invite customers in for education. Pre-/post-event data. Someone commented, though, that this is not really needed in California. Their goal is 20% renewables by 2017; that is set and won't be changed by a deliberative poll.
- Geothermal experts to help with technical questions during municipal utilities contract approval processes. Have SWAT teams go out—they have to be analysts, not advocates.
- For utility staff, multiple shorter sessions are better.
- SMUD will organize brown-bag lunches once a month, and this is a venue that could be used for one-hour talks on geothermal energy. Develop a turnkey brown-bag lunch presentation and ship it out to utilities.
- SMUD will want external speakers, which will lead to larger attendance.

Other comments

- The public process makes adversaries of public and developers. When the CEC comes in, it's a circus. The public process should be done for the public good. There is no leadership to turn this around! Someone has to say we want 20% renewables as a matter of public policy. Gas price bubbles keep happening. The policy should be for 30 to 40 years. The energy infrastructure, like the interstate highway system, has to have *long* time horizons. Decision-making has been marginalized.
- Deal with policy issues (e.g., federal and state agencies) —should a policy include all renewables? They could have a margin that geothermal and wind and solar could fill together. If you use 3000 MW, who gives up the right to 1500 MW capacity? That is the *biggest* problem.
- 600 miles of wire is very expensive. Don't go over the summit with lines.
- Old reports on geothermal are out there (20-30 years old). They discuss issues such as mercury, etc. Lake County is the only one in the state that is in full compliance with air quality regulations because of how The Geysers is operated.
- Commercial and industrial are our biggest customers. 20% of the revenue is 100% of the voting base. Should C&I customers be educated? Not in Palo Alto, but maybe in general.
- First get the utilities on board.
- We've done customer surveys and based our program designs on those data.

Appendix D. Findings from Workshop Evaluation Forms

Findings from Workshop Evaluation Forms
Part One: Results from Utility Participants

What were the strengths of today's workshop?

12/16/03 Workshop responses:

- Very knowledgeable people
- Wide range of detailed information by an unbiased group
- In-depth presentation of geothermal
- Good information about current state and status of geothermal energy, including technology and costs
- Excellent overview of geothermal technology that was very understandable. Good interaction of presenter and group. Excellent debate/discussion
- Depth of information presented; overall view of resources and their locations
- Opportunity for utility participants to address and share real-life issues related to geothermal resource development.

12/18/03 Workshop responses:

- Knowledge and information from Jim at GeoThermex
- Well-organized; kept on time and generally on track.

How could the workshop be improved?

12/16/03 Workshop responses:

- Maybe a little more in the economics and financial analysis area
- A little more discussion on current political issues; RECs, etc.
- There is quite a bit of redundancy in Section One and in Sections Two through Five
- Provide evaluation at beginning so participants can rate and comment when things are fresh in their minds
- Specifics about operating characteristics of actual plants
- Focus on fewer topics.

12/18/03 Workshop responses:

- Need to get more utility resource planners involved
- Need to look at geothermal in the context of all the renewable and resource issues going on
- Schedule further from holiday break
- Provide more readable handouts.

What information would you still like to receive about geothermal power?

12/16/03 Workshop responses:

- Findings on cost of construction, operation, value of green tickets
- Would like ongoing information on legislative activities
- Financial information
- Periodic updates of resource developments—newsletter is fine
- Economics, financial, and operational data.

What information would you still like to receive about geothermal power? (continued)
12/18/03 Workshop responses:
- Technology development updates
- Access database of resources
- Computer model used to conduct the Monte Carlo simulations.

On a scale of 1 to 10, please indicate how useful each of the following topics was to you as a utility resource planner. [1 = Not at all useful; 10 = Very useful]
(Utility participant responses from both workshops scored together [n = 10])

Workshop topic	Range of responses	Mean score
Nature of geothermal resources	7-10	9.1
Development and operational issues	7-10	8.8
Economics	6-10	8.3
Emerging technology	4-10	8.0
Risks	4-10	7.8
Utility experience and perspectives	5-10	8.1[4]

Overall, the Utility Geothermal Workshop . . .

Response	Percentage (n = 10)
Exceeded my expectations	40%
Met my expectations	60%
Failed to meet my expectations	0

Overall, how valuable was the Geothermal Utility Workshop to you in your role as a utility resource planner? [1 = Not very valuable; 10 = Extremely valuable]
Range of responses: 7 - 10
Mean response: 8.3
Reasons for responses:
- The economics of geothermal on its face will be the driving force of what decision is made for the benefit of the utility
- Good organization of information
- We are in a process of implementing RPS for my company
- Geothermal has (it appears) fallen on the wayside—not much information out
- One-stop shop for geothermal industry update
- Useful information on resource, data, incentive status, current status of development
- The need to meet state RPS goals and the possibility that geothermal can help meet this goal
- I learned some things I did not know already; met some useful contacts; and was able to contribute.

[4]For this item, n = 9 respondents.

What sources of information concerning geothermal resources are your utility's decision makers most likely to use? [Please check all that apply.]

Information Source	**Percentage (n = 10)**
Technical reports	80%
Workshop formats	50%
Meetings/custom presentations	40%
Websites	30%
Brochures	20%
Other [*Please specify*][5]	10%
Depends on the decision maker	20%[6]

What types of information about geothermal power would be most useful to your utility's decision-makers?

- Site-specific evaluation in the context of larger resource acquisition processes
- Reliability
- Transmission congestion relief contributions
- Economics; economic potential (beyond technical potential)
- Financial data
- Costs
- Price
- Risks
- Job creation
- New technologies
- Technology improvements
- Historical and operational information
- Resource on people knowledgeable in geothermal
- Presentation tailored specific to own utility would be useful.

Other comments? One respondent commented that the workshop was well done.

[5]Specified were: hands-on site visits; resource evaluation.

[6]At least "to some extent."

Findings from Evaluation Forms
Part Two: Results from Nonutility Participants

What were the strengths of today's workshop?

12/16/03 Workshop responses:

- Technical detail was laid out that is not widely available
- The workshop was not just a sales pitch for geothermal—it included pros and cons
- Utility engagement
- Hearing utility and SCAPPA perspectives, insights, experiences in renewables development
- Comprehensive information in coherent package
- Resource input from team participants
- Utility participation; good size for interactions; knowledgeable participants
- Good size; focused agenda; good speakers.

12/18/03 Workshop responses:

- Flexible approach
- Solid prepared talk with opportunity to divert onto issues of interest
- Covered the topics in an interesting fashion
- Presentation was comprehensive
- Good technical detail
- Candid discussion between utilities, with useful input from one developer present
- Included case study of transmission analysis
- Good discussion.

How could the workshop be improved?

12/16/03 Workshop responses:

- Economics and transmission
- More utility representation
- Provide handouts in larger scale (too many slides per page—can't read)
- Breaking presentation into more discrete segments
- More research on specific utility needs going into workshop
- More diversity of presenters
- Better handouts
- Keep on track.

12/18/03 Workshop responses:

- More photos of geothermal plants
- Better attendance from utilities
- More depth in economic analysis
- Better integration with other renewables and fuels.

What information would you still like to receive about geothermal power?

12/16/03 Workshop responses: (3 said this question was not applicable to them as nonutility participants)

- Economics and transmission
- Financial analysis
- Better identification of barriers
- Target criteria for geothermal models of increased use
- Risks of competition.

12/18/03 Workshop responses:

- For this forum, interest seemed to focus on risk; own or build decision; transmission
- Transmission study on Medicine Lake
- Paper regarding economics
- Parties interested in purchasing geothermal power
- Specific examples of contract terms and historical costs (if such information were in the public domain).

On a scale of 1 to 10, please indicate how useful each of the following topics was to you as a utility resource planner. [1 = Not at all useful; 10 = Very useful]

(Nonutility participant responses from both workshops scored together [n = 10])

Workshop topic	Range of responses	Mean score	NA[7]
Nature of geothermal resources	5-10	7.3	2
Development and operational issues	7-10	8.1	1
Economics	6-10	7.2	1
Emerging technology	4-10	7.5	2
Risks	4-10	7.2	1
Utility experience and perspectives	5-10	8.3	2

Overall, the Utility Geothermal Workshop . . .

Response	Percentage (n = 10)
Exceeded my expectations	30%
Met my expectations	70%
Failed to meet my expectations	0

[7]Number of nonutility respondents indicating the question was not applicable to them.

Overall, how valuable was the Geothermal Utility Workshop to you in your role as a utility resource planner? [1 = Not very valuable; 10 = Extremely valuable]

All but one of the 10 nonutility respondents said the question was not applicable to them (they were not utility resource planners). The tenth respondent rated the Workshop's value as a 5 on the 1-10 scale.

Comments:
- Work on the wire/reliability side
- I picked up some information of use in educating about geothermal and working with industry.

What sources of information concerning geothermal resources are your utility's decision makers most likely to use? [Please check all that apply.]

All 10 of the nonutility respondents indicated this question was not applicable to them. One commented that analysis by utility staff should be added to the list.

What types of information about geothermal power would be most useful to your utility's decision-makers?

Although this question was not applicable to the nonutility respondents, one commented that another type of information would be other utilities' reasons for going with geothermal.

Appendix E. Participant Lists

GEOTHERMAL WORKSHOP

December 16, 2003

Sign-In Sheet

Name	**Organization**
Mo Beshir	LADWP
Ray Dracker	Center for Resource Solutions
Steven Endo	Pasadena W & P
Barbara Farhar	National Renewable Energy Lab
Noe Gutierrez	Imperial Irrigation District
Roger Hill	Sandia Labs
Jim Lovekin	Geothermex, Inc.
Randy Manion	WAPA
Fred Mason	City of Banning
Rhonda Mills	CEERT
Manny Robledo	SCPPA
LeeAnne Uhler	City of Riverside
Jon Wellinghoff	GPW/Sandia
Ben Wong	Los Angeles Dept. W & P

GEOTHERMAL WORKSHOP

December 18, 2003

Sign-In Sheet

Name	**Organization**
John Berlin	NCPA
John Henry Beyer	CEC
Anna Carter	Geothermal Education Office
David Christy	WAPA
Ray Dracker	Center for Resource Solutions
Barbara Farhar	National Renewable Energy Lab
Curtis Framel	DOE
Pablo Gutierrez	CEC
Roger Hill	Sandia Labs
Karl Knapp	City of Palo Alto
Elaine Sison-Lebrilla	CEC
Jim Lovekin	Geothermix, Inc.
Randy Manion	LADWP
Roger Peake	CEC
Jack Pigott	Calpine
Val Tiangco	CEC
Bruce Vincent	SMUD
Gail Wigget	CEC

Appendix F. Workshop Evaluation Form

Name (optional):_____ Date:_____

Evaluation of the Geothermal Utility Workshop

What were the strengths of today's workshop? _____

_____

_____

How could the workshop be improved? _____

_____

_____

What information would you still like to receive about geothermal power? _____

_____

_____

On a scale of 1 to 10, please indicate how useful each of the following workshops topics was to you as a utility resource planner. ***[Please circle one response for each item.]***

	Not at all useful									**Very useful**
1. Nature of geothermal resources	1	2	3	4	5	6	7	8	9	10
2. Development and operational issues	1	2	3	4	5	6	7	8	9	10
3. Economics	1	2	3	4	5	6	7	8	9	10
4. Emerging technology	1	2	3	4	5	6	7	8	9	10
5. Risks	1	2	3	4	5	6	7	8	9	10
6. Utility experience and perspectives	1	2	3	4	5	6	7	8	9	10

Overall, the Utility Geothermal Workshop . . . ***[Please check one response.]***

___ Exceeded my expectations
___ Met my expectations
___ Failed to meet my expectations

Overall, how valuable was the Geothermal Utility Workshop to you in your role as a utility resource planner? ***[Please circle one response.]***

Not very valuable									**Extremely valuable**
1	2	3	4	5	6	7	8	9	10

Why do you feel this way? _____

_____

_____

What sources of information concerning geothermal resources are your utility's decision makers most likely to use? ***[Please check all that apply.]***

___ Meetings/custom presentations
___ Workshop formats
___ Websites
___ Brochures
___ Technical reports
___ Other ***[Please specify]*** _____
___ Depends on the decision maker

What types of information about geothermal power would be most useful to your utility's decision-makers?

_____

_____

_____

Other comments?

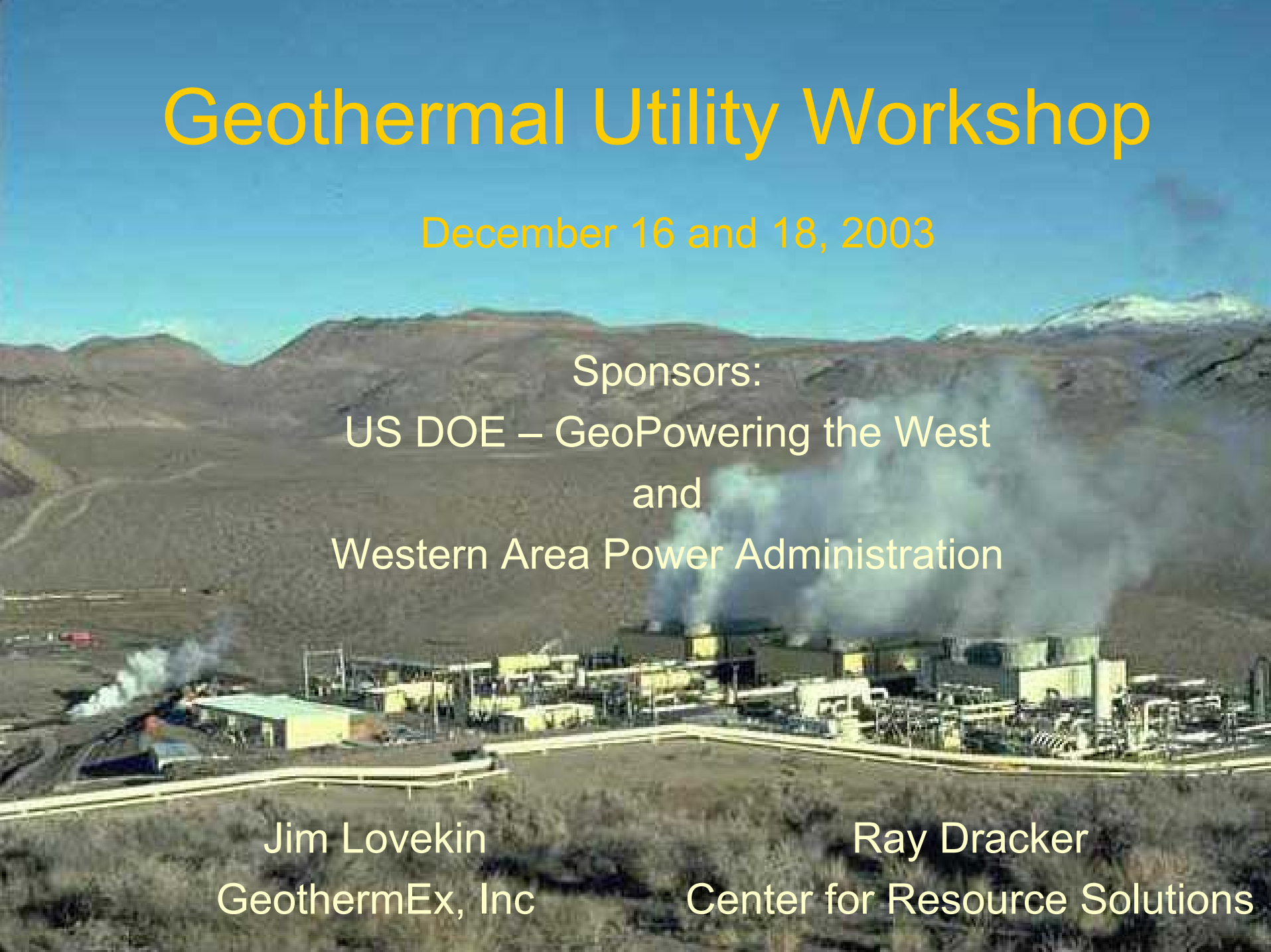
Thank you very much for your evaluation!

Appendix G. Geothermal Utility Workshop Presentation

Presented by Jim Lovekin and Ray Dracker

Geothermal Utility Workshop

December 16 and 18, 2003



Sponsors:
US DOE – GeoPowering the West
and
Western Area Power Administration

Jim Lovekin
GeothermEx, Inc

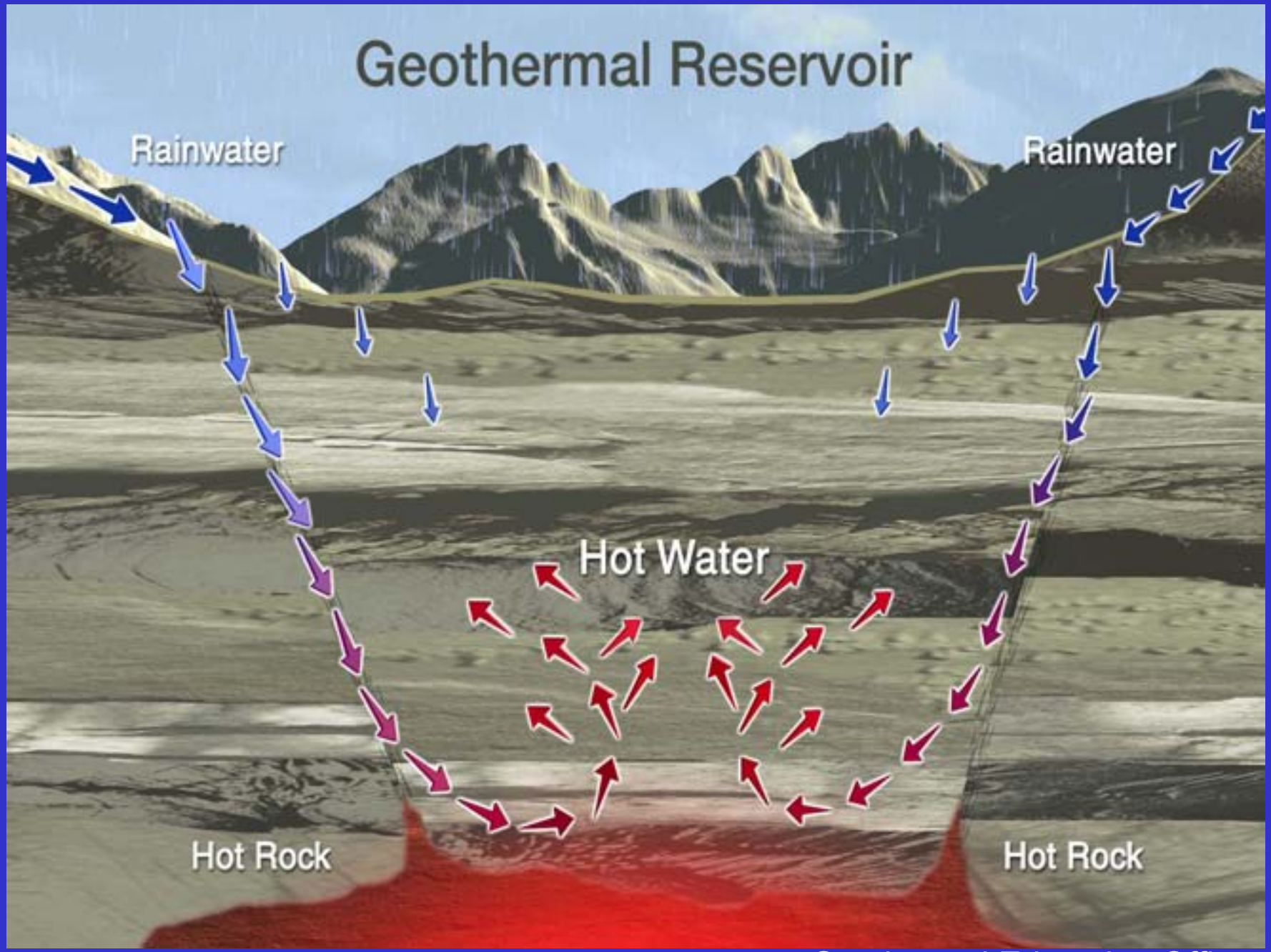
Ray Dracker
Center for Resource Solutions

