California Energy Commission

California Energy Commission's Geothermal Program: Development of Geothermal Energy in California

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California Energy Commission

The California Energy Commission (CEC) was created in 1974 by the California Legislature as the State's primary energy policy and planning agency under the Warren-Alquist Act.

The CEC has five major responsibilities:

- **Licensing thermal power plants 50 MW or larger**
- **Forecasting future energy needs and keeping historical energy data**
- **Promoting energy efficiency through appliance and building standards**
- **Planning and directing state responses to energy emergencies**
- **Developing and supporting research and development of renewable energy technologies. The Geothermal Program is just one of the several Programs for renewable energy research and development.**

CEC Renewable Energy Policy Drivers

The CEC's primary energy policy drivers are:

- **AB 32 Global Warming Solutions Act of 2006**
- **Energy Action Plan (EAP) 2003**
- **SB 107 Accelerated Renewables Portfolio Standard (RPS)**

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California's Electricity System Supply

California's electricity generation system generates more than 296,000 GWh/year.[1.]

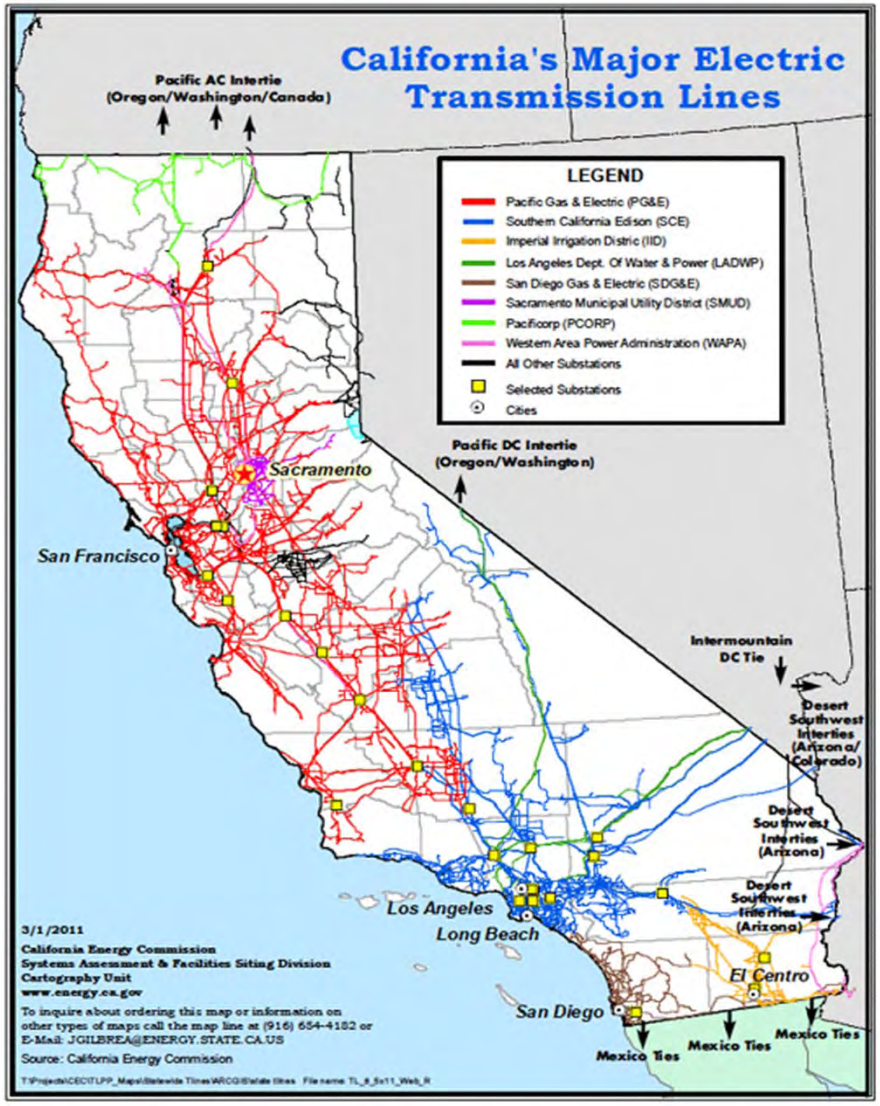
There are over 32,000 miles of transmission lines.

In 2009, California produced 69% of its electricity in-state.

Imported 7% from the Pacific Northwest, and 24% from the U.S. Southwest.

The installed capacity of the 1,008 in-state power plants totals

69,709 MW.