Workshop Outline

1. **Nature of geothermal resources from a utility perspective**
2. Development and operational issues
3. Economics
4. Emerging technology
5. Risks
6. Utility overview

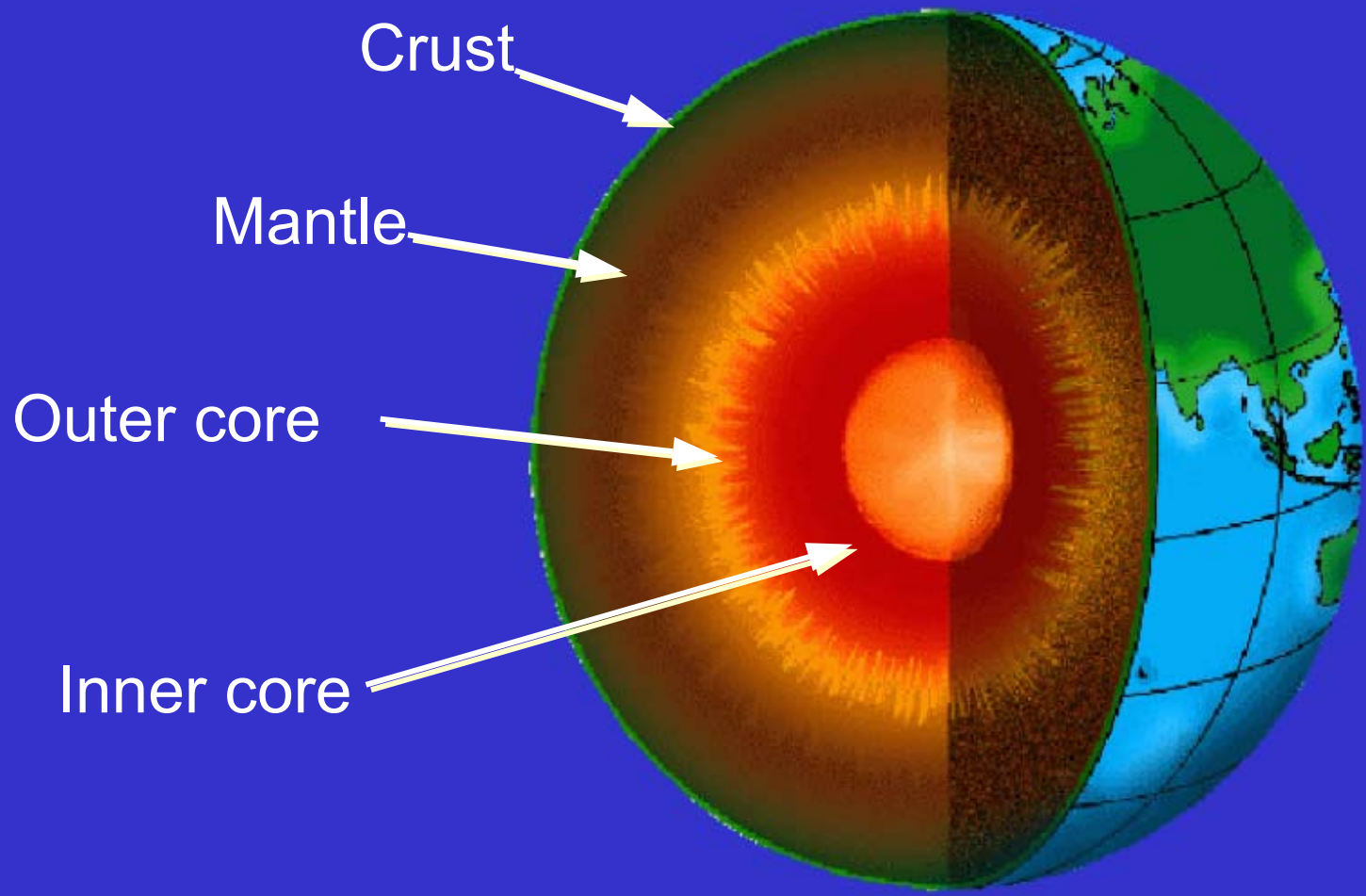
Nature of Geothermal Resources

- Location: where are the most developable geothermal resources?
- Development potential: how much capacity can be anticipated?
  - California Energy Commission / Hetch Hetchy project to assess geothermal resources
- Geothermal resource types
  - Resource characteristics
  - Conversion technologies



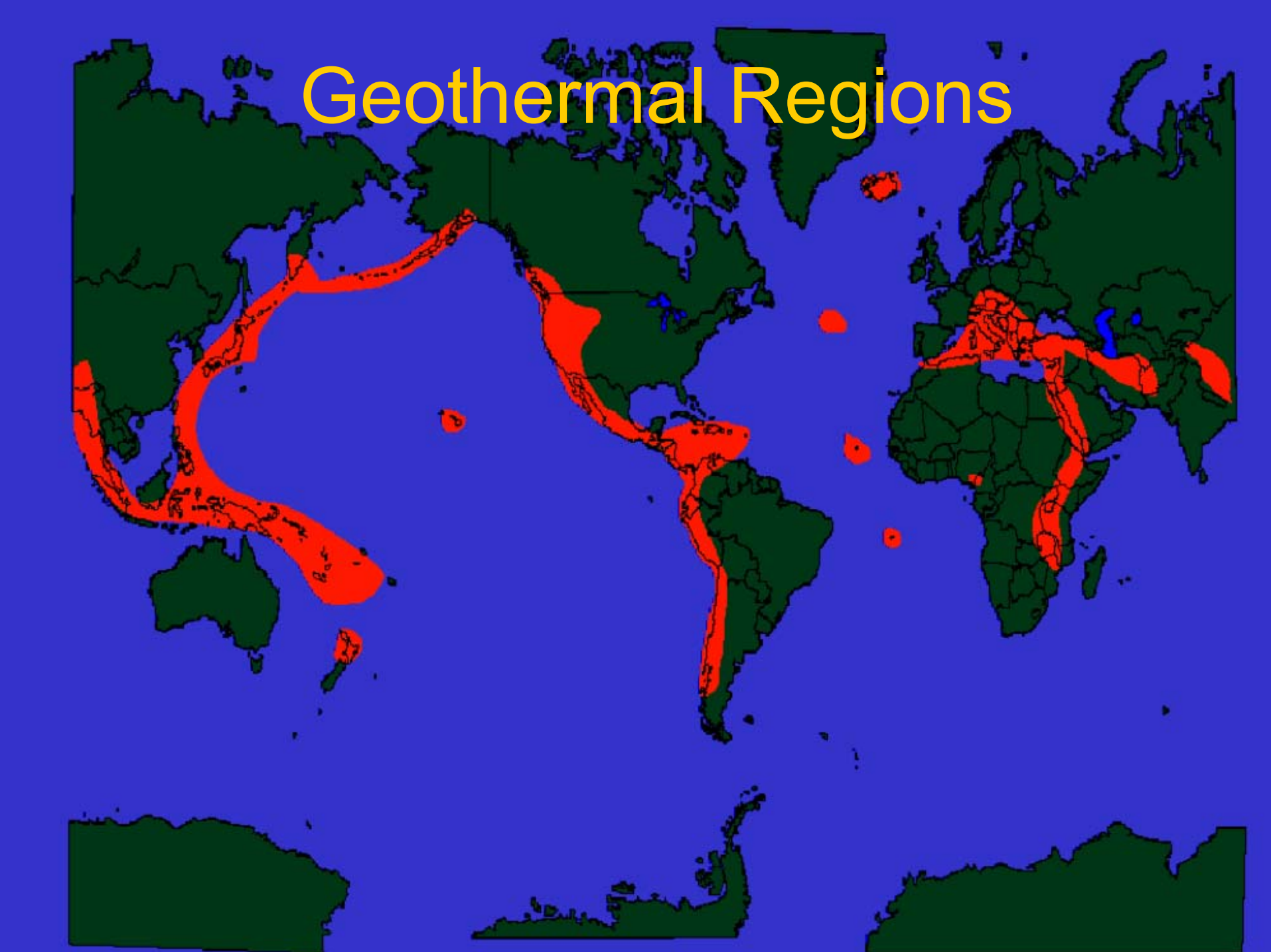
Geothermal Education Office

The Earth



Geothermal Education Office

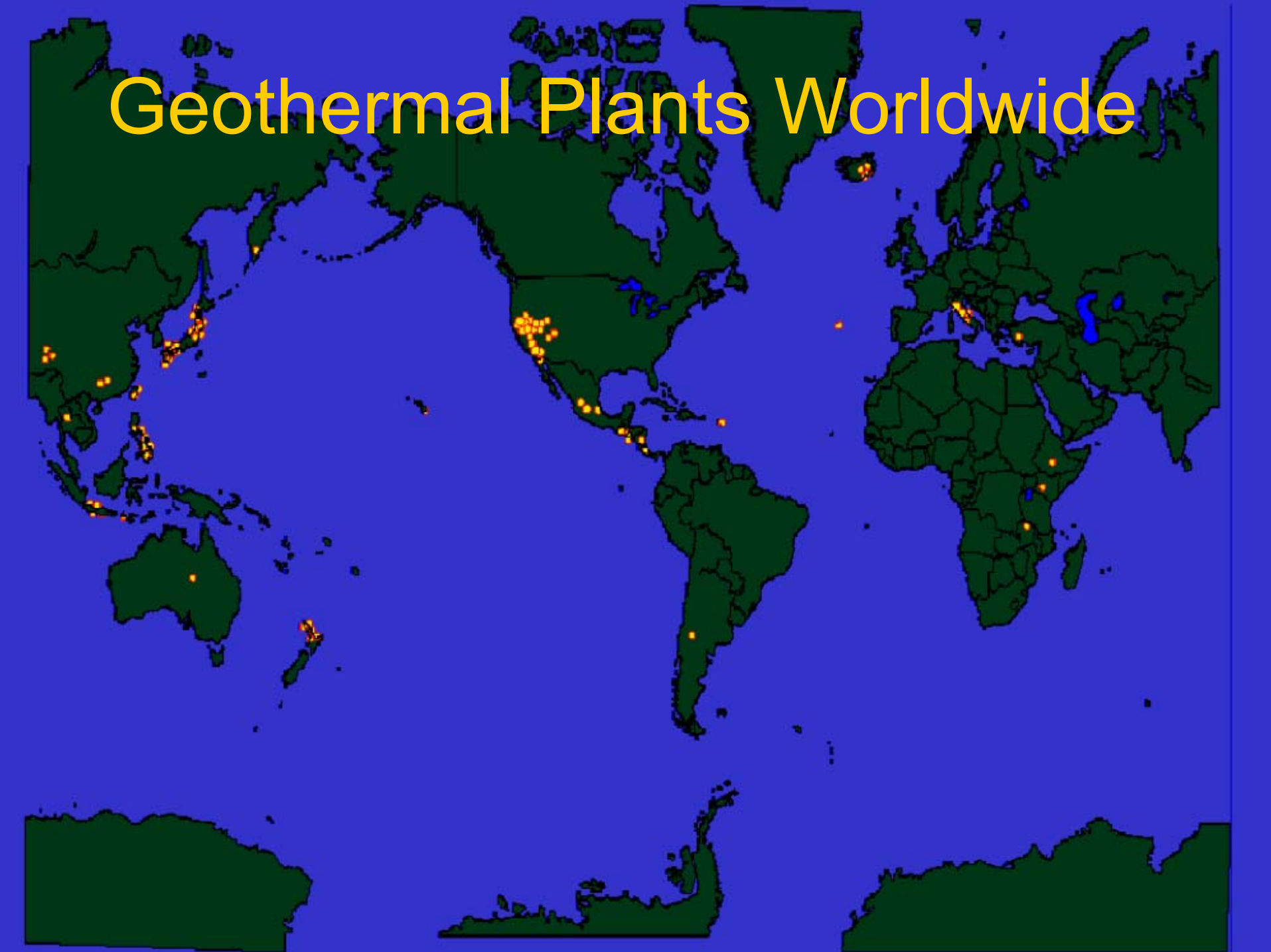
Geothermal Regions



Geothermal Use Worldwide

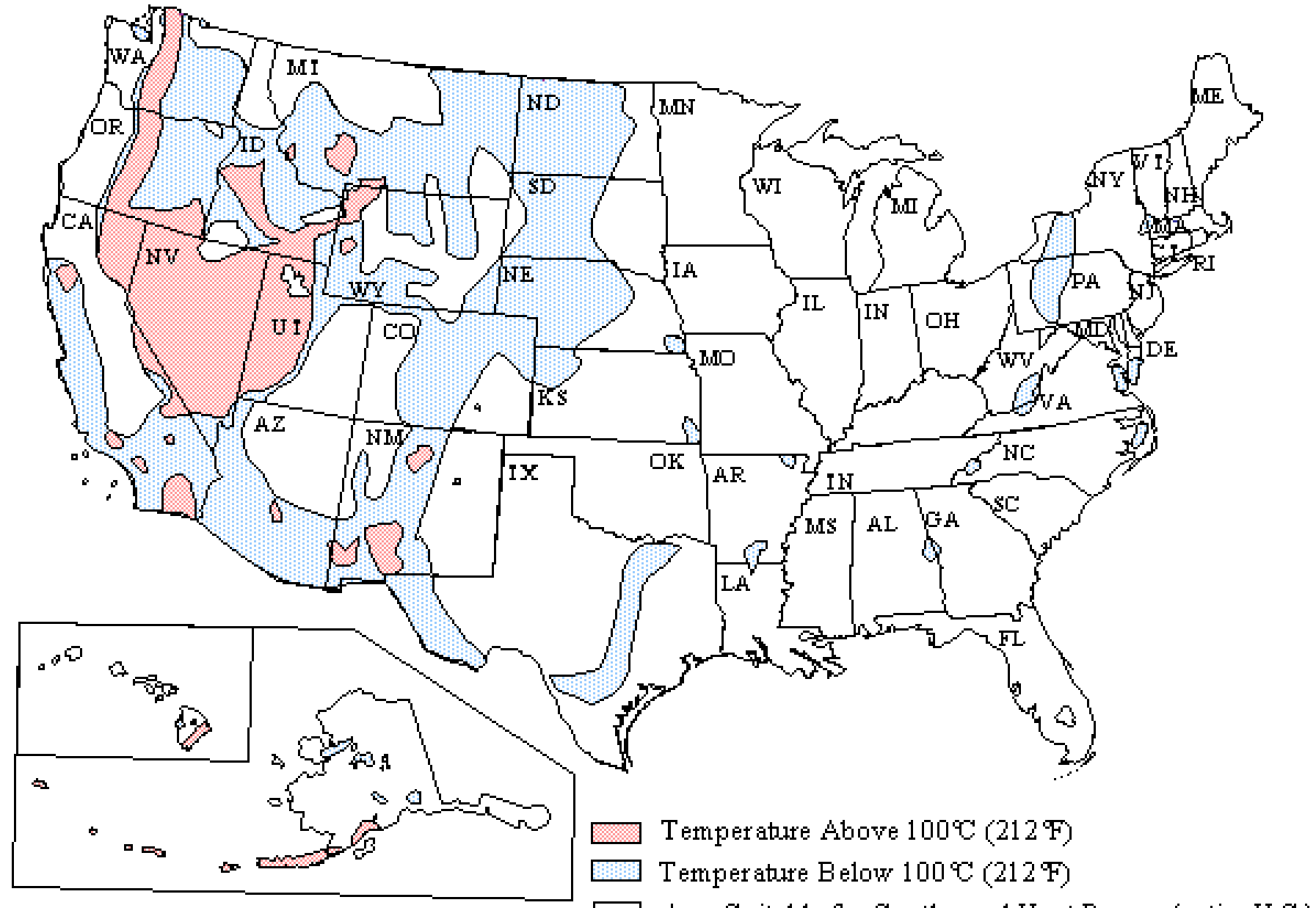
Geothermal power plants are producing about 8,000 megawatts of electricity in 21 countries, supplying about 60 million people -- mostly in developing countries.

Geothermal Plants Worldwide



Geothermal Use in US

Approximately 2,150 megawatts of electricity from geothermal power plants are supplying about 3 million people in the U.S.



Source: ESRI, 1995

Figure 6. Map showing estimated ultimate conventional resource potential for the Salton Sea geothermal field as of July 2002.

Source: adapted from Hul02a

Figure SAL00-2:
Map showing geographic areas
used for capacity estimate, Salton Sea geothermal field, California

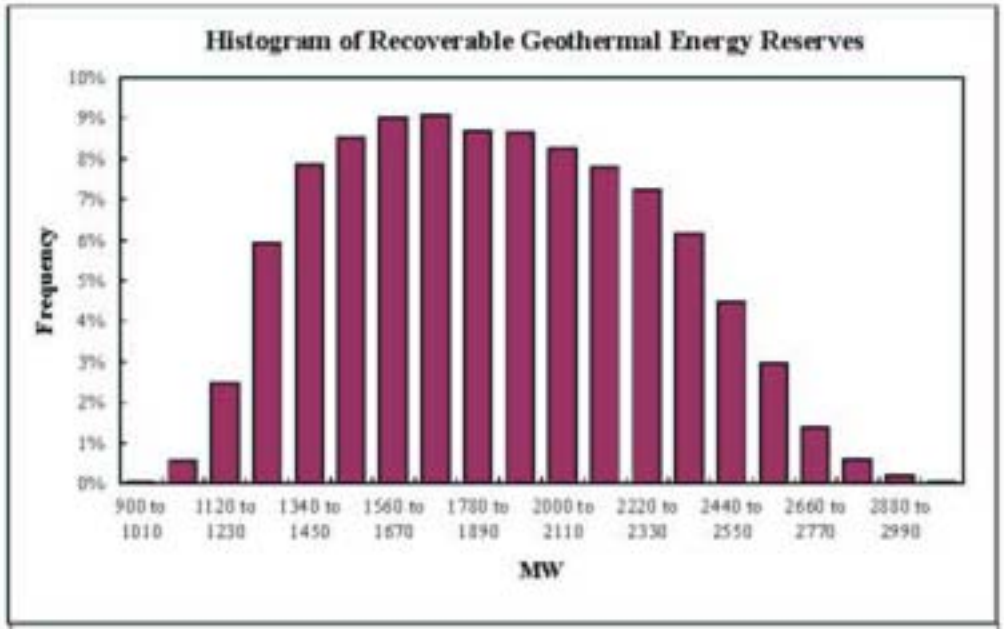
SUMMARY OF INPUT PARAMETERS

Variable Parameters	Minimum	Most Likely	Maximum
Reservoir Area (sq. mi.)	18.0	18.1	18.2
Reservoir Thickness (ft)	5500	7500	8500
Rock Porosity	0.1		0.2
Reservoir Temperature (°F)	550	575	600
Recovery Factor	0.10		0.20

Fixed Parameters		
Rock Volumetric Heat Capacity	39.0	BTU/cu. ft°F
Rejection Temperature	75	°F
Utilization Factor	0.45	
Plant Capacity Factor	0.90	
Power Plant Life	30	years

RESULTS

Statistics	MW	MW/sq. mi.	Recovery Efficiency
Mean	1881.13	103.93	1.99%
Std. Deviation	403.80	22.31	0.38%
Minimum (90% prob.)	**1352.01**	74.74	1.45%
Most-likely (Modal)	**1754.66**	97.02	1.47%