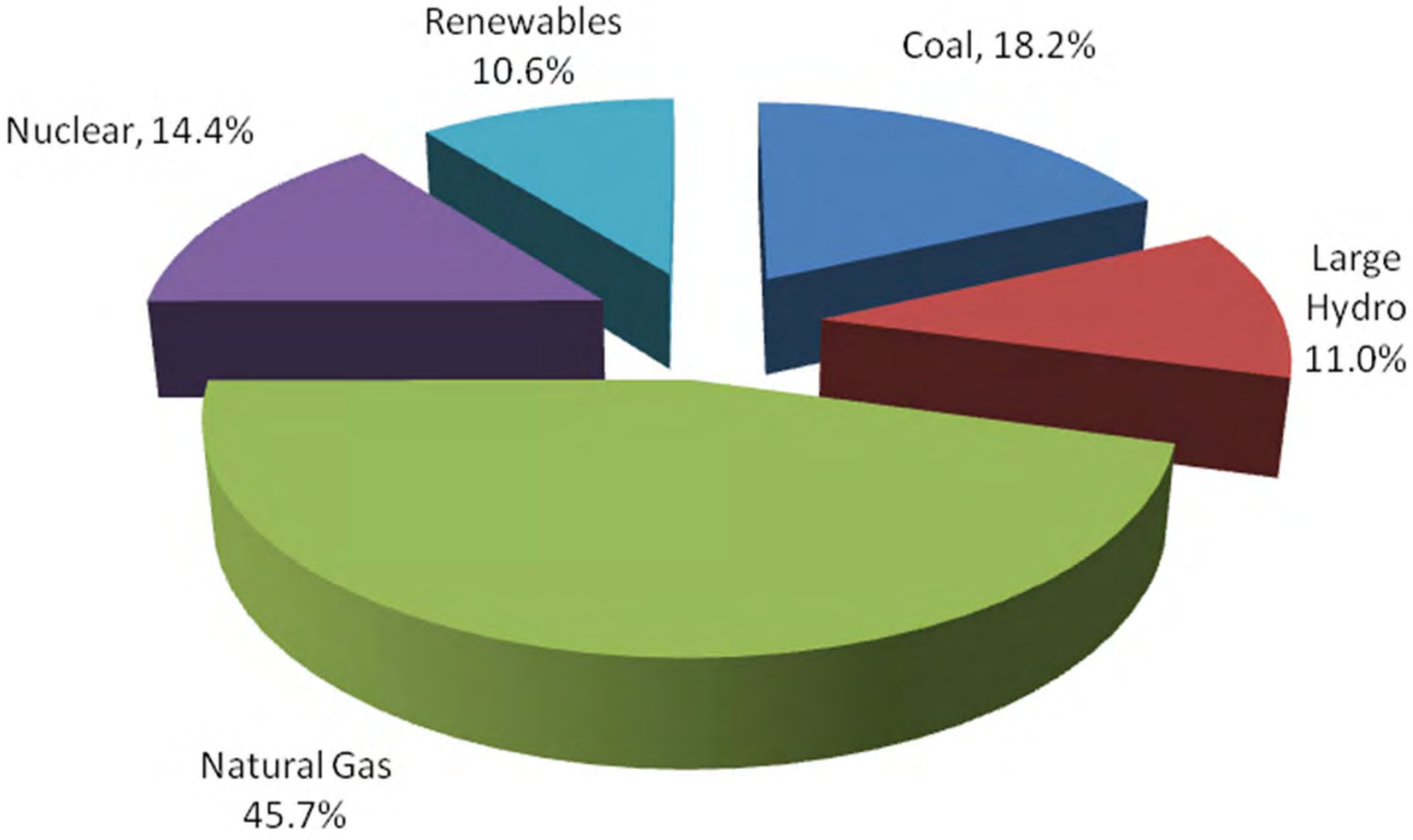


1. California Energy Commission, 2009 Integrated Energy Policy Report

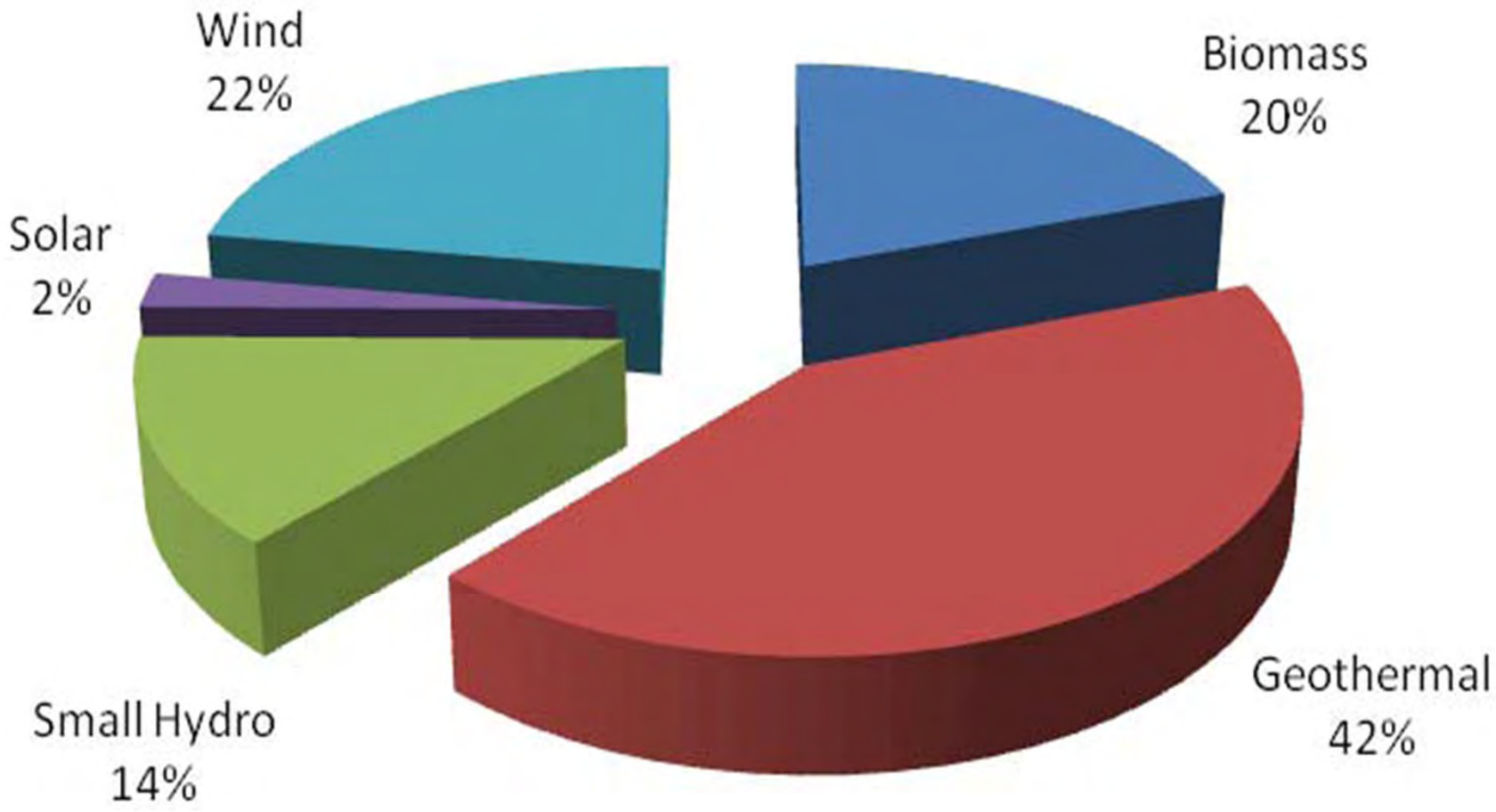
California's Electricity System Challenges

- **Insufficient generating capacity to accommodate projected future needs**
- **Transmission and distribution congestion especially in high-demand centers like Los Angeles, San Francisco, and Silicon Valley**
- **Lack of a diversified resource and generation supply system**
- **Aging infrastructure**

California's Electricity Supply



California's Renewable Electricity Supply



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Geothermal Generation in California

California has a very large geothermal resource base.[1.]

- **2,565 MWe installed capacity, 49 power plants**
- **30 power plants are under some stage of development, with the potential to increase installed capacity from 712 – 738 Mwe**

1. Geothermal Energy Association, Annual U.S,. Geothermal Power Production and Development Report, April 2011.

Geothermal Generation in California

- **California has developed over 60% of the U.S. geothermal projects delivering ~2,100 MW of baseload power**
- **High temperature geothermal resources are distributed throughout the state including:**
  - **The Geysers (1,250 MW)**
  - **Long Valley/Eastern Sierra (37 MW)**
  - **Coso (240 MW)**
  - **Imperial Valley (625 MW)**
- **Nearly 40 geothermal companies are based in California representing nearly 60 percent of the U.S. geothermal industry**

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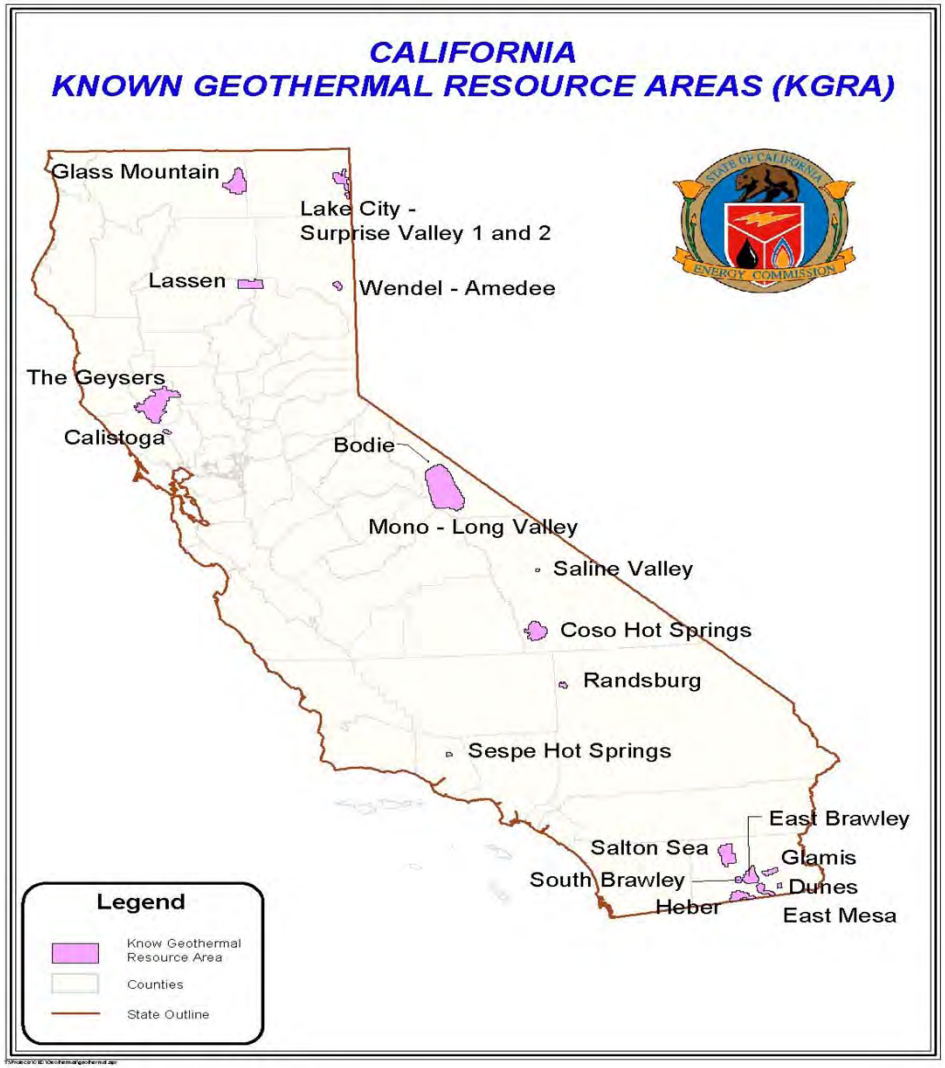
Geothermal Potential in California

- **Additional geothermal potential is estimated up to 4,600 MW [2].**
- **Undiscovered resources may provide an additional 3,200 to 25,000 MW [2].**
- **Many unknown or smaller resource areas currently unexploited**



Barriers to Geothermal Development

- Financing/capital costs
- Drilling costs
- Exploration costs
- Environmental permitting delays
- Lack of information – e.g. resource assessments
- Loss of incentives (production tax credits)
- Licensing requirements (power plants >50 MW)
- Supply shortages – e.g. competition with oil and gas companies for drilling rigs
- O and M costs
- Location of transmission or distribution systems are too far away, or non existent near geothermal resources

CEC's Geothermal Program

In 1980, the California Legislature established the CEC's Geothermal Program (AB 1905). It also created the Geothermal Resources Development Account (GRDA) as the source of funding to promote the development of new or existing geothermal resources and technologies. Funds for GRDA come from revenues paid to the U.S. government by geothermal developers for leases on federal land in California. Financial assistance is provided to private and public entities for geothermal research, development and commercialization projects.

Since 1980, the Geothermal Program provided funding for over 174 geothermal research, development, and demonstration projects.

CEC's Geothermal Program

Provides research funding for:

- **RD&D projects that reduce the life-cycle cost of geothermal electricity generation**
- **RD&D projects that reduce the uncertainty and cost of drilling, and enhancing geothermal reservoir systems**
- **Projects that mitigate the adverse impacts of geothermal development**
- **Projects that provide significant environmental enhancement**

Identifying Geothermal Research Issues

- **Research gaps and needs analysis:**

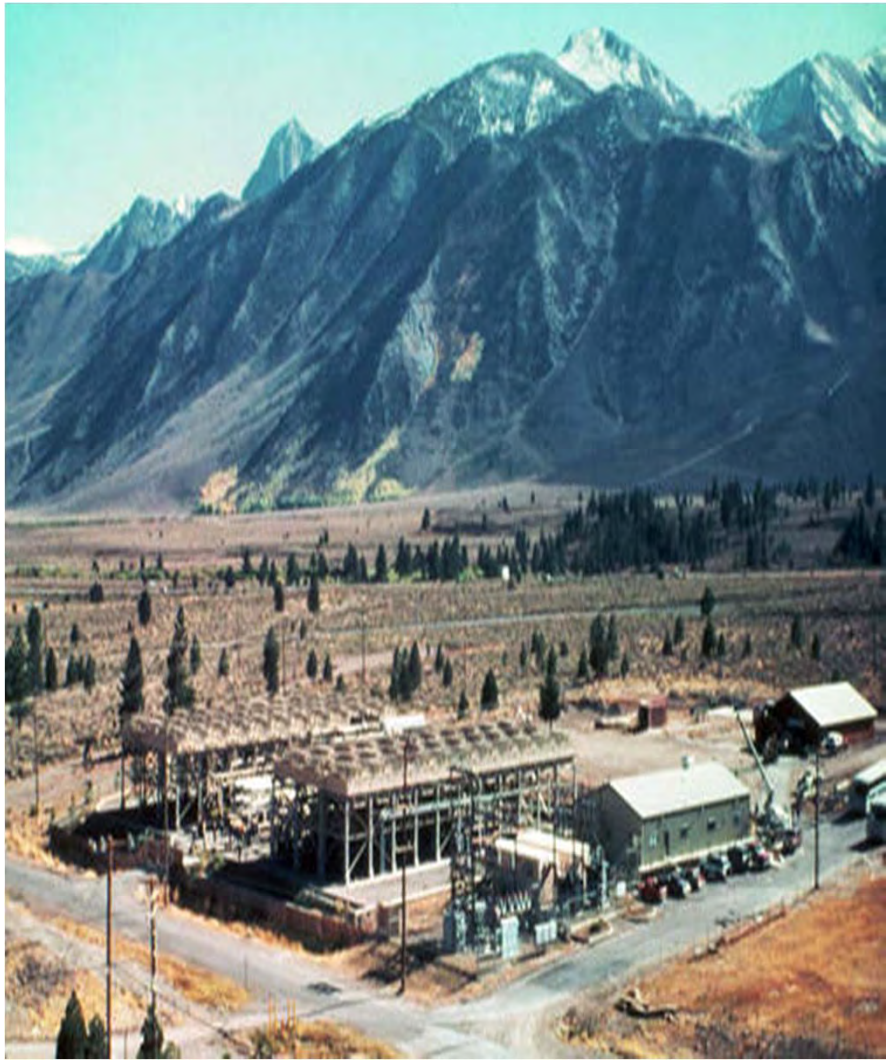
  What are the significant knowledge gaps and needs?