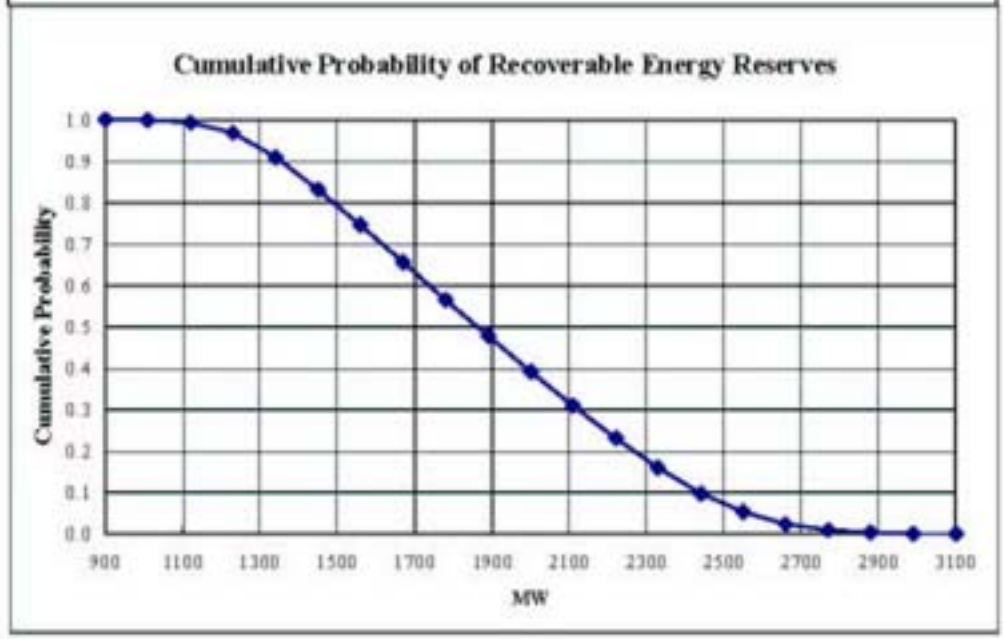
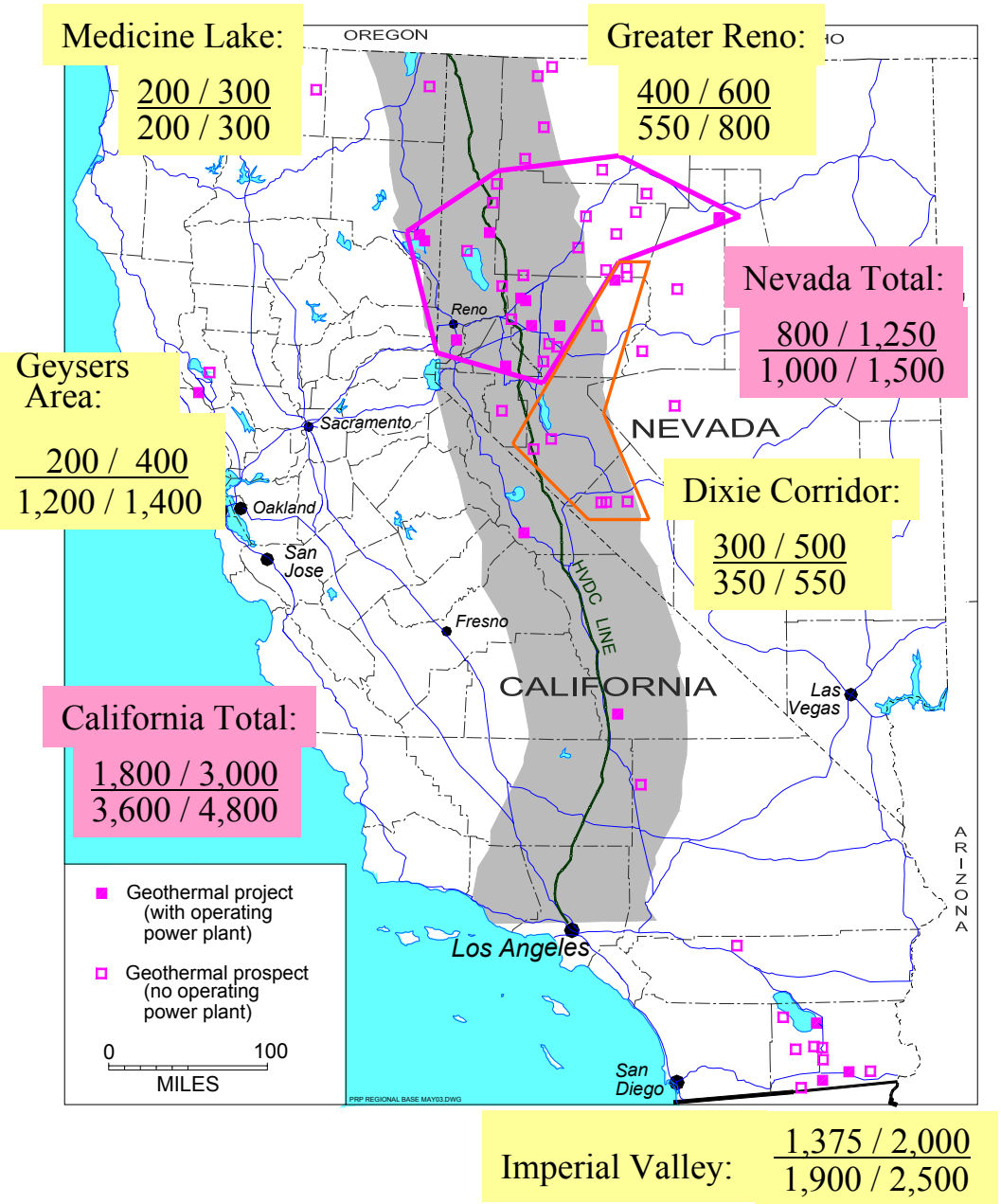


Figure SAL00-3:
Probabilistic Calculation of Geothermal Energy Reserves
SALTON SEA FIELD, CALIFORNIA

Generating Capacities of Major Geothermal Resource Areas in California and Nevada (Gross MW)



LEGEND

Minimum Incremental	Most Likely Incremental
Minimum Total	Most Likely Total

GeothermEx, Inc. 2003

Resource Types: Types of Circulating Fluid

- Hydrothermal
- Hot Dry Rock
  - Enhanced Geothermal Systems (EGS)
- Geopressured
- Magma Energy

Resource Types: Other Descriptors

- Heat source
  - Magma
  - Deep groundwater circulation
- Rock type
  - Volcanics
  - Sedimentary
  - Basement rocks
- Depth
- Temperatures

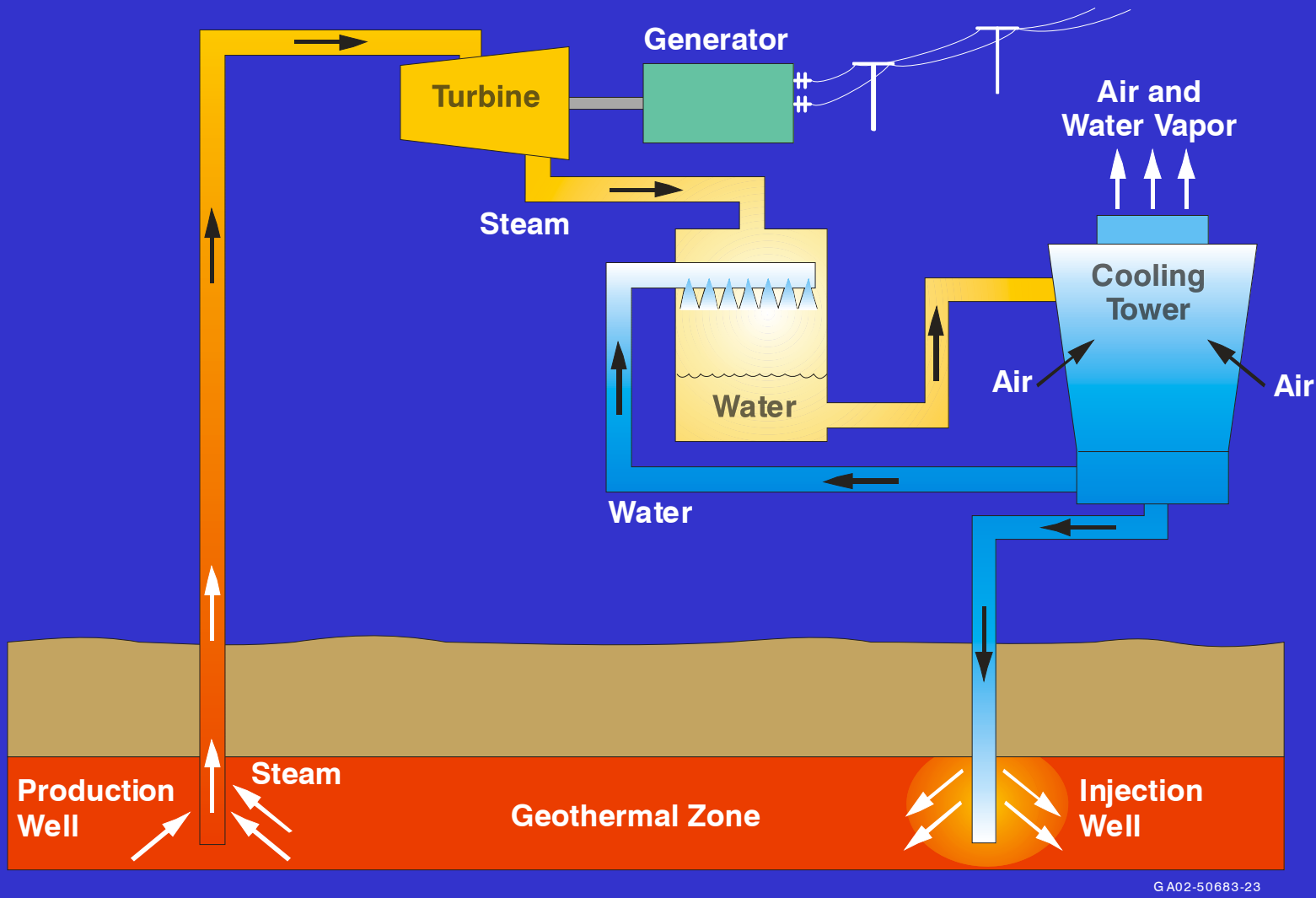
Resource Types: Plant-Operator's Perspective

- Dry steam at wellhead
- Two-phase at wellhead
- Hot water at wellhead

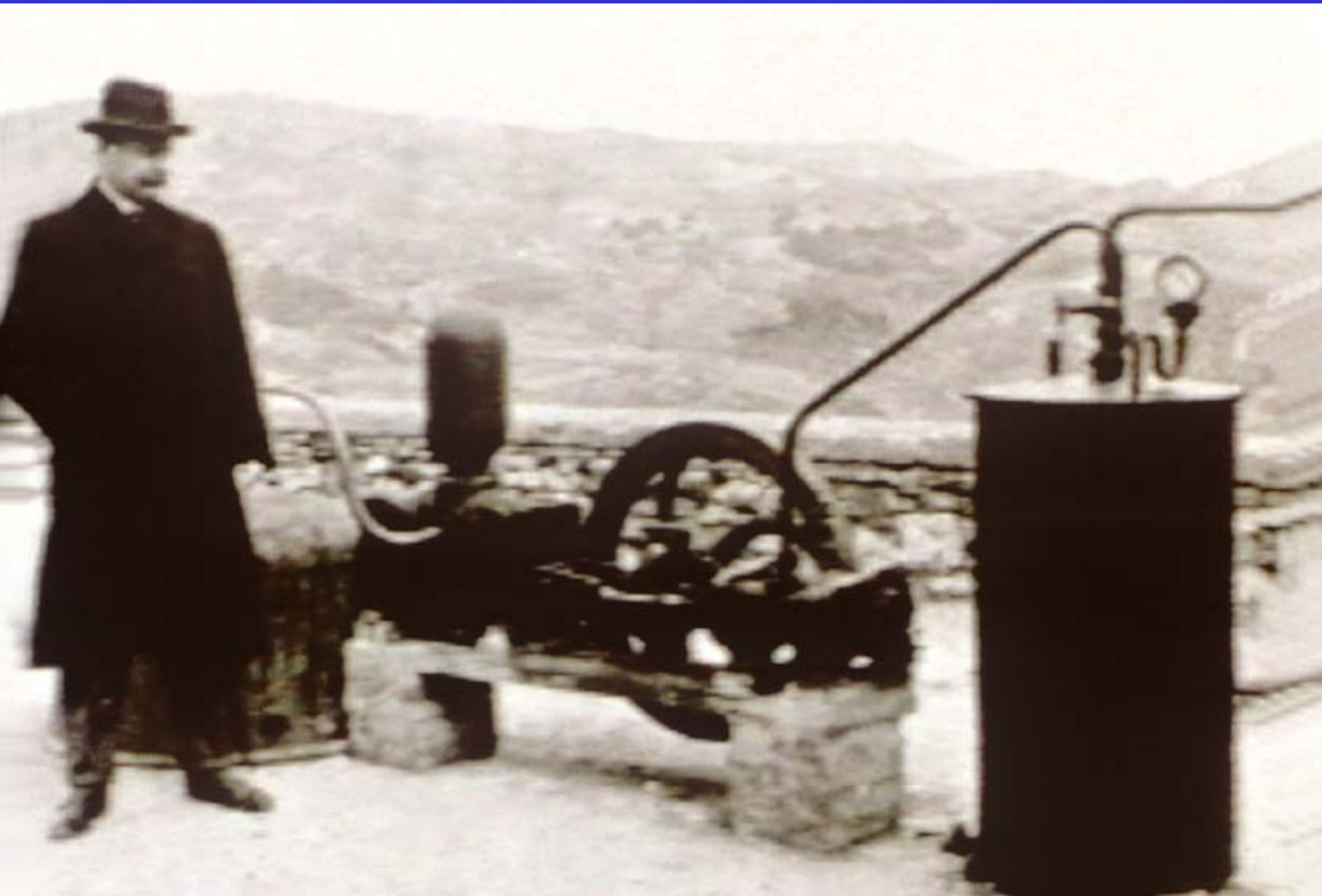
Conversion Technologies

- Dry steam plants
- Flash plants
  - Single-flash
  - Double-flash
  - Triple-flash
- Binary plants
  - Water-cooled
  - Air-cooled
- Hybrid (Combined Cycle) Plants