- **Market Issues:**

  Where are the opportunities to address barriers and promote geothermal development?

- **Policy issues:**

  Are California energy/environmental policy issues being addressed?



Geothermal Research

Resource Assessment:

- **Need for technologies to locate unknown high and moderate temperature resources, without surface expression**
- **Need to assess known areas in finer-grained detail for targeted exploration and well drilling**
- **Evaluation and analysis of co-located resources**
- **Improved environmental protection**
- **Advanced tools and techniques for exploration and resource assessment including remote sensing tools to reduce costs, risk, time**
- **Refined models and modeling tools for reservoir management**
- **Establishment of a publicly available, statewide, GIS resource database that can incorporate a diverse variety of geological and geophysical data**

Geothermal Research

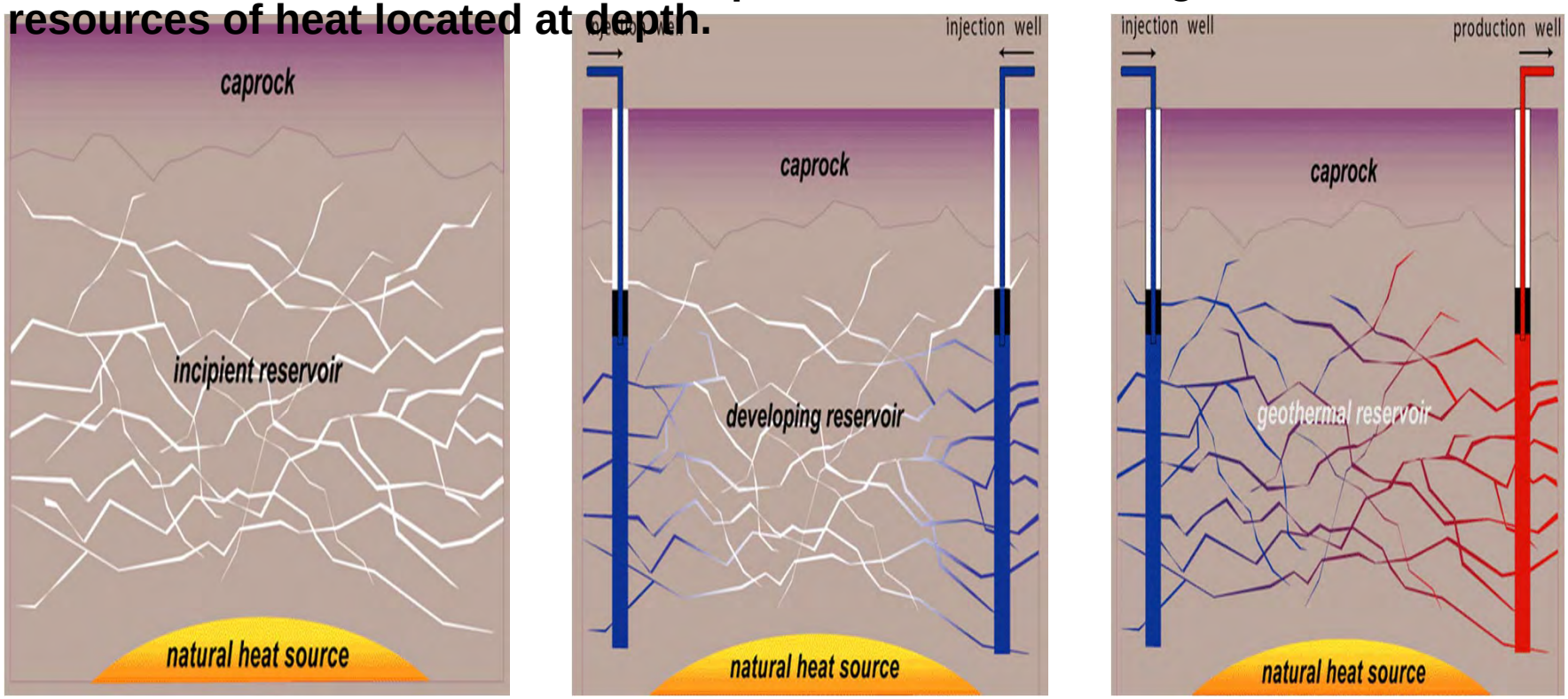
Technological Improvements:

- Adoption of tools and techniques from the oil and gas industry
- Advanced drilling bits
- Casing while drilling that enable reduced frequency of trips
- "Smart" tools needed for drilling and exploration – Logging While Drilling systems
- Under reamers to reduce mechanical failures of systems at high temperature in hard rock
- High efficiency binary plants for exploitation of lower temperature resources
- Reduce the number of casing strings required
- Leaner casing designs for well completions
- Innovative water use for wet-dry cooling
- New materials and methods for use in corrosive and high pressure brine environments
- Packer, tubular materials, valves or nonmechanical diverters
- Lost circulation materials that are drillable, retrievable, or degradable
- Components for high precision seismic, fluid flow, downhole pressure and monitoring
- Geothermometers and geochemical tools

Geothermal Research

Enhanced Geothermal Systems (EGS):

Engineered or enhanced reservoirs created to produce energy from geothermal resources that are otherwise not economical due to a lack of fluid and/or permeability. EGS can enhance existing geothermal systems and create new systems where appropriate thermal and geologic characteristics occur. EGS has the potential for accessing the Earth's vast resources of heat located at depth.



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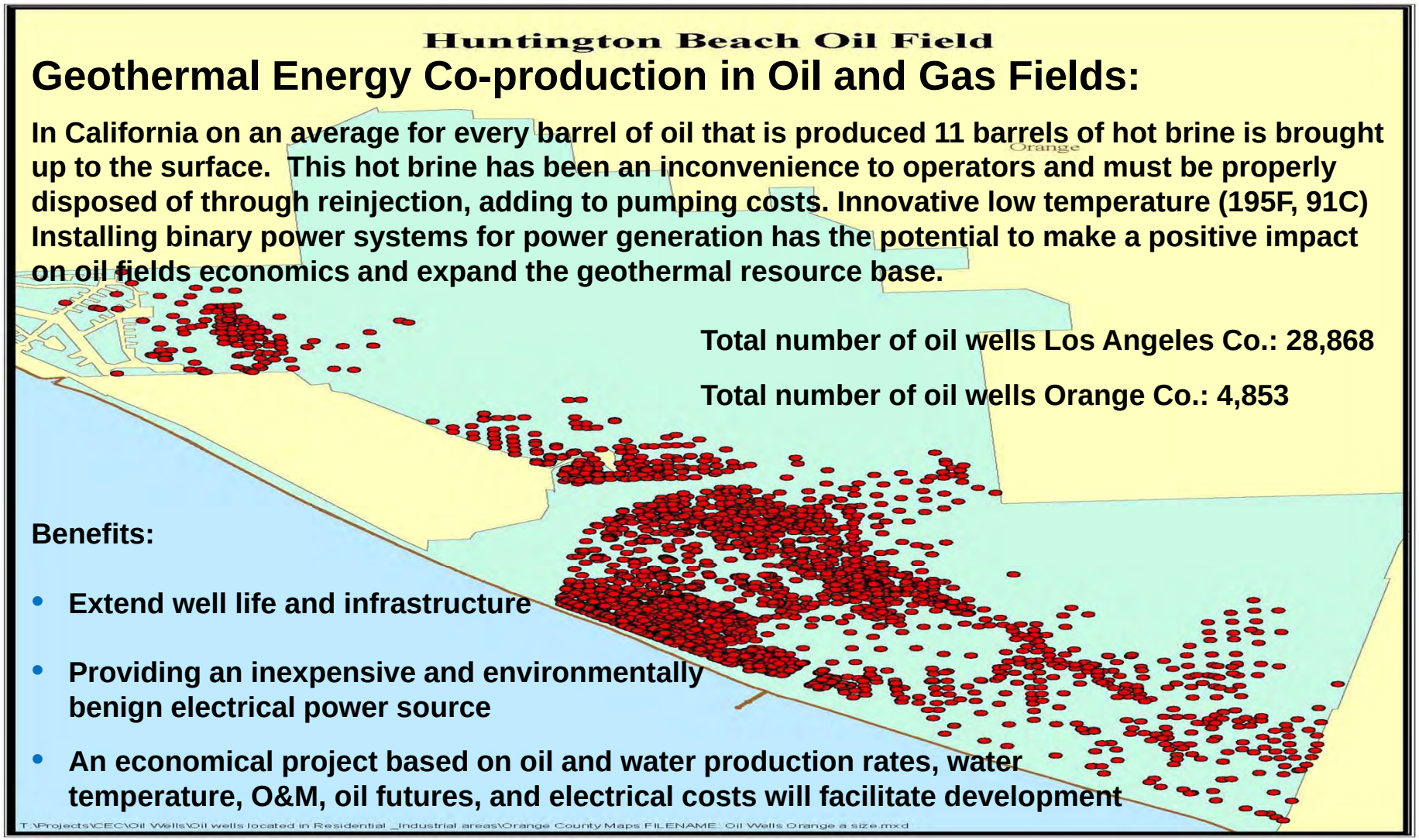
Geothermal Research



Geothermal Energy Co-production in Oil and Gas Fields:

In California on an average for every barrel of oil that is produced 11 barrels of hot brine is brought up to the surface. This hot brine has been an inconvenience to operators and must be properly disposed of through reinjection, adding to pumping costs. Innovative low temperature (195F, 91C) Installing binary power systems for power generation has the potential to make a positive impact on oil fields economics and expand the geothermal resource base.

Total number of oil wells Los Angeles Co.: 28,868

Total number of oil wells Orange Co.: 4,853

Benefits:

- **Extend well life and infrastructure**
- **Providing an inexpensive and environmentally benign electrical power source**
- **An economical project based on oil and water production rates, water temperature, O&M, oil futures, and electrical costs will facilitate development**

GRDA Research Funding

- **Practically all aspects of geothermal research, development, demonstration, planning and mitigation are eligible for funding**
- **GRDA funding is divided into three Project Categories:**

  1) Resource Development, 2) Planning, and 3) Mitigation
- **No limit on funding that can be requested per project, although allocation of GRDA funds to Project Categories may constrain the overall amount available in each Category**
- **Proposals are in rank order within each Project Category**
- **Proposals are ranked beginning with the 1st ranked of each Project Category**

GRDA Project Categories

- **Resource Development Projects: activities that assess, develop, and/or convert a geothermal resource for electrical generation**

- **Planning Projects: activities that regulate and/or guide the development and use of geothermal resources**

- **Mitigation Projects: activities that identify the adverse environmental impacts, and/or implement measures to reduce or eliminate those impacts due to geothermal development**

GRDA Project Categories - Resource Development

Resource development projects may include, but are not limited to:

- **Demonstration or commercialization of geothermal technologies**
- **Resource assessment, including geological, hydrological, geophysical, and geochemical studies**
- **Evaluation, drilling and testing of exploration, production and injection wells**
- **Electricity production**

GRDA Project Categories - Planning

Planning projects may include, but are not limited to, collection and analysis of environmental data.

- **Note: Activities related to data collection, for regulatory compliance, such as CEQA certification, EIRs, drilling or construction permits are ineligible for GRDA funding**

GRDA Project Categories - Mitigation

Mitigation projects may include, but are not limited to:

- **Identification and control of adverse impacts to water, air, wildlife, vegetation, viewshed, ground surface levels, and ambient noise levels**
- **Environmental enhancement**
- **Identification of social and economic impacts of geothermal development**

GRDA Eligibility

- **Private entities include individuals and private for-profit organizations**
- **Local jurisdictions include cities, counties, school districts, and special districts, regional planning agencies and public utility districts**
  - **Exception: Any public utility that generates more than 50MW of electricity for sale is not eligible to apply for GRDA funding as the primary applicant**
- **Universities, national laboratories, and not-for-profit organizations may be eligible for funding only in partnership with a local jurisdiction or private for-profit entity**

GRDA Match Funding Requirements

Private for-Profit Entities: Match share of at least 50% of the total project cost

Local Jurisdictions: Match share must be at least 20% of the total project cost

- **Exception: Local Jurisdictions located in a county that has received County-of-Origin funds from GRDA > $50,000 in each of the previous three years must provide a Match Share of at least 50% of the total project cost**