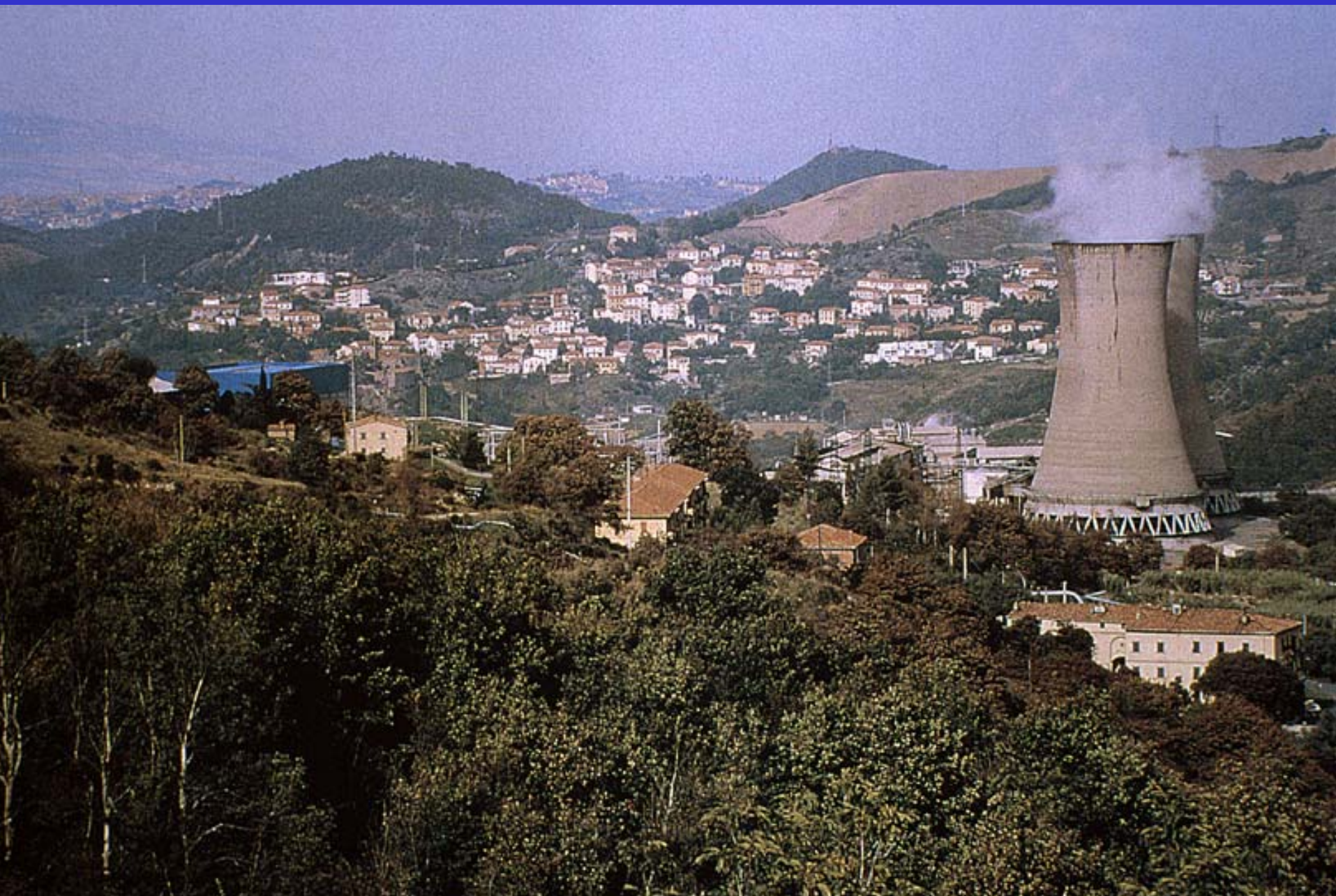
Dry-Steam Plant



First Geothermal Power Plant – Larderello, Italy 1904

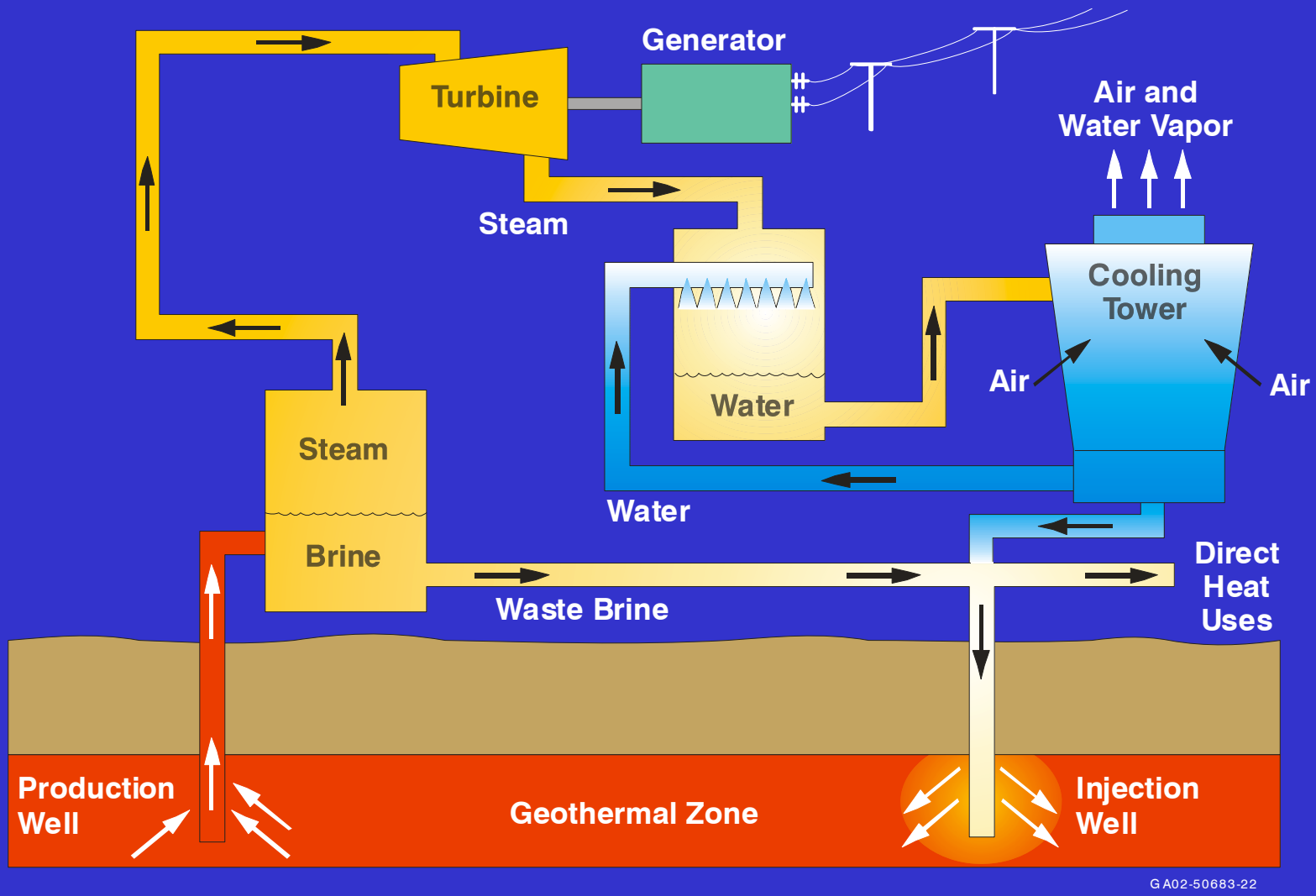


Larderello Today



The Geysers, California

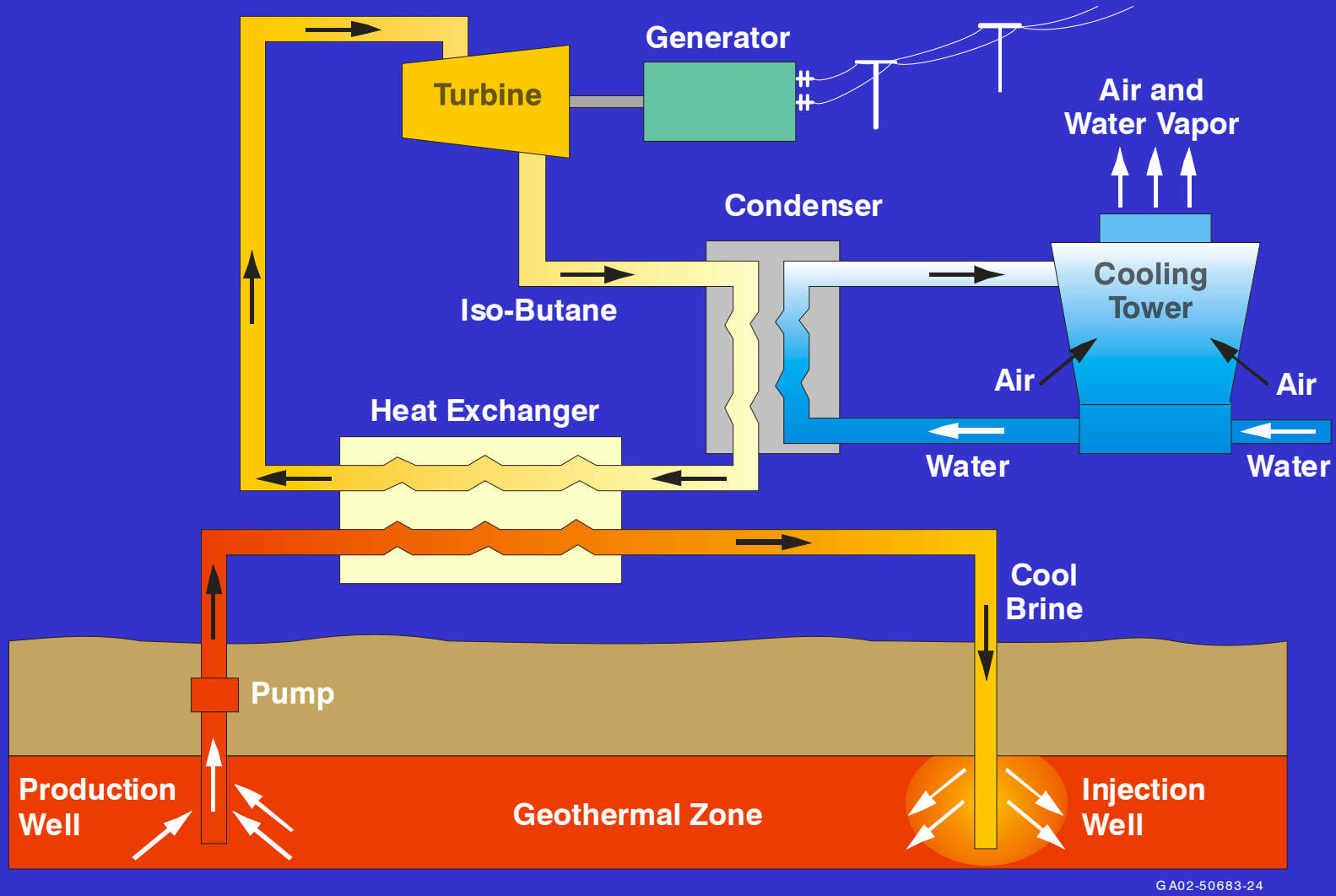
Flash Plant



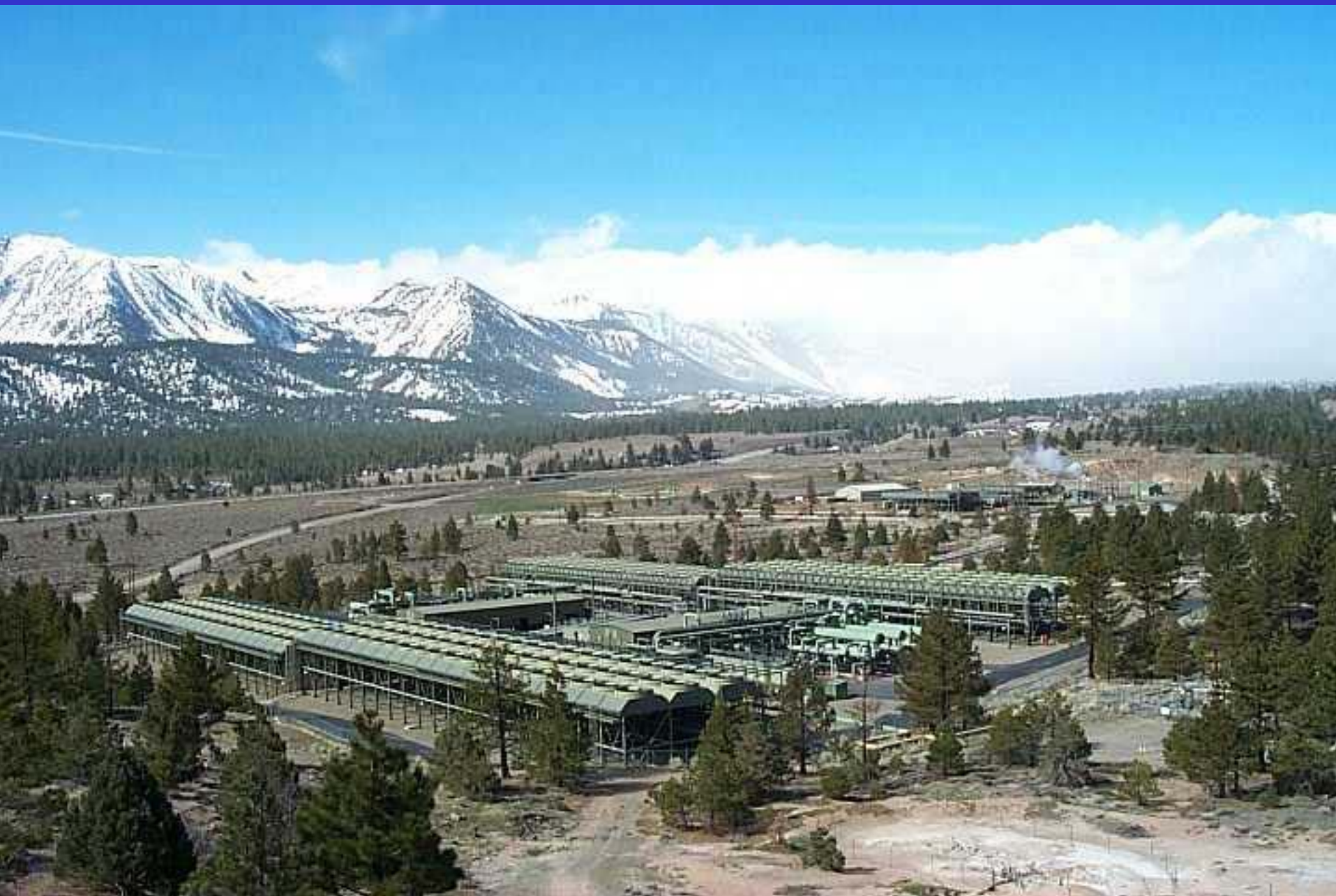
Dixie Valley, Nevada

Salton Sea, California

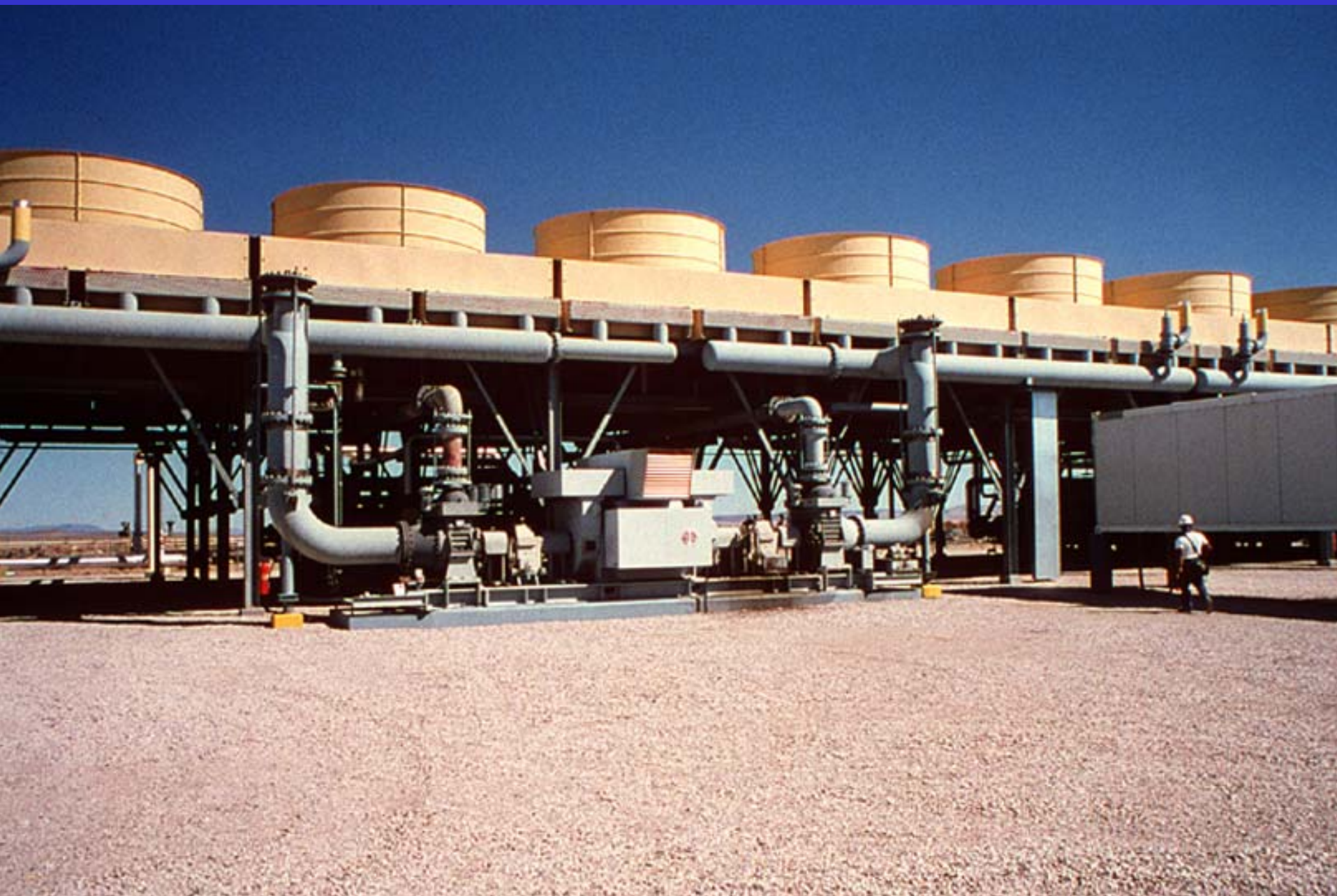
Binary Plant



Mammoth-Pacific, California

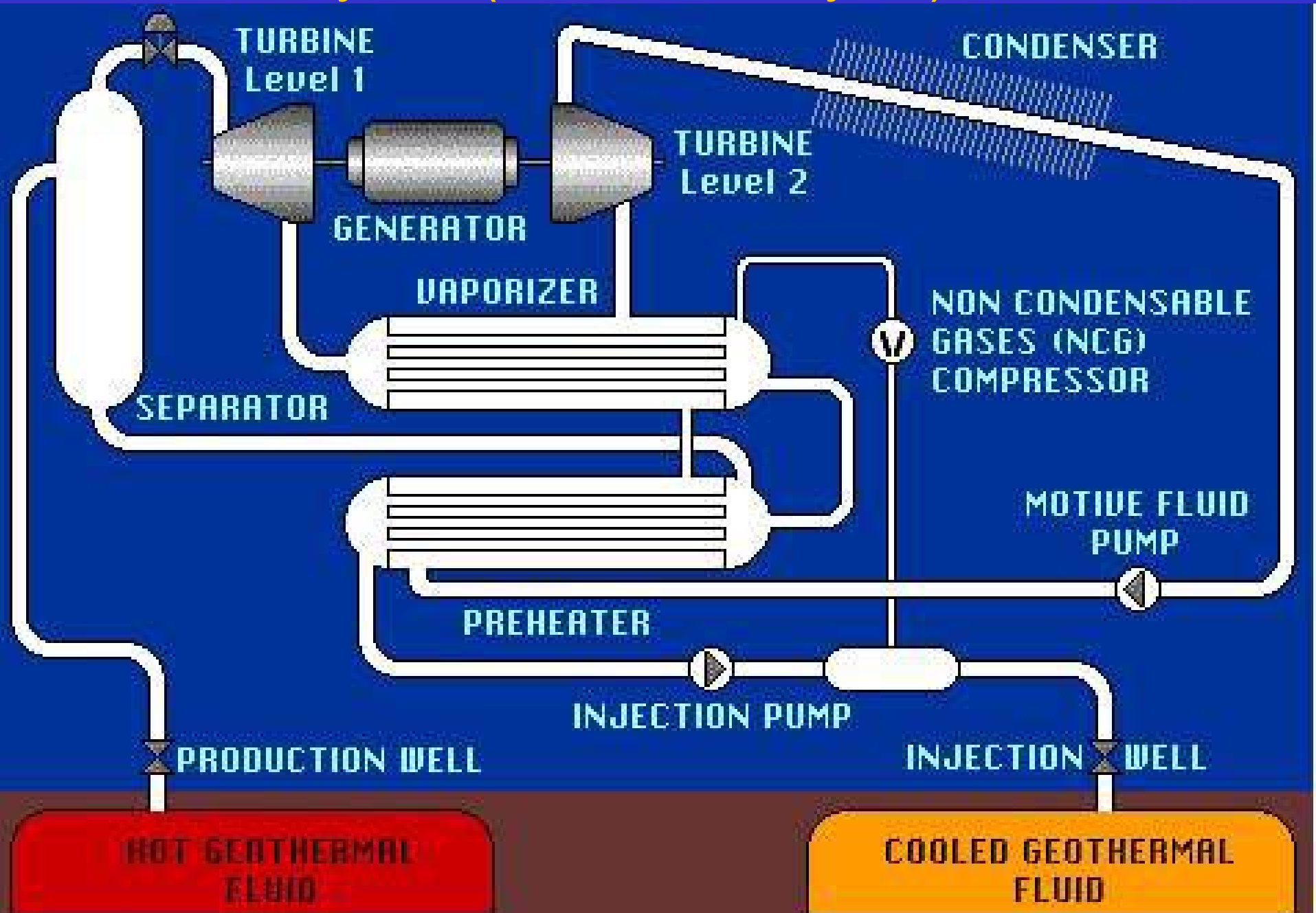


Soda Lake, Nevada



Wendel-Amedee, California

Hybrid (Combined Cycle) Plant

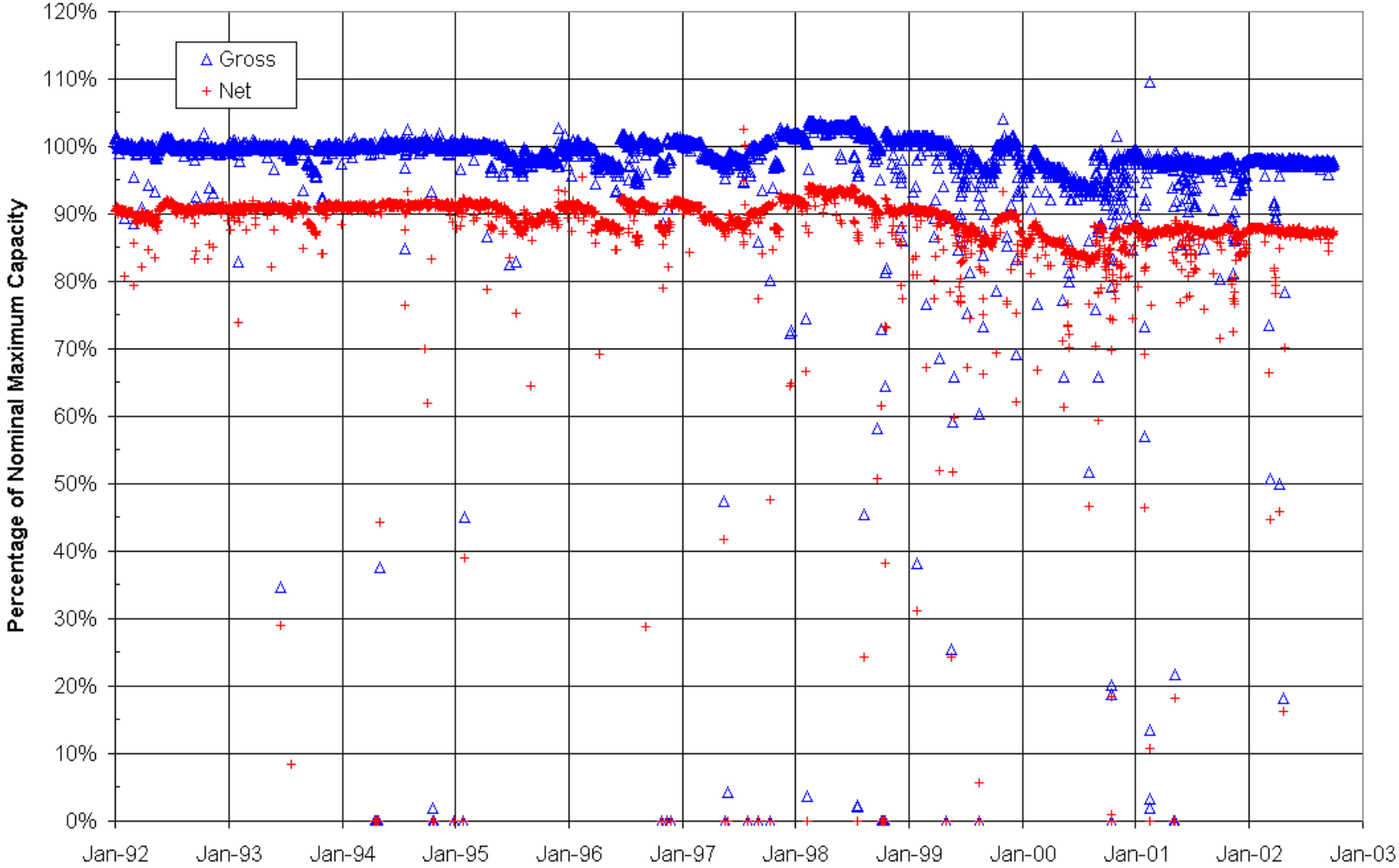


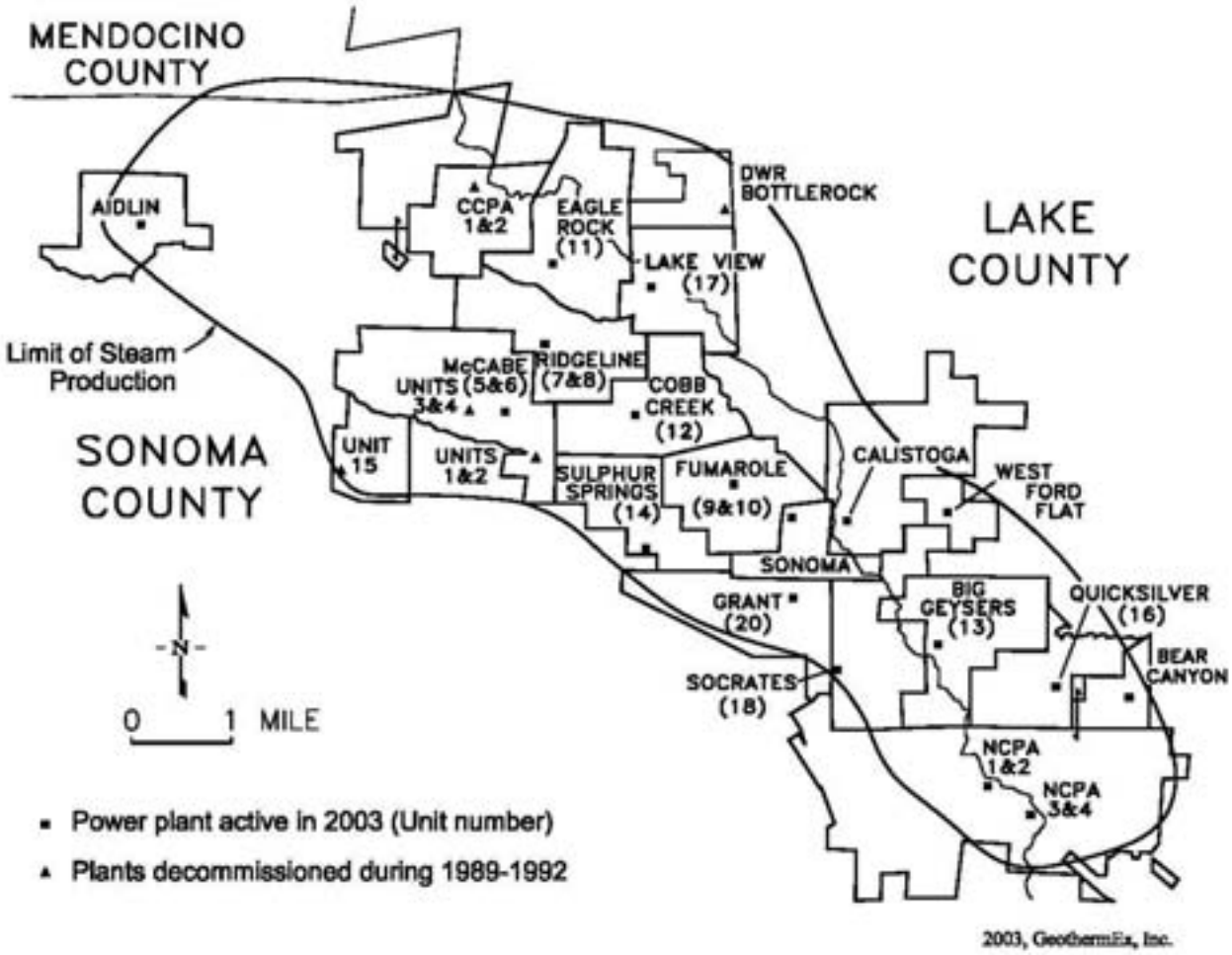
Puna, Hawaii

Characteristic Output