GRDA Proposal Evaluation

- **Proposals will be evaluated and scored on the basis of the information submitted in the administrative, budget and technical sections**
- **Proposals should provide clear, logical and concise project description, work statement and budget**
- **Proposals should identify economic and technical goals**
- **Proposals should provide mass balance and energy balance analysis and diagrams, or similar schematics to describe methodologies or technologies**
- **Proposals should provide references to past related work and results obtained from previous studies, research, etc.**
- **Proposals should disclose participation in previous CEC or Department of Energy funded projects**

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GRDA - SCORING CRITERIA

RESOURCE DEVELOPMENT PROJECTS – Passing Score for all categories: 80 points

Criteria	Possible Pts.
Econ. and Employment Benefits	15
Demonstration Value	15
Payback and Cost Effectiveness	15
Resource	15
Likelihood of Success	15
Match Contribution	15
Overriding Issues	30

MITIGATION PROJECTS

Criteria	Possible Pts.
Documented Impact	15
Demonstrated Need	15
Alt. to Mitigate the Impact	15
Timeliness	15
Likelihood of Success	15
Overriding Issues	30

PLANNING PROJECTS

Criteria	Possible Pts.
Demonstrated Need	15
Stimulation of Geo. Energy Dev.	15
Proven Extent of the Resource	15
Implementation	15
Public Involvement	15
Match Contribution	15
Overriding Issues	30

Geothermal Program 2011 Grant Awards

- **Imageair, Inc., Surface Deformation Baseline in Imperial Valley from Satellite Radar Interferometry, $672,234**
- **Layman Energy Associates, Inc, Exploratory Well to Confirm Liquid-Dominated Hydrothermal Resource on Margin of The Geysers Steamfield, $2,377,364**
- **Renovitas LLC, Exploration Drilling and Assessment of Wilbur Hot Springs, $1,492,722**
- **Simbol, Inc., Potassium Production from Geothermal brines, $949,545**

Project Title: Geothermal Tubular Expandables Technologies
Grantee: Geothermal Expandables Inc.
Project Amount: $890,950

Abstract: Demonstrate cost reductions and technical performance improvements geothermal development by using the new tubular technology in wells, pipelines, and production systems. Major improvements for difficult production conditions is the more effective and efficient use of the advanced alloy properties required by aggressive chemical and abrasive environments. Refinement of the technology will ultimately result in development of higher performing wells, increased hardware longevity downhole, enhanced brine treatment to lower corrosiveness, lowered operating costs, and accelerated development of resources.

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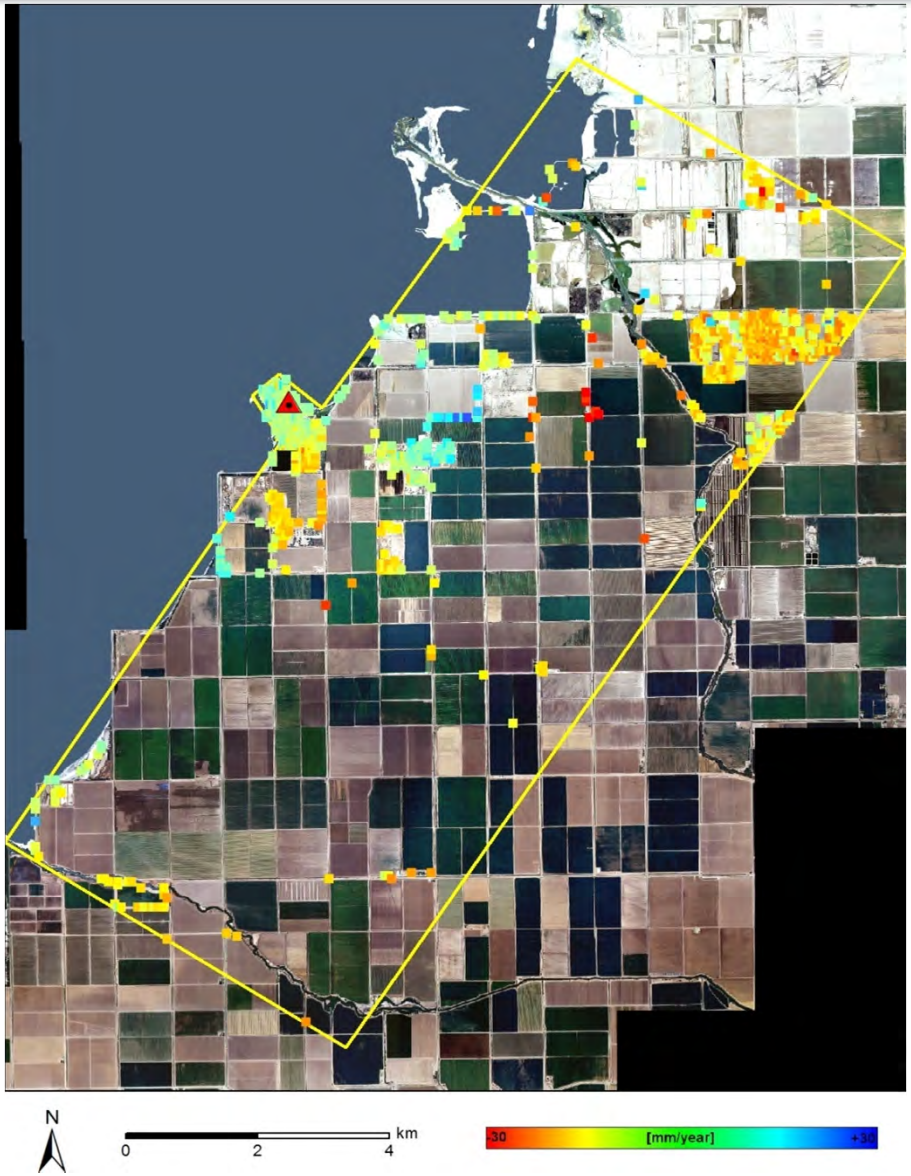
Project Title: Application of Permanent Scatter Synthetic Aperature Radar (PS InSAR) for the Detection of Surface Deformation in the Salton Sea Geothermal Field, Imperial Valley, CA

Grantee: Imageair, Inc.

Project Amount: $292,725

Abstract: This project demonstrated the use of PSInSAR for the detection of surface deformation associated with injection and production from geothermal operations. Ground-based leveling surveys were used to verify land subsidence. Regional GPS measurements were used to infer extensional tectonic movements, with significantly larger horizontal than vertical components. Increase of geothermal activities in will result in greater surface subsidence.