- Either base load or load-following
- Generally high capacity factors
- Potential limitations:
  - Reservoir pressure support
  - Reservoir cooling
    - Injection breakthrough
    - Groundwater influx
  - Air-cooled binary plants affected by ambient temperatures

Power Output of Dual-Flash Plant





GEY00-1:
Location of power plants
and unit areas at The Geysers

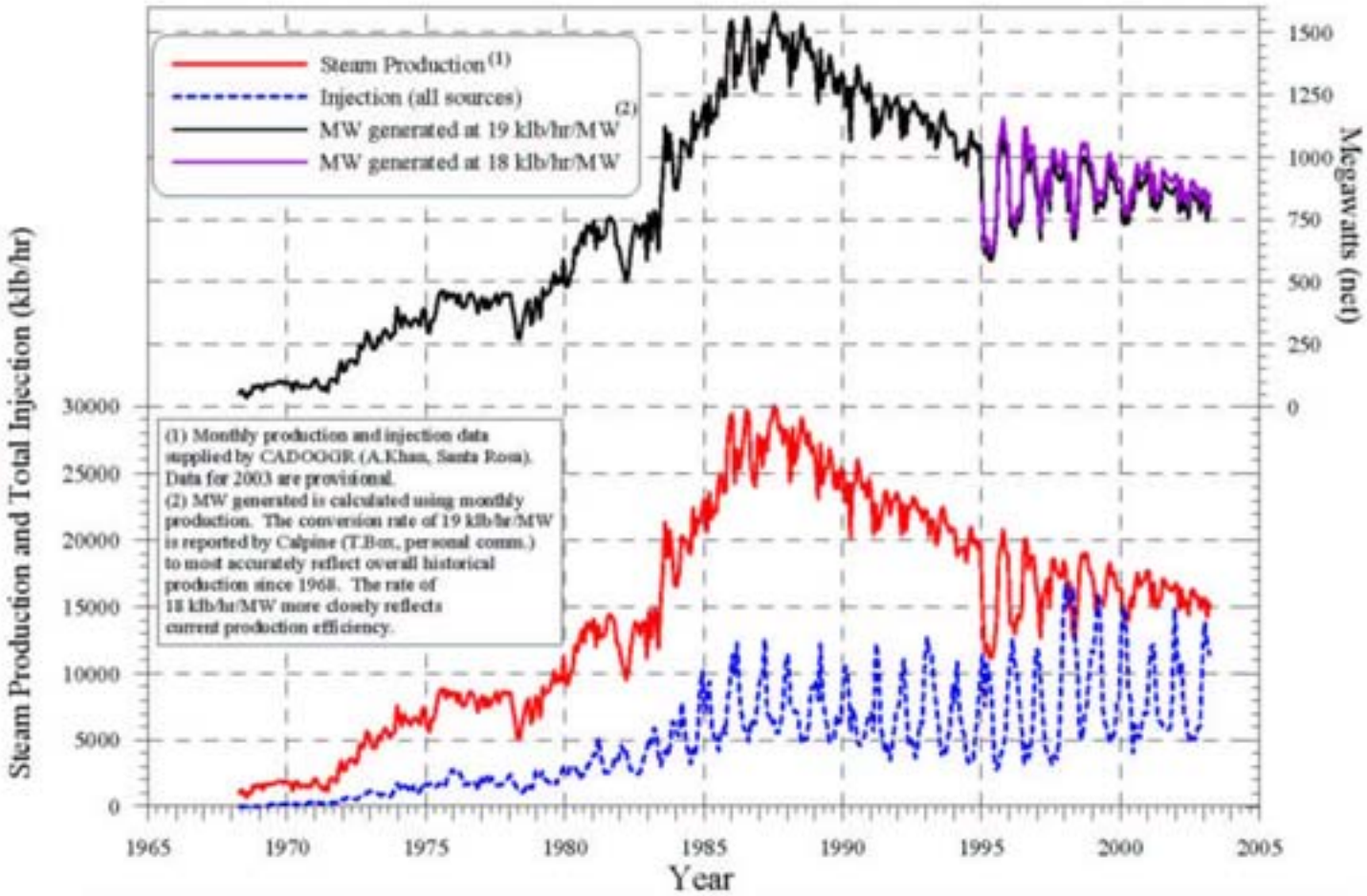


Figure GEY00-7: Geysers fieldwide steam production and injection and MW generated

Coso Lease Areas

GeothermEx, Inc. 2003

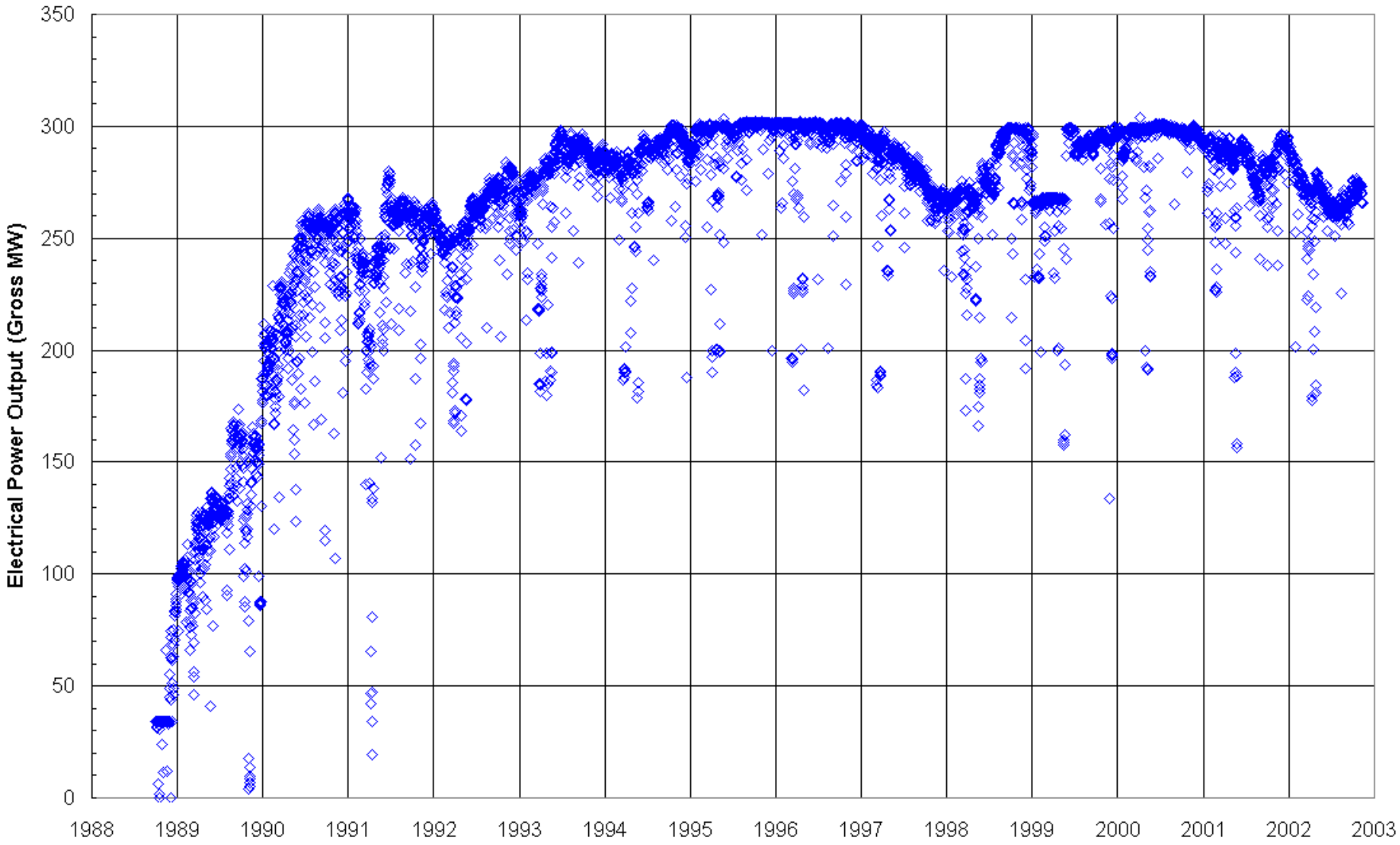
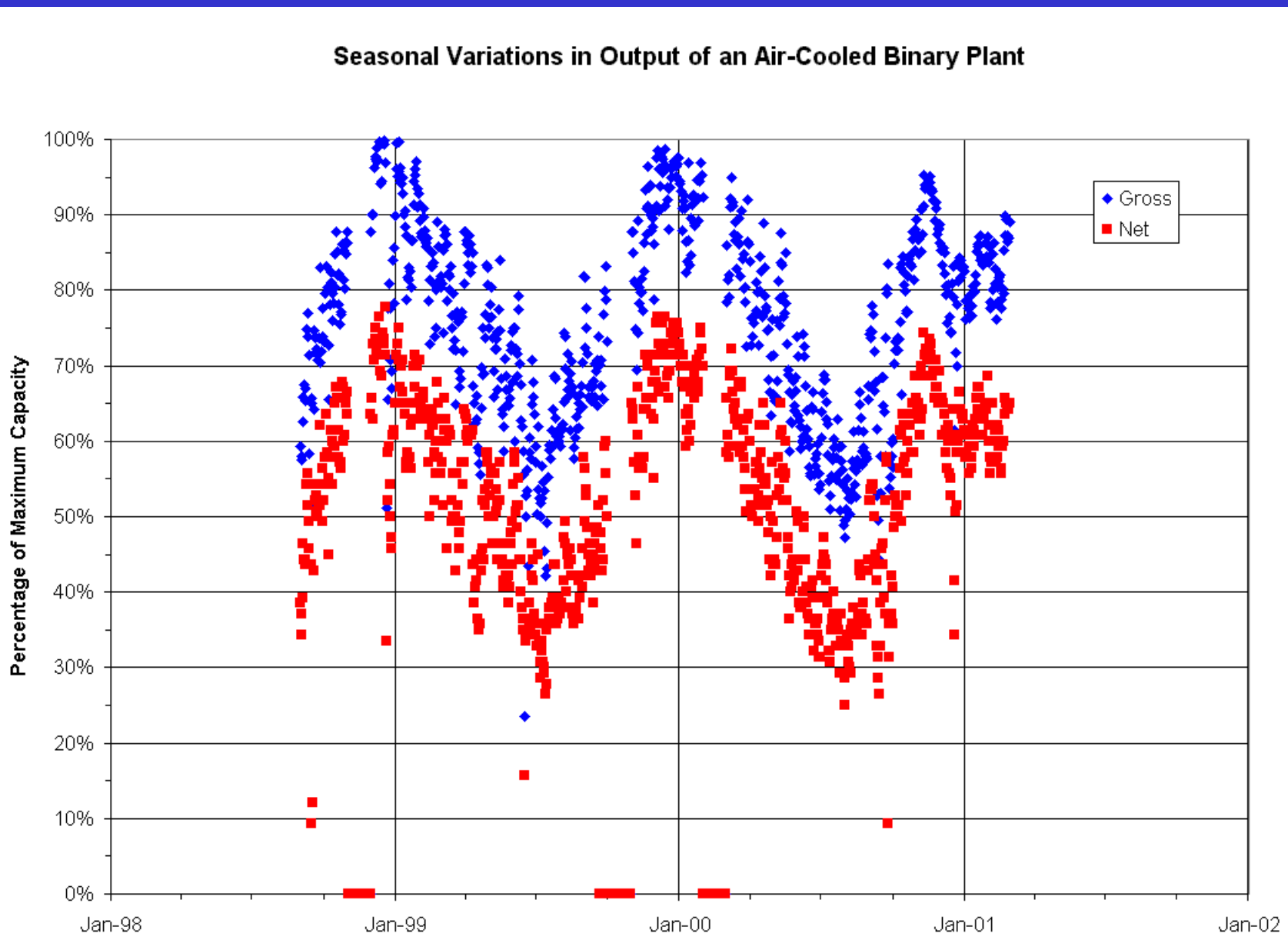
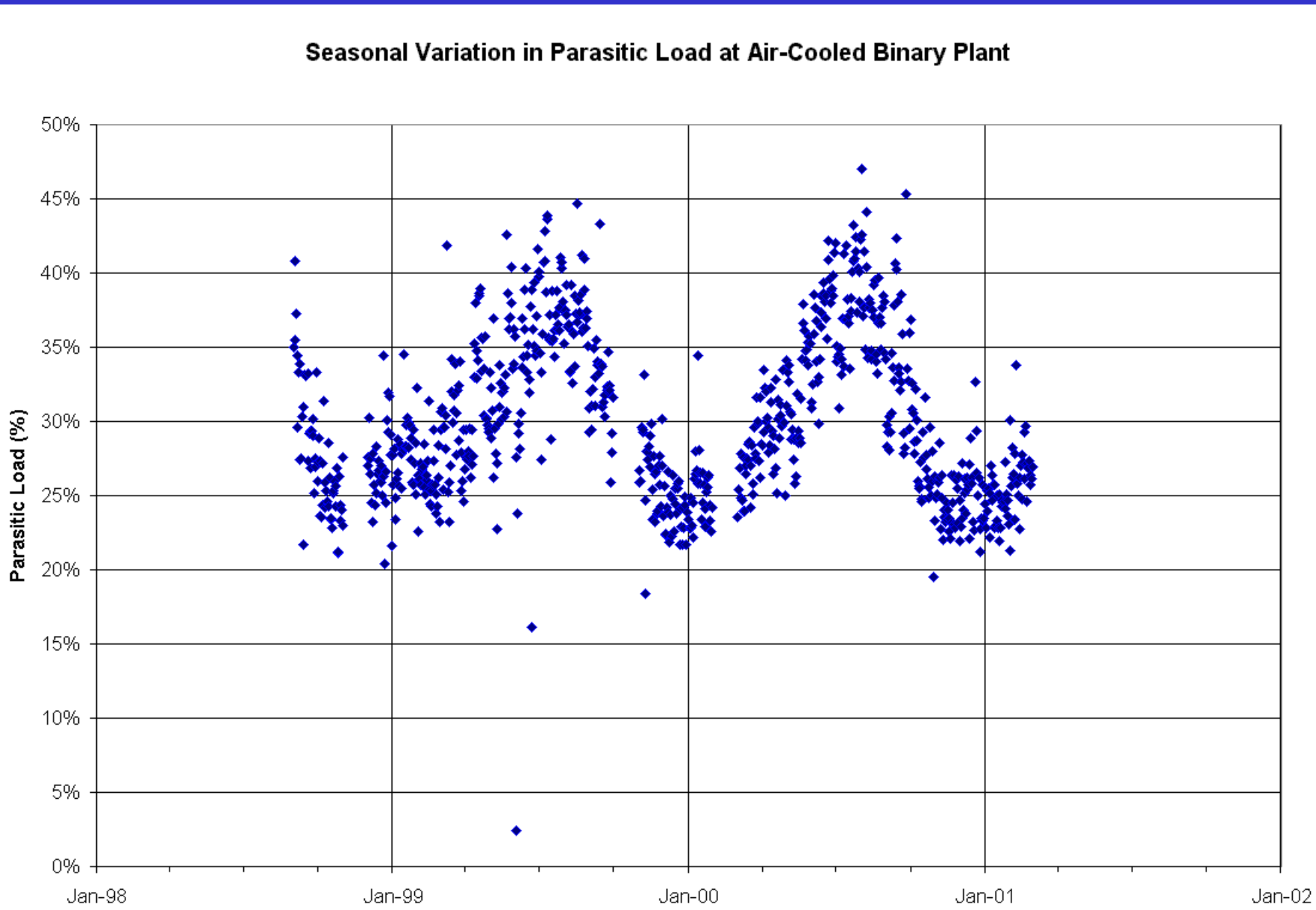
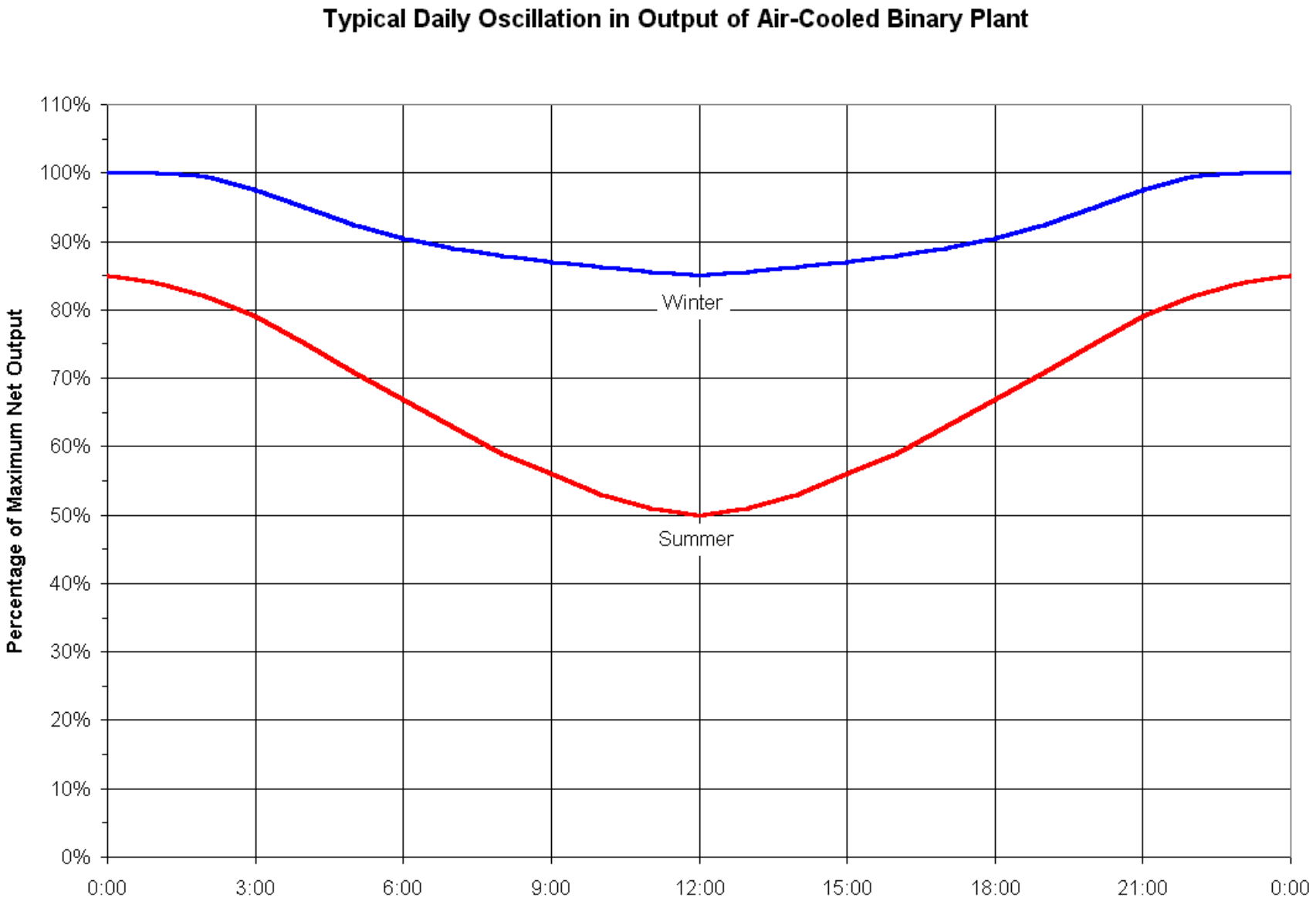


Figure COS00-3:
Historical power output of Coso field

Source: Caithness Energy, LLC
(used by permission)


Seasonal Variations in Output of an Air-Cooled Binary Plant
Percentage of Maximum Capacity
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Gross
Net


Seasonal Variation in Parasitic Load at Air-Cooled Binary Plant
Parasitic Load (%)
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02


Typical Daily Oscillation in Output of Air-Cooled Binary Plant
Percentage of Maximum Net Output
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0:00
3:00
6:00
9:00
12:00
15:00
18:00
21:00
0:00
Winter
Summer

Output of Nominal "25-MW" Air-Cooled Binary Plant					
	Gross MW	Percent of Maximum Gross MW	Parasitic Load (% of Gross MW)	Net MW	Percent of Maximum Net MW
Maximum Output (Winter Night)	30	100%	20%	24	100%
Winter Average	29	97%	25%	22	90%
Annual Average	27	90%	30%	19	80%
Summer Average	25	83%	35%	16	67%
Minimum Output (Summer Mid-Day)	20	67%	40%	12	50%

Nature of Geothermal Resources - Summary

- Incremental geothermal power available in California and Nevada:
  - Minimum 2,600 Gross MW
  - Most Likely 4,250 Gross MW
- Conversion technologies
  - Dry steam, flash, and binary
- Base load or load-following
- High capacity factors
  - Exceptions:
    - Resource limitations
    - Properties of air-cooled binary plants

Workshop Outline

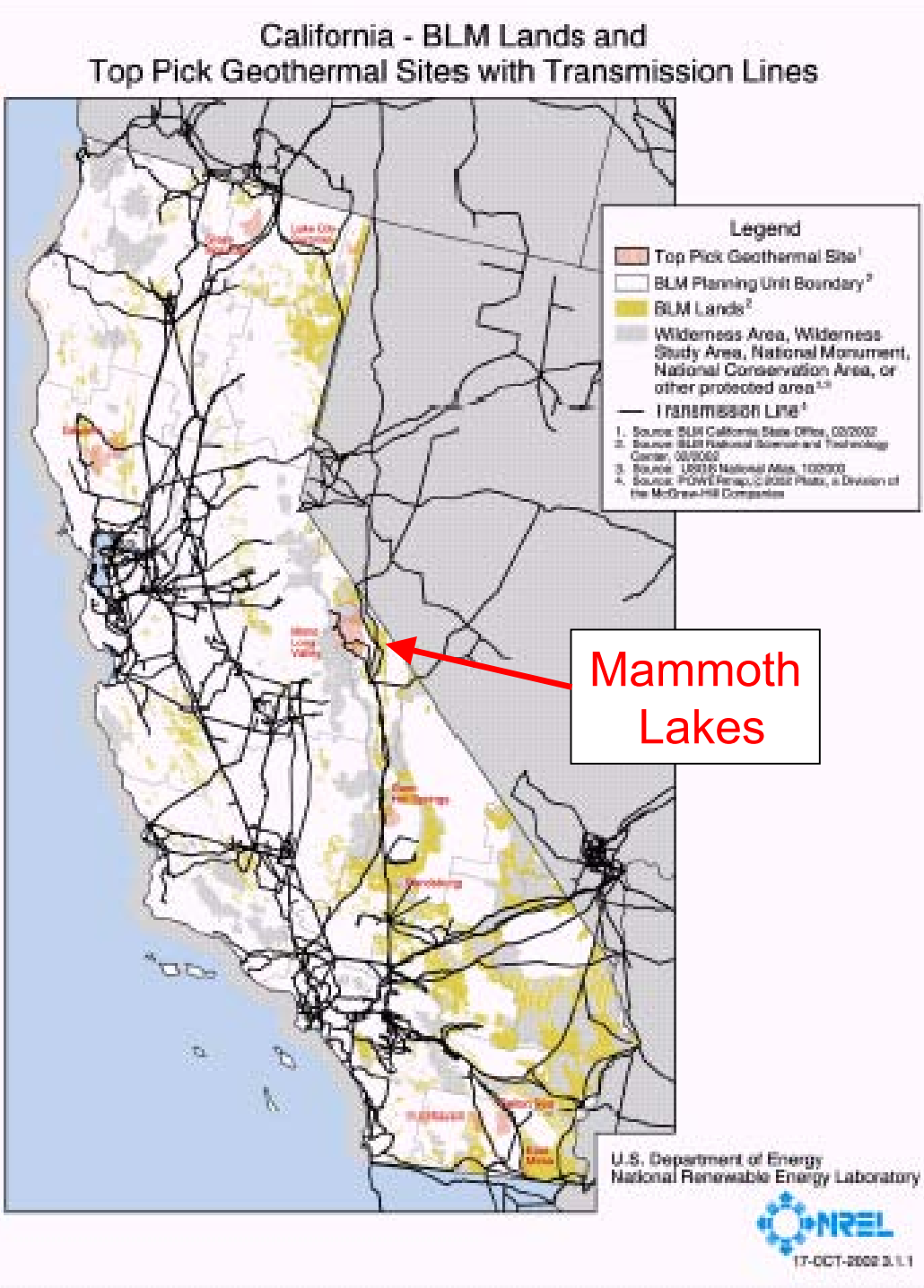
1. Nature of geothermal resources from a utility perspective
2. **Development and operational issues**
3. Economics
4. Emerging technology
5. Risks
6. Utility experience and perspectives

Development and Operational Issues

- Voltage support: small plants at decentralized locations
- Large project sites and opportunities
- Environmental and siting issues
- Renewable Portfolio Standards

Voltage Support

- Many geothermal sites in remote areas
- Proximity to local load centers enhances ability of transmission system to maintain voltage
- Contribution to voltage support should be taken into account in determining value of geothermal power
- Example: Mammoth Lakes, California



Mammoth Lakes Location Map

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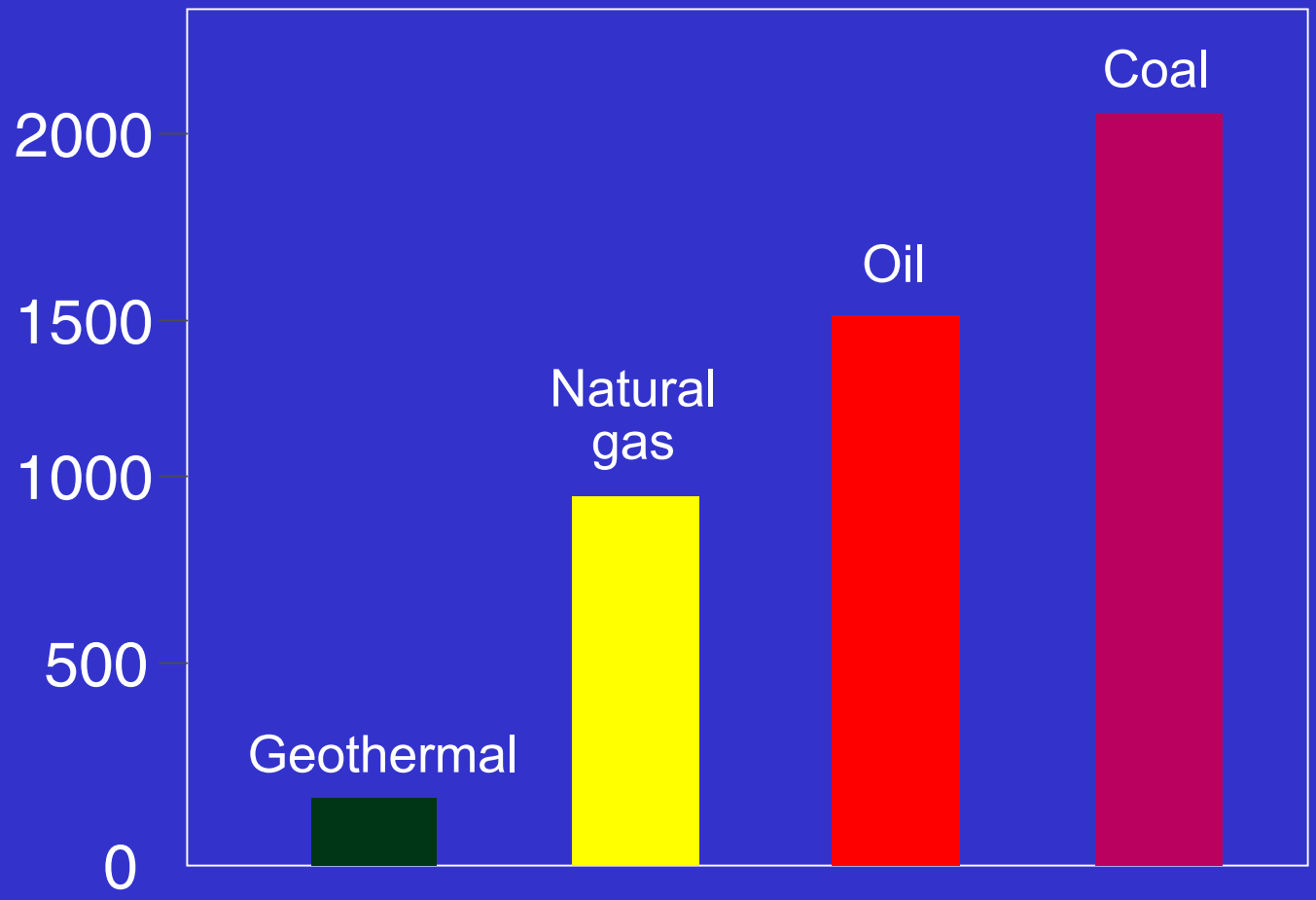
Large Project Sites

- Economies of scale
- Use of existing infrastructure and local workforce
- A few sites account for most of incremental potential
- Examples (at 90% probability):
  - Salton Sea – 1,000 MW incremental
  - Geysers – 200 MW incremental
  - Medicine Lake – 200 MW new power
  - Brawley area – 220 MW new power
  - Dixie Valley, NV – 120 MW incremental

Environmental Benefits of Geothermal Energy

- Sustainable resource
- Adds to resource diversity
- Indigenous – avoids fuel imports
- Relatively small area affected
- Low greenhouse gas emissions

CO_2 Emissions Comparison (lbs/MW-hr)



Source EIA 1998; Bloomfield and Moore 1999

Environmental Challenges

- Hydrogen sulfide (H_2S) emissions
- Solid waste disposal
  - Silica filter cake from Salton Sea
  - Sulfur from H_2S abatement
  - Hazardous scale containing sulfides, arsenic
- Pollutants in cooling tower drift (boron, etc.)
- Hydrocarbon releases
  - Losses of working fluid in binary plants
  - Injection of lube oil for downhole pumps
- Subsidence
- Seismicity

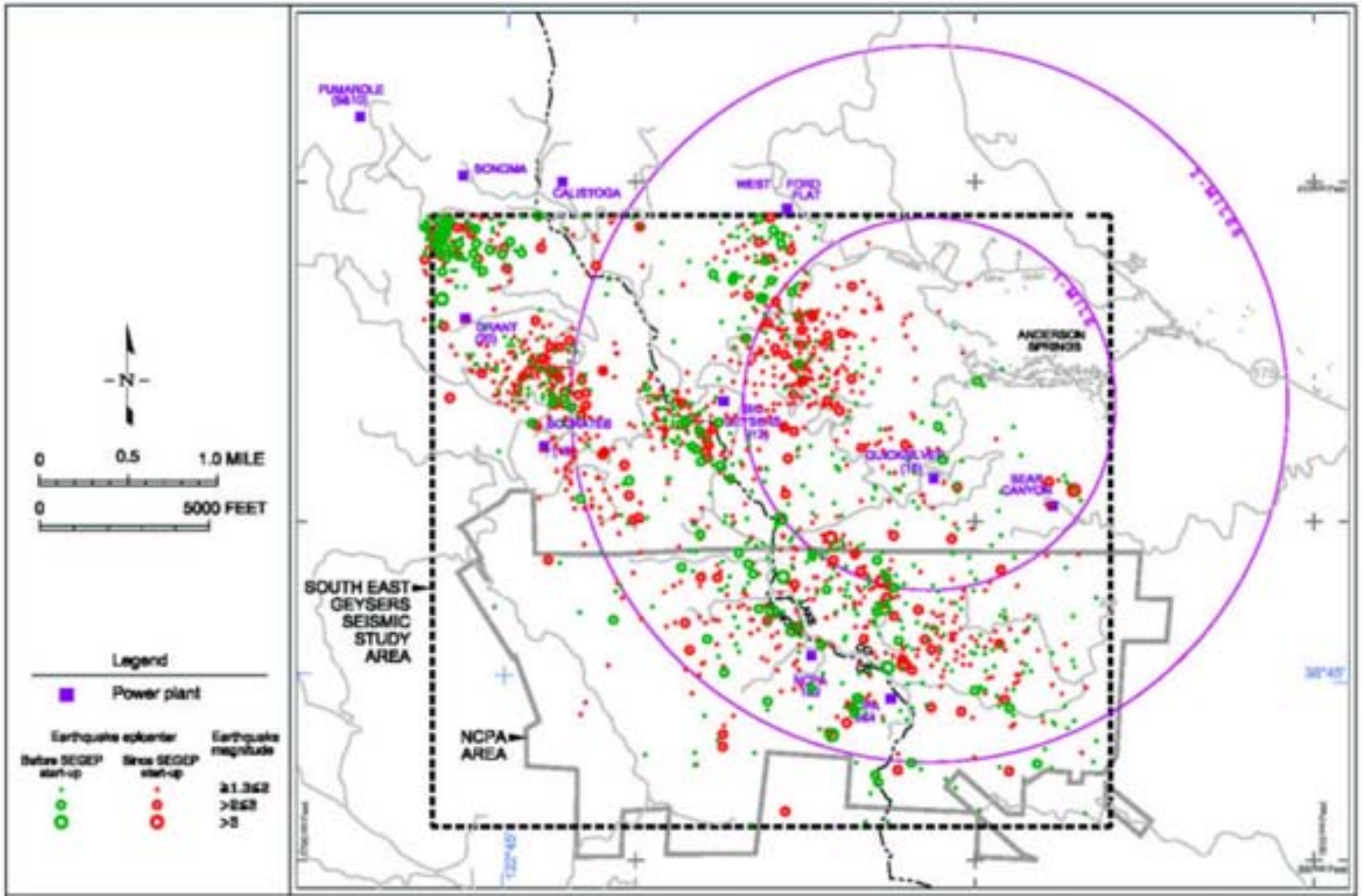


Figure 8: Earthquake epicenters, 9/1/93 through 8/31/01, SEGEP area

GeothermEx, Inc. GEOTHERMAL EXPLORATION DEVELOPMENT AND OPERATIONS Richmond CA USA WW@GEOTHERMEX.COM Tel. (510) 527-9876

Siting Issues

- Industrial presence in pristine areas
- Visibility (steam plumes and pipelines)
- Noise and light
  - Especially during drilling
- Endangered species
- Impacts on archaeological sites
- Effect on natural springs
- Cultural sensitivities
  - Native American lands

Hot Creek, near Mammoth Lakes, CA

Photo from Geothermal Education Office

Core Rig

Photo from Geothermal Education Office

Renewable Portfolio Standards

- Geothermal is eligible under Renewable Portfolio Standards (RPS) legislation
- California: SB 1078 (September 2002)
  - Utilities to increase total renewable energy sales by 1% annually until they reach 20%
  - Must be at 20% by 2017
- Nevada: SB 372 (PUC Order May 2002)
  - 5% of electrical sales to retail customers by 2003
  - Growing 2% biannually to 15% in 2013
- Federal RPS: under consideration

Development and Operational Issues - Summary

- Geothermal plants at remote sites can enhance voltage support
- Several large sites have potential for substantial increments in generating capacity
- Geothermal energy offers several environmental benefits, including low greenhouse gas emissions
- Environmental challenges can largely be mitigated with current technology
- Cultural sensitivities remain an issue at several sites
- Geothermal plants are eligible under requirements of RPS legislation