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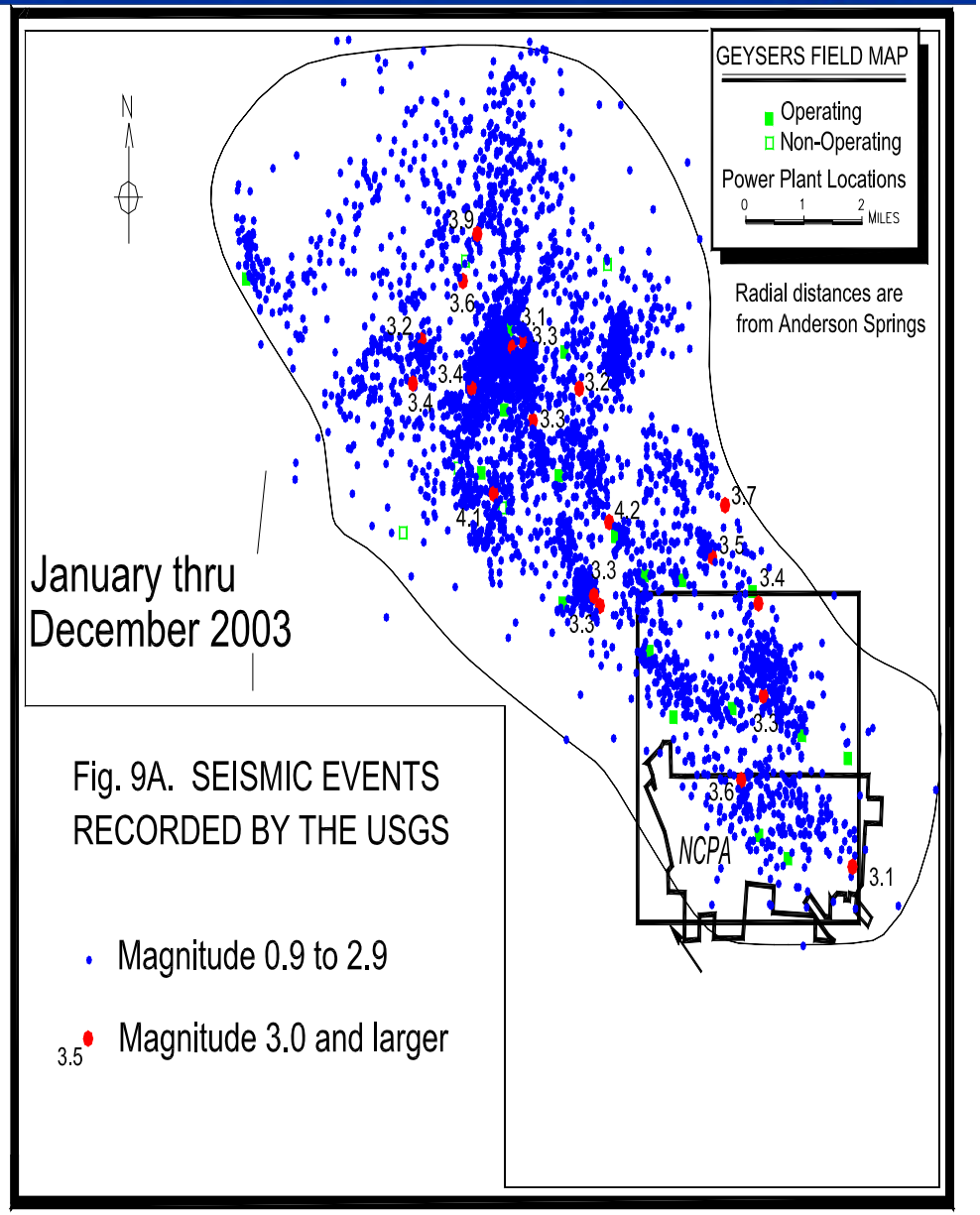
Project Title: Integrated High-Resolution Micro Earthquake Analysis and Monitoring for Optimizing Steam Production at The Geysers Geothermal Field, California

Grantee: Northern California Power Agency/Ernest Orlando Lawrence Berkeley National Laboratory

Project Amount: $600,000

Abstract: The purpose of this project was to develop and apply high resolution micro earthquake (MEQ) methodology for the entire Geysers geothermal field, in order to produce an effective monitoring and process definition methodology that will be capable of providing detailed records, for MEQ occurrences induced by injection of large volumes of water via the Santa Rosa wastewater project. The detailed analysis provided some assurance to the local residential and environmental community that the induced seismicity is documented and understood such that if necessary, timely mitigation actions can be undertaken, and that there would be no hazard associated with the increased rate and volume of injection.



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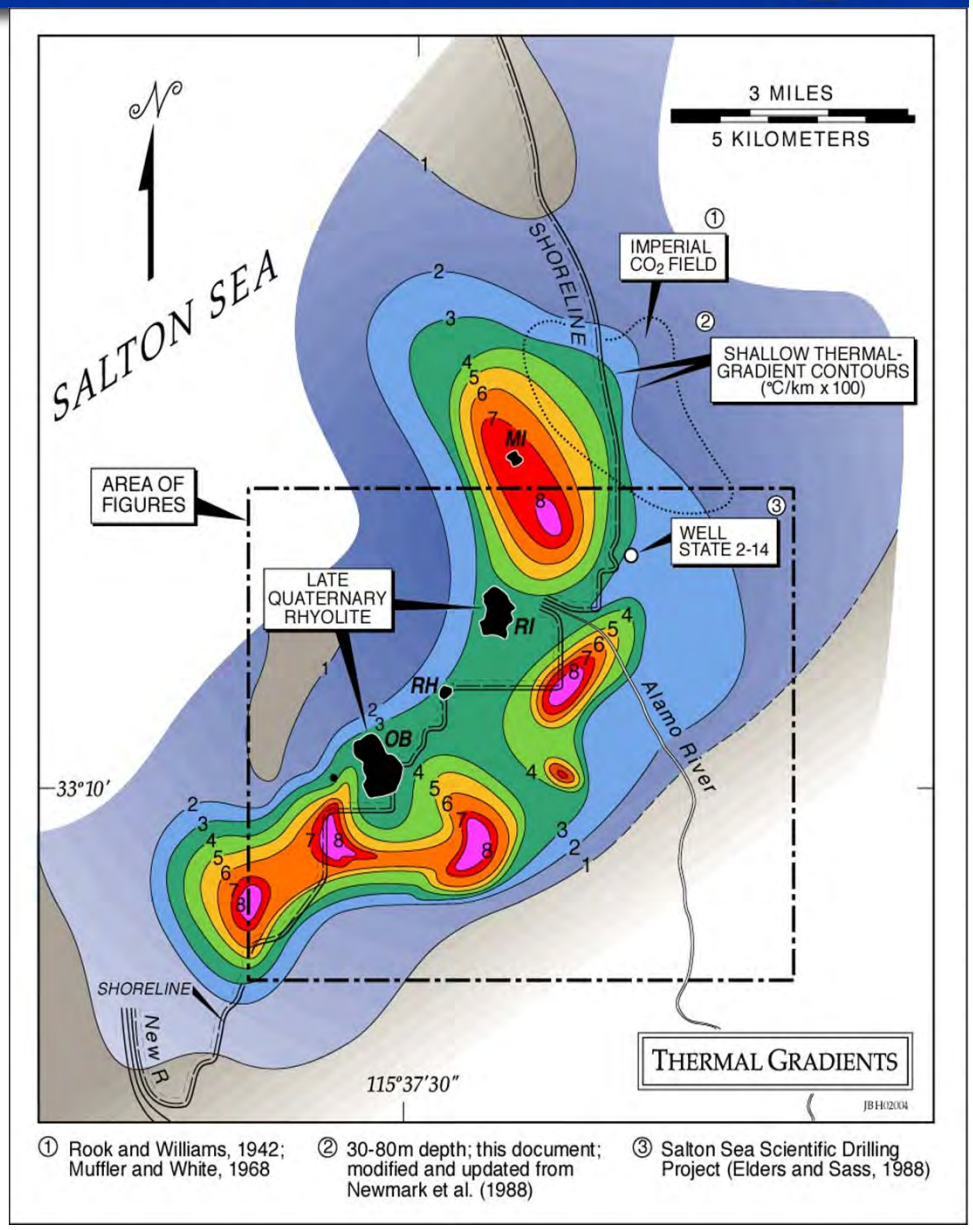
Project Title: Geothermal Exploration under the Salton Sea using Marine Magnetotellurics