Workshop Outline

1. Nature of geothermal resources from a utility perspective
2. Development and operational issues
3. **Economics**
4. Emerging technology
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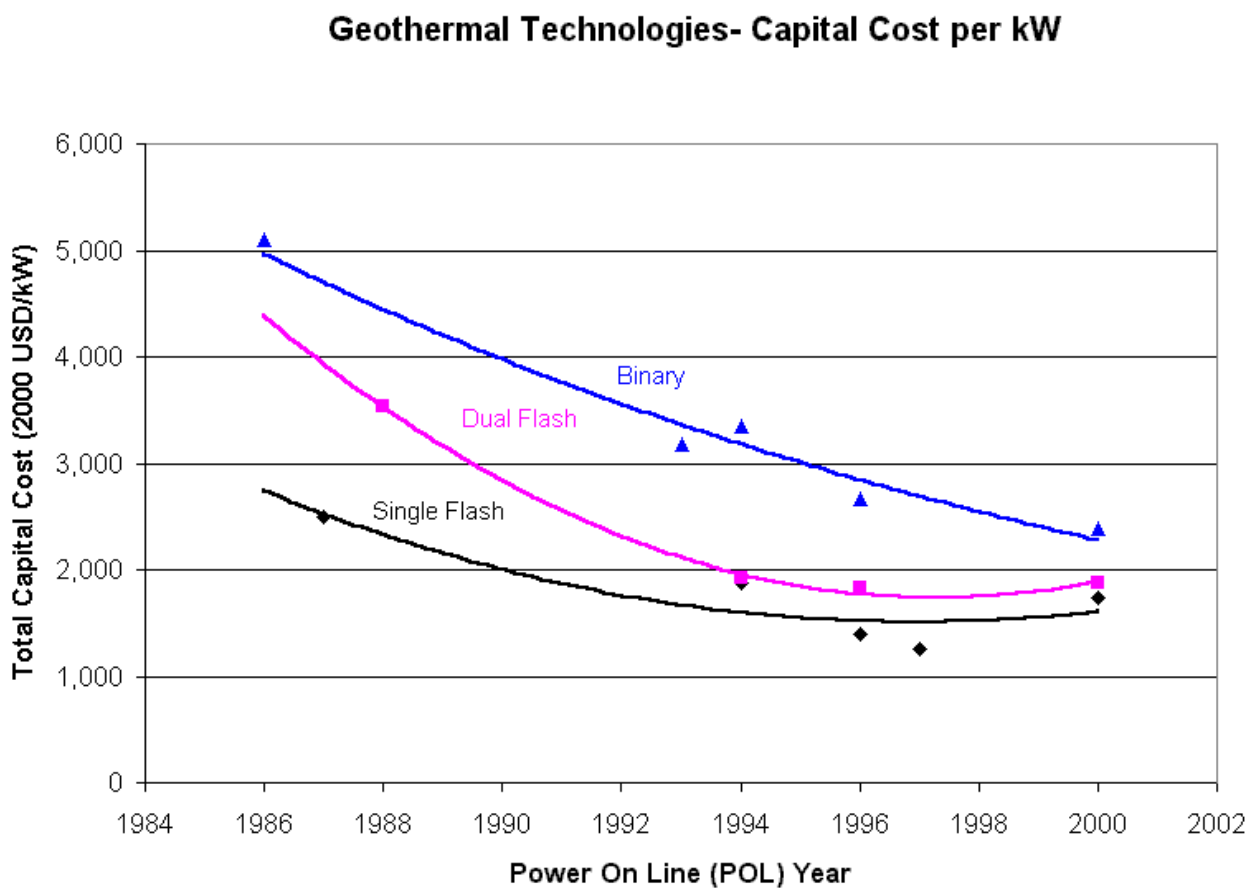
Economics

- Capital costs
- Make-up drilling
- Operation and maintenance (O&M) costs
- Cost of electricity
- Tax incentives
- Transmission issues

Capital Costs

- Wide range: $1,200 - $3,200 per kW installed
- Wellfield costs (exploration & drilling) are typically 30 – 40% of total
  - For many sites, exploratory drilling was done decades ago by earlier owners – full drilling cost not reflected in current economics
- Costs have declined significantly over the past 25 years
- Distinction between technologies not as great as before

Geothermal Capital Costs by Plant Type



Source: Entingh & McVeigh, 2003

Make-up Drilling

- Individual production and injection wells may decline in capacity over time
  - Production wells may be affected by declining reservoir pressures, cooler fluids, or mechanical blockage
  - Injection wells may plug off due to scale or entrained solids
- Remedial work with a drilling rig or coiled-tubing unit is called a “workover” and is treated as expense
- Drilling new wells (or re-drilling to a new downhole location from same wellhead) may be needed if workover is unsuccessful or infeasible
  - Treated as capital items
  - Typically several make-up wells during life of project

O&M Costs

- Again, a wide range: 1.2 – 2.8¢ / kWh
- Binary plants typically toward the upper end of the spectrum
  - But without binary technology, some resources would be unusable
- Public-domain information does not always segregate site costs, corporate overhead and interest costs
- Municipal utilities can derive some benefit by tax-exempt sources of financing

Cost of Electricity

- Bids in response to recent solicitations by US utilities have typically been in the range of 5.0¢ to 6.5¢ / kWh
- Several topics for negotiation:
  - Structure of energy vs capacity price
  - Value of base load vs load-following
  - Value of voltage support at remote sites

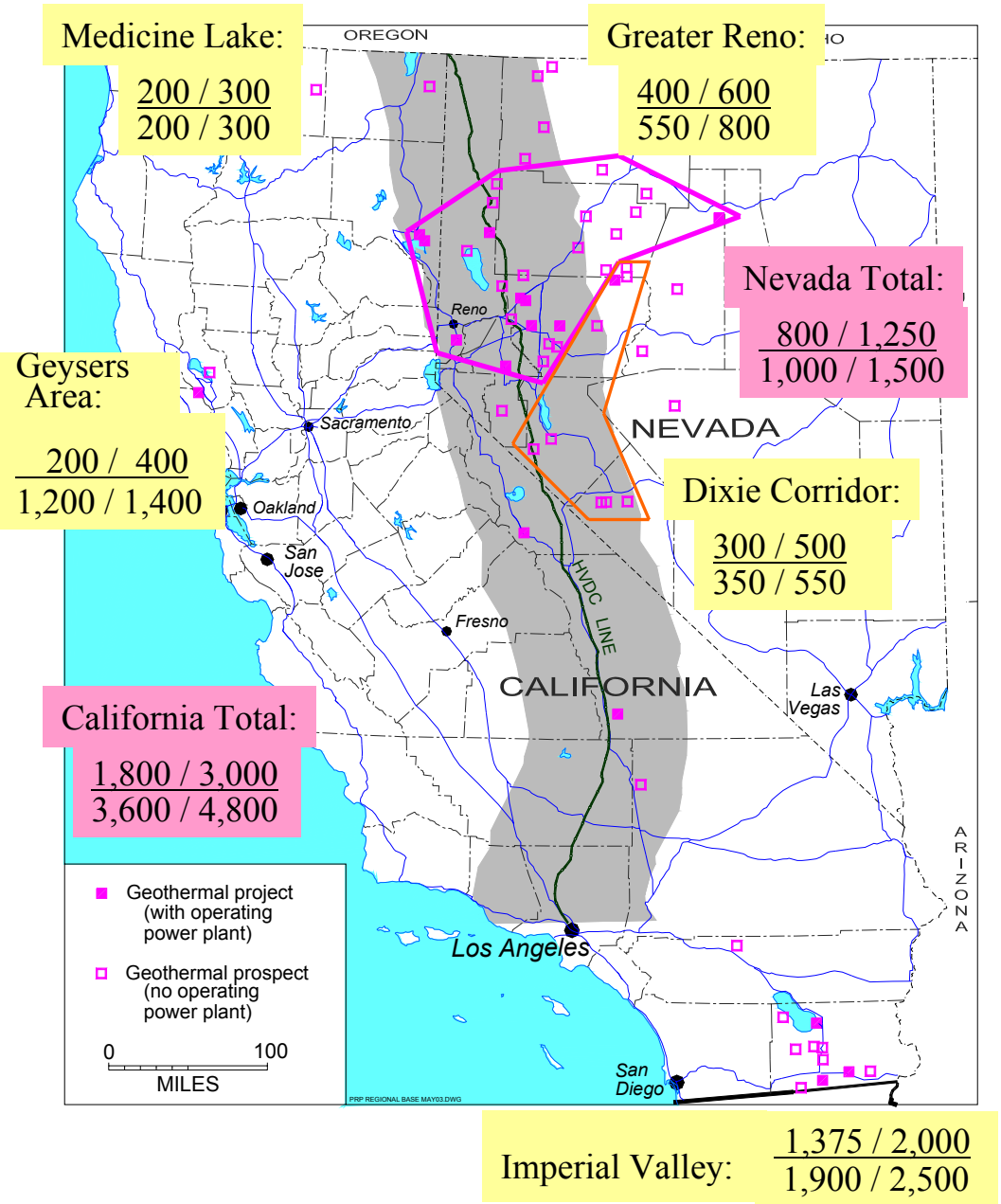
Tax Incentives

- 10% Investment Tax Credit presently available
- Energy Bill (not yet passed) contemplated:
  - Production Tax Credit (PTC) of 1.8 cents/kWh
  - PTC available for 5 years of production
  - PTC available for projects coming on line before 2007
- Other considerations:
  - PTC transferable? (tax-exempt to tax-liable entity)
  - PTC available on top of ITC? (not likely)
- All of this subject to change

Transmission Issues

- Cost of transmission lines has significant impact, especially on small, remote projects
- Existing plants often have some spare transmission capacity for expansion
  - But large expansions may require substantial upgrades
- Aggregation of small projects may achieve overall savings in transmission costs
  - Greater Reno
  - “Dixie Corridor” from central Nevada direct to California grid

Generating Capacities of Major Geothermal Resource Areas in California and Nevada (Gross MW)



LEGEND

Minimum Incremental	Most Likely Incremental
Minimum Total	Most Likely Total

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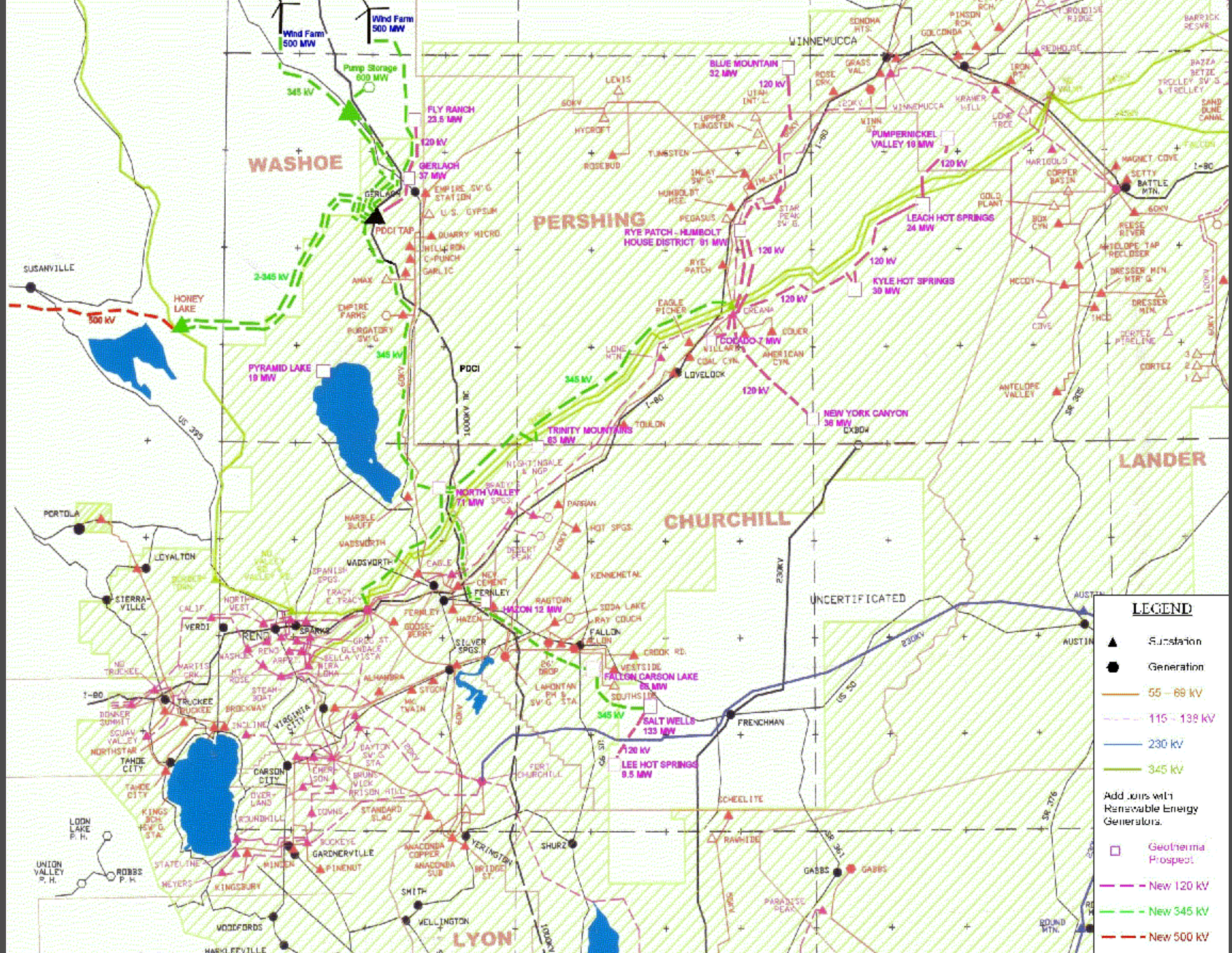
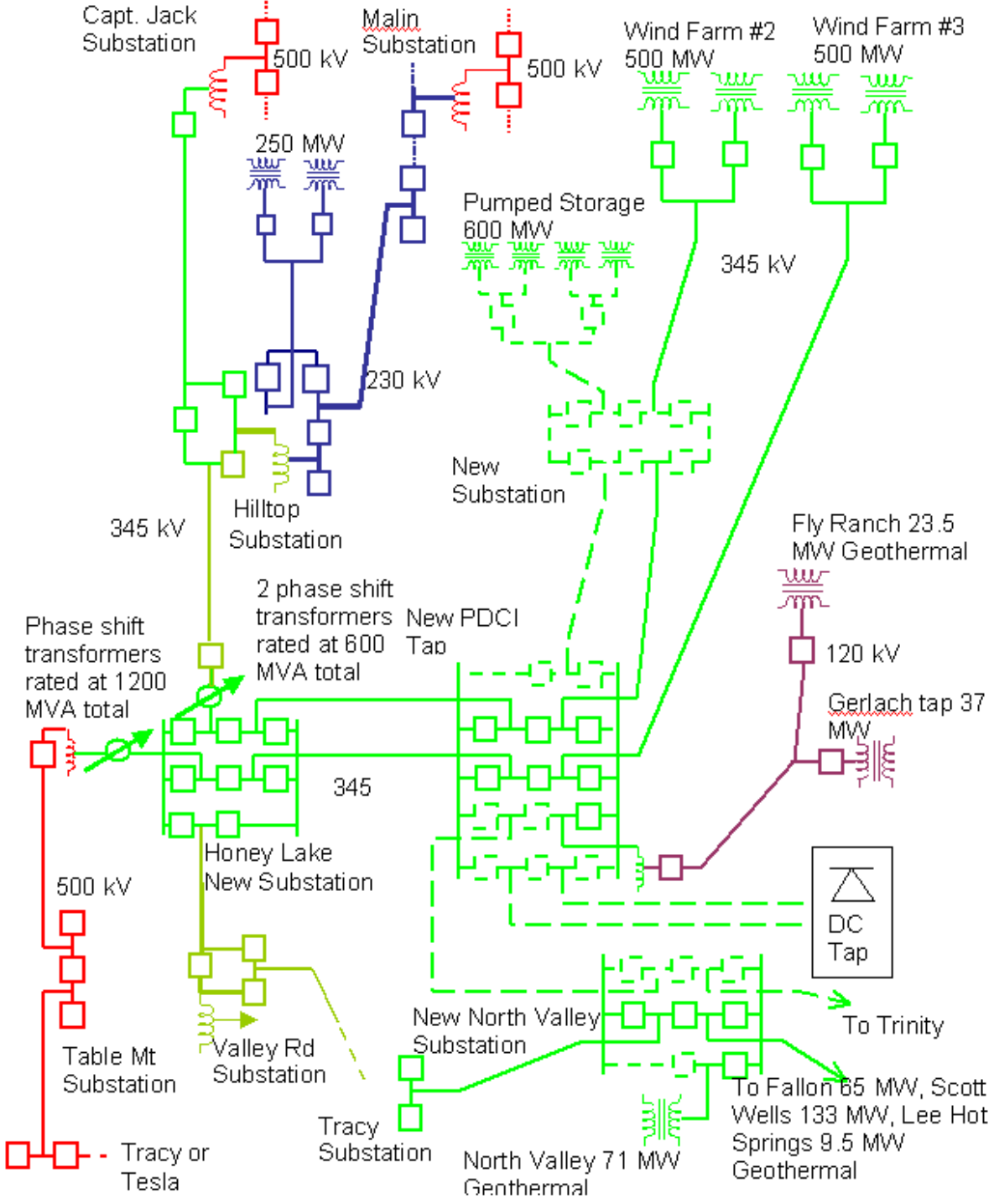
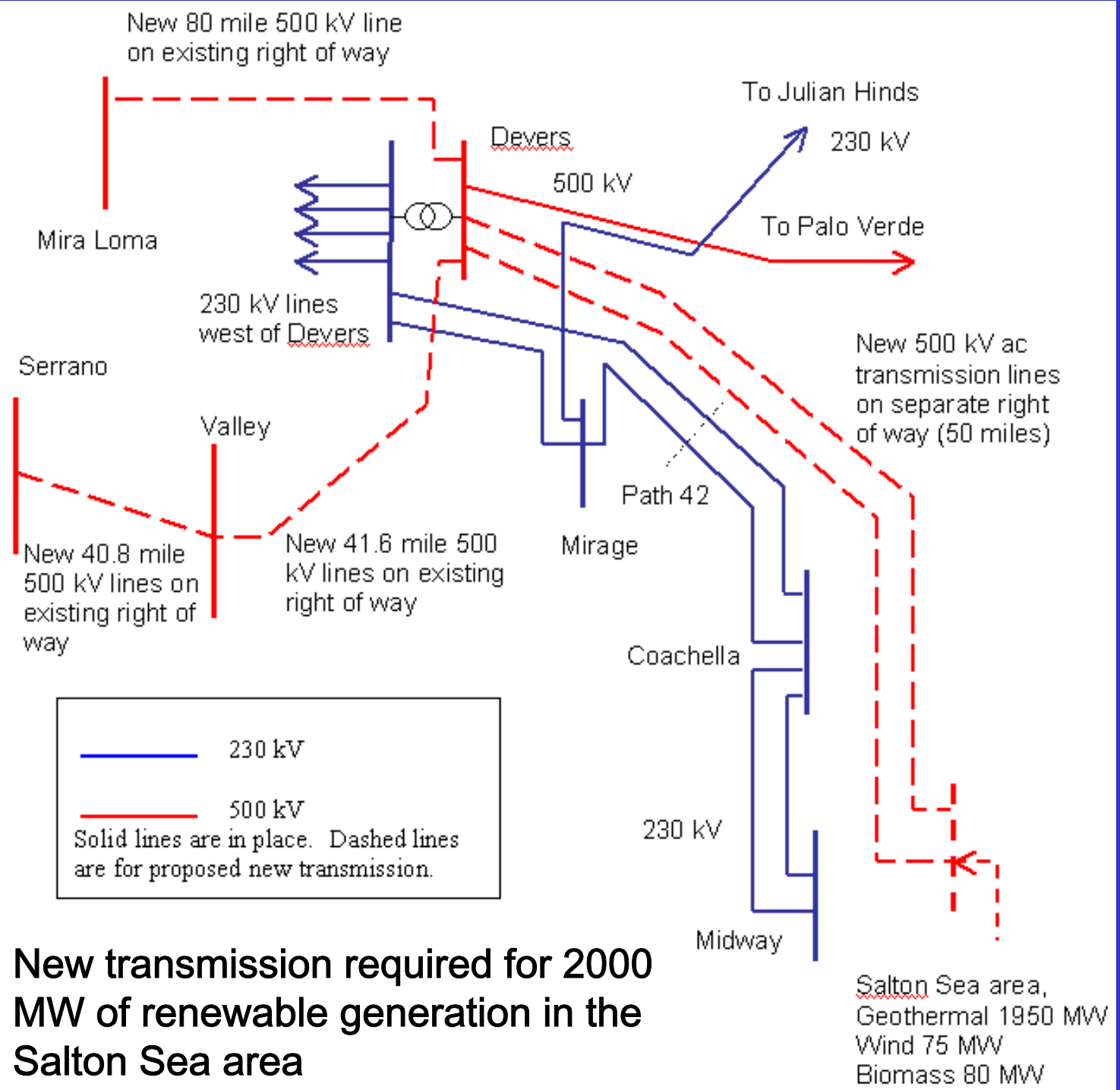

WASHOE
PERSHING
CHURCHILL
LANDER
LYON
UNCERTIFICATED
WINNEMUCCA
RENO
SPARKS
SUSANVILLE
PORTOLA
LOVELOCK
FALLON
FERNLEY
SILVER SPGS.
TRUCKEE
TAHOE CITY
CARSON CITY
GARDNERVILLE
MINDEN
YERINGTON
SHURZ
SMITH
WELLINGTON
WOODFORDS
GABBS
FRENCHMAN
AUSTIN
Wind Farm 500 MW
Wind Farm 500 MW
Pump Storage 600 MW
FLY RANCH 23.5 MW
GERLACH 37 MW
PYRAMID LAKE 19 MW
HONEY LAKE
TRINITY MOUNTAINS 63 MW
NORTH VALLEY 71 MW
HAZEN 12 MW
FALLON CARSON LAKE 85 MW
SALT WELLS 133 MW
LEE HOT SPRINGS 9.5 MW
BLUE MOUNTAIN 32 MW
PUMPERNICKEL VALLEY 19 MW
RYE PATCH - HUMBOLT HOUSE DISTRICT 91 MW
LEACH HOT SPRINGS 24 MW
KYLE HOT SPRINGS 30 MW
COCADO 7 MW
NEW YORK CANYON 36 MW
345 kV
500 kV
2-345 kV
120 kV
230 kV
1000kV DC
PDCI
PDCI TAP
I-80
US 395
US 50
LEGEND
Substation
Generation
55 – 69 kV
115 – 138 kV
230 kV
345 kV
Add lines with Renewable Energy Generators.
Geothermal Prospect
New 120 kV
New 345 kV
New 500 kV



Hypothetical tap to the PDCI in northwestern Nevada

ELECTRANIX



New transmission required for 2000 MW of renewable generation in the Salton Sea area

ELECTRANIX

Economics - Summary

- Capital costs in range of $1,200 to $3,200 per kW installed
  - Expansions are at lower end of spectrum due to existing infrastructure
- Operating costs in range of 1.2 – 2.8¢ / kWh, depending on conversion technology and resource characteristics
- Recent responses to utility solicitations in range of 5.0¢ to 6.5¢ / kWh
- Production Tax Credit (on the order of 1.8¢ / kWh) would have a significant impact

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Emerging Technology

- Minerals recovery
- Enhanced Geothermal Systems (EGS)
- Injection supplementation
- High-temperature, high-volume electric submersible pumps (ESPs)
- Binary cycles for lower-temperature resources
- Evaporative pre-cooling

Minerals Recovery

- Revenue from byproducts to lower effective cost of generating electricity
- Salton Sea zinc recovery
  - CalEnergy plant planned for 30,000 tons per year
  - Now up and running after a couple years of debugging
- Silica recovery
  - Testing by Brookhaven National Lab and Caithness at Steamboat Springs plant near Reno
  - Silica used as filler in rubber and polymer products, in desiccants, paints, and inks
  - Also used chromatography and pharmaceutical industry
  - Economic analysis suggests silica revenue could lower the effective cost of electricity by ½¢ / kWh

Enhanced Geothermal Systems

- Hydraulic stimulation of geothermal reservoirs with low permeability
- Successor to Hot Dry Rock program
- DOE-funded research currently underway at Coso (California) and Desert Peak (Nevada)
- Attempting to understand stress regime to optimize stimulation
- Goal is to demonstrate economic viability on margins of active fields, to get benefit from existing infrastructure

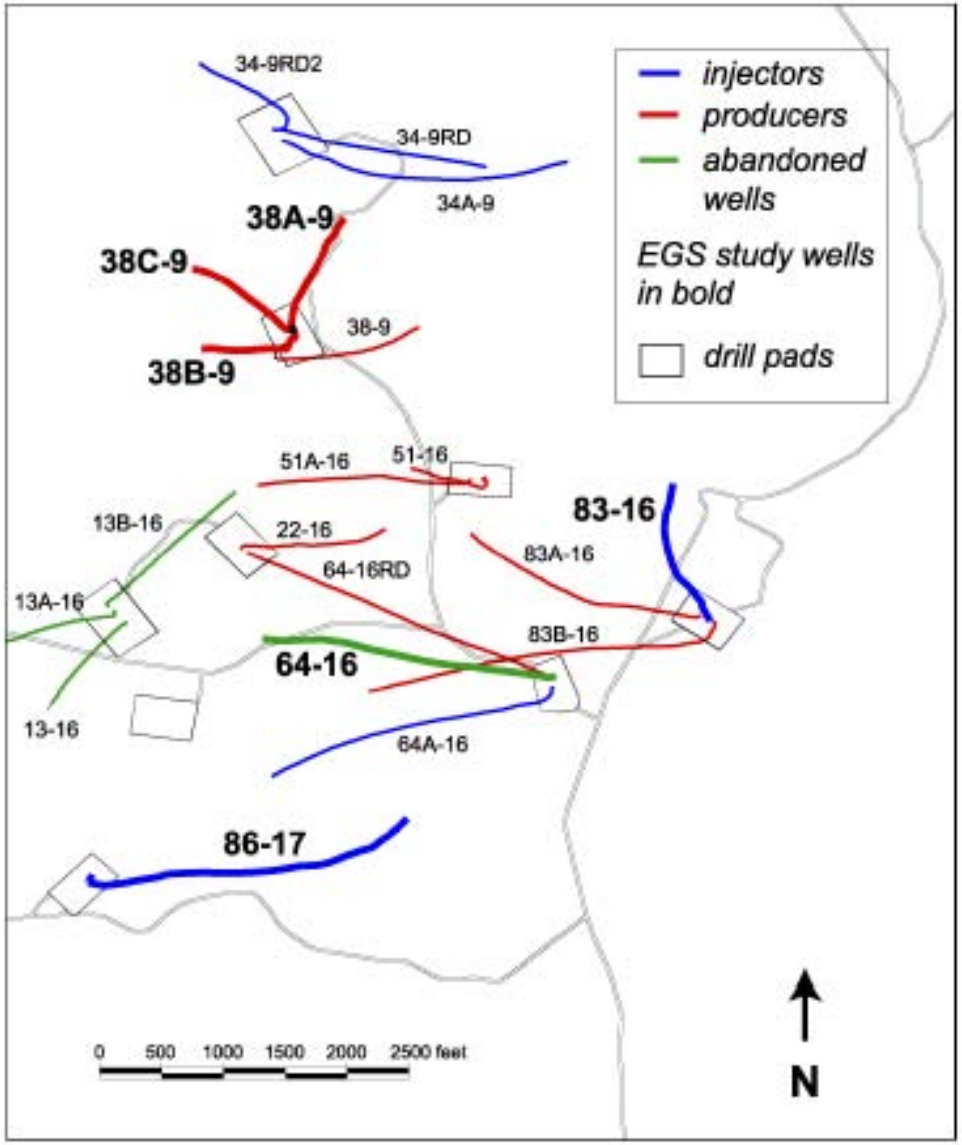


Figure 1. Locations and trajectories of wells within the east flank EGS study area of the Coso geothermal field.

Source: Rose et al, 2002

Injection Supplementation

- Maintenance of reservoir pressure by injection of water from non-geothermal sources
- Large-scale implementation at Geysers by injection of treated sewage effluent
  - Southeast Geysers Effluent Pipeline (SEGEP) started in 1997, injects 8 million gallons per day
  - Resulted in increment of about 70 MW above previously extrapolated decline trend
  - Injection of additional water from Santa Rosa has just started, projected to yield another 85 MW
- Caithness is using injection supplementation at Dixie Valley, and is considering use at Coso

Electric Submersible Pumps (ESPs)

- Current models operating at downhole temperatures above 360°F
- Production rates up to 3,600 gallons per minute
- Improvements over line-shaft pumps:
  - Higher flow rates
  - Can be installed in deviated wells
  - Eliminates injection of lubricating oil downhole
  - Less visible and less noisy than having motor at surface
- Challenge has been to increase run times and demonstrate long-term reliability

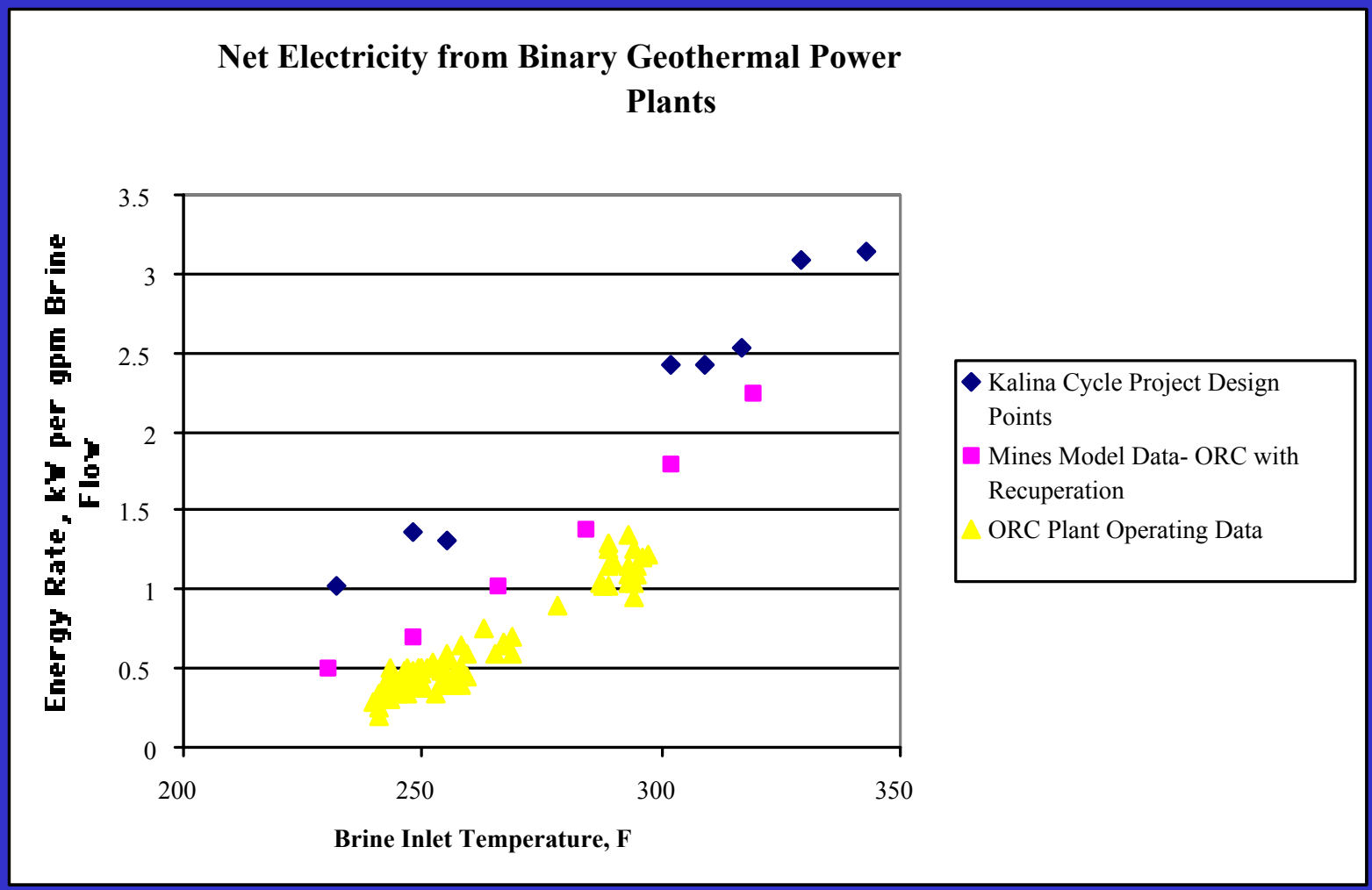
Binary Cycles for Lower-Temperature Resources

- Ammonia-water mixture as working fluid (Kalina Cycle)
  - Boils at variable temperature
  - Reportedly more efficient heat extraction
- Geothermal plant using Kalina Cycle at Husavik in Iceland
  - Started up July 2000
  - Performance test November 2001

Kalina Cycle Geothermal Plant, Husavik, Iceland

Recurrent Resources, LLC

Kalina vs. Organic Rankine Cycle



Recurrent Resources, LLC

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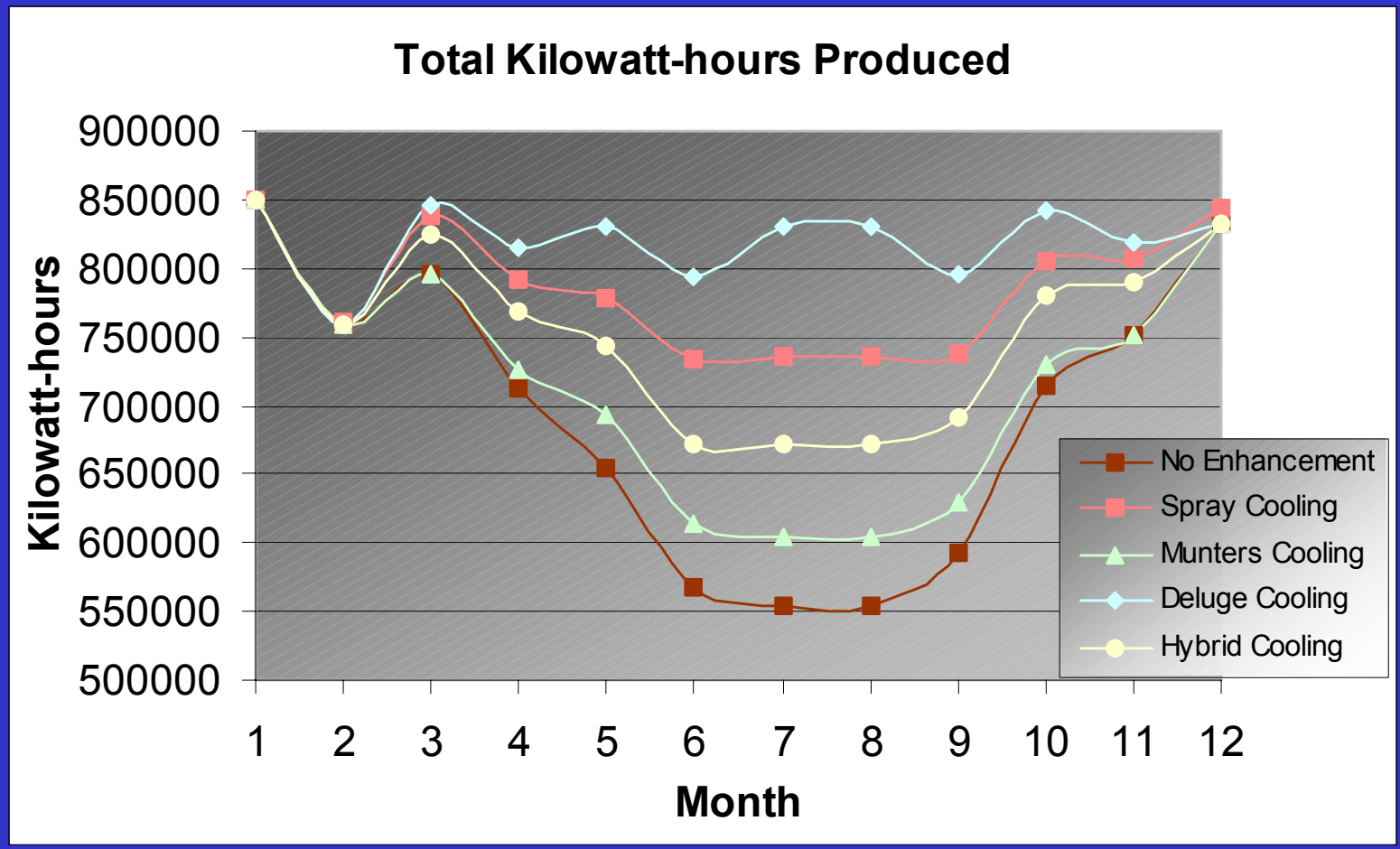
Evaporative Pre-Cooling

- Decreases the variation in output of air-cooled binary plants
- Various forms of evaporative cooling to cool air at inlet to air-cooled condensers

Empire Power Production with Evaporative Pre-cooling



Source: NREL

Emerging Technology - Summary

- Six technologies highlighted:
  - Minerals recovery – Zinc and silica
  - EGS on margin of existing fields
  - Injection supplementation to maintain reservoir pressure
  - Electric submersible pumps (ESPs)
  - Kalina Cycle – improving heat recovery from lower-temperature resources
  - Evaporative pre-cooling – improving efficiency of air-cooled binary plants

Workshop Outline

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Risks of Geothermal Power

- Oversizing plant capacity with respect to resource available
- Developers with insufficient capital to follow through
- Competing leaseholds on single resource
- Delays due to environmental or land-use constraints

Oversizing Plant Capacity

- Geysers is classic case
  - Approximately 2,000 MW of capacity installed by mid-1980s
  - Field never sustained output much above 1,500 MW
  - Several plants decommissioned, some never ran
- Industry now tends to be more conservative
- Most large projects develop in increments
  - Numerical simulation studies based on operating histories

Developers With Insufficient Capital to Follow Through

- Resource may be adequate, but may require more wells than planned
- Example: Rye Patch, Nevada
  - 12-MW binary facility almost completed
  - Only enough wells drilled to supply 6 MW
  - Resource appears capable of supporting the 12 MW and more, with sufficient dedicated acreage
- Can be mitigated by researching track record and financial backing of developer

Competing Leaseholds

- Geysers is again the classic case
  - Operators on opposite sides of lease lines did not share data or coordinate in field development
  - Contributing factor in the installation of more plant capacity than field could sustain
- Several fields have consolidated operation under one operator (or a small number that share information)
  - Geysers
  - East Mesa
  - Heber
  - Brady / Desert Peak

Delays Due to Environmental or Land-Use Constraints

- Medicine Lake example
  - Exploration wells drilled by Unocal in 1980s
  - Glass Mountain Federal Unit formed
  - Telephone Flat Project in area with productive wells was stopped by finding of Environmental Impact Assessment that Native American cultural sensitivities could not be mitigated
  - Environmental assessment process was reopened in recent years, and project now has approval to proceed – more than 20 years after first drilling

Risks - Summary

- Oversizing plant capacity, exacerbated by lack of coordination among offset operators, led to problems at the Geysers
- Industry and regulatory authorities are now more aware of need for coordinated development to ensure sustainable output
- Tendency of developers to be overly optimistic about prospects for success is still present, but can be tempered by power purchasers insisting on solid track record and strong financial backing
- Environmental approvals will always require some lead time, but there has been renewed commitment on part of government agencies to give fair weight to environmental benefits of geothermal

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Workshop Summary

- Geothermal energy is already competitive with conventional energy sources in some markets
- Renewable portfolio standards are stimulating renewed interest
- Updates of inventories of geothermal resources available are underway by CEC, USGS and others
- Geothermal deserves serious consideration as part of a portfolio electricity supply sources

For Further Information

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    - mw@geothermex.com
  - Ray Dracker, Center for Resource Solutions
    - **(415) 561-2135**
    - rdracker@resource-solutions.org
- Useful web sites:
  - Public Renewables Partnership
    - http://www.repartners.org/geothermal.htm
  - Geothermal Resources Council
    - http://www.geothermal.org
  - GeoPowering the West
    - http://www.eren.doe.gov/geopoweringthewest/

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13. SUPPLEMENTARY NOTES

14. ABSTRACT *(Maximum 200 Words)*

The federal government devotes significant resources to educating consumers and businesses about geothermal energy. Yet little evidence exists for defining the kinds of information needed by the various audiences with specialized needs. This paper presents the results of an evaluation of the Geothermal Municipal Utility Workshops that presented information on geothermal energy to utility resource planners at customer-owned utilities in California. The workshops were sponsored by the Western Area Power Administration and the U.S. Department of Energy's GeoPowering the West Program and were intended to qualitatively assess the information needs of municipal utilities relative to geothermal energy and get feedback for future workshops. The utility workshop participants found the geothermal workshops to be useful and effective for their purposes. An important insight from the workshops is that utilities need considerable lead-time to plan a geothermal project. They need to know whether it is better to own a project or to purchase geothermal electricity from another nonutility owner. California customer-owned utilities say they do not need to generate more electricity to meet demand, but they do need to provide more electricity from renewable resources to meet the requirements of the state's Renewable Portfolio Standard.

15. SUBJECT TERMS
Geothermal; Geothermal Municipal Utility Workshops; Western Area Power Administration; GeoPowering the West Program; utilities and geothermal power; utility resource planners; customer-owned utilities.

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