Grantee: Schlumberger, Electromagnetic Instruments, Inc. (EMI),

Project Amount: $391,465

Abstract: This project addressed the issue of geothermal exploration offshore at the Salton Sea geothermal field using marine magetotellurics technology. EMI developed an ocean bottom deployable MT system that has been used for oil exploration. This project consisted of three phases. Phase one was survey design, planning and simulation. In phase 2 was a full survey of 50 marine and 30 land based stations. The final stage consisted of data processing and interpretation. EMI and CalEnergy produced data interpretations that were consistent with the existing geological and reservoir models.



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Project Title: Horizontal Injection Well to Enhance Geothermal Production at The Geysers

Grantee: Northern California Power Authority

Project Amount: $1,594,439

Abstract: A Dual Horizontally Completed Injection Well was drilled to a depth of about 8,000 feet at The Geysers geothermal field in northern California. The purpose of this technologically challenging project was to develop and demonstrate a substantially more effective means to inject and distribute an increasing supply of wastewater so that additional injection-derived-steam is recovered. The increased steam production will result in an increased amount of electricity being generated from the nearby existing power plants for distribution to the customers of public power in California.

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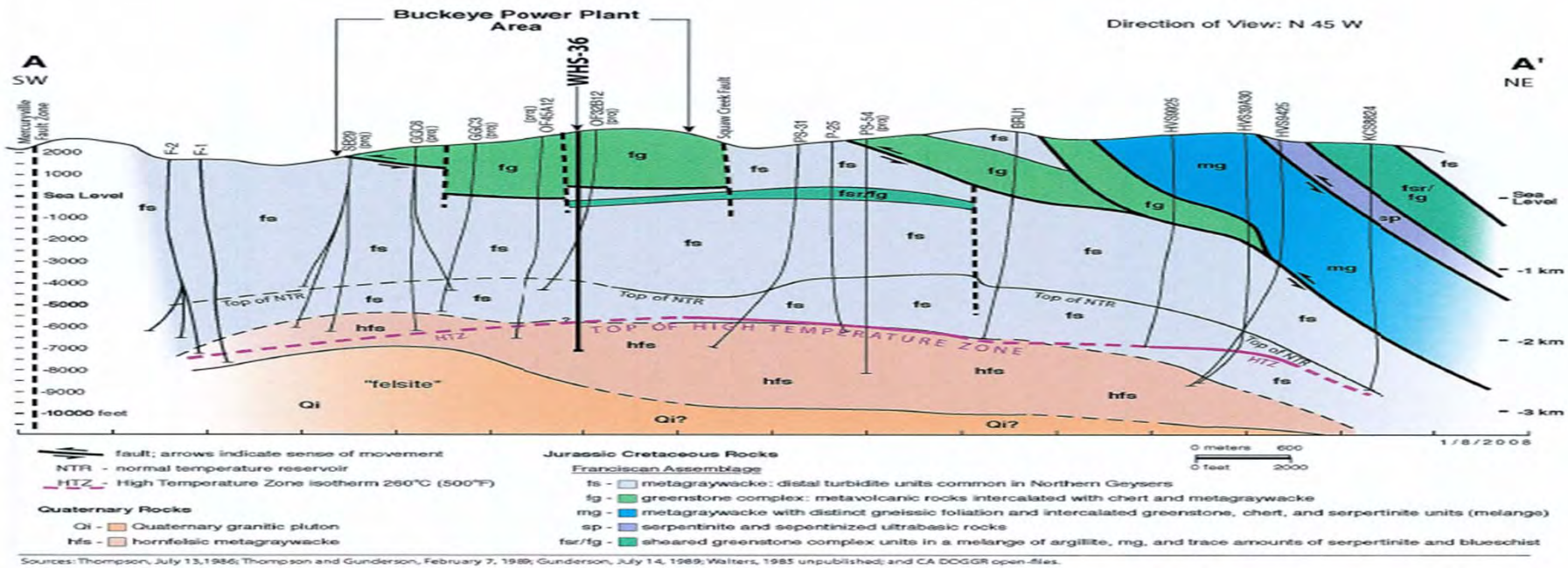
Project Title: Wildhorse State (WHS-36) Confirmation Well: Demonstrate structurally-isolated reservoir "compartment" of The Geysers steam field

Grantee: Calpine

Project Amount: $1,750,000

Abstract: A 1000-acre area beneath Ottoboni Ridge in the NW Geysers has been delineated through preliminary exploration work as a promising geothermal reservoir. Calpine proposes to build a new 25 MW power plant if an economically viable resource can be confirmed. This project drilled and tested the WHS-36 well, one of two wells needed to confirm the reservoir. Infrastructure costs for WH-36 were borne by Calpine; an injection water distribution pipeline supplied by the Santa Rosa Geysers Recharge Pipeline Project already crosses the proposed power plant area and has the capacity to recharge the reservoir. Drilling and testing results of the WHS-36 will be made publicly available and will provide additional information for the development of the area surrounding the proposed plant.



Benefits

- Energy Independence: improves energy security
- Environmentally friendly: renewable and CO2 and NOx emissions reductions
- More on-site distributed generation: baseload power
- Modular technology allows for incremental development, rapid deployment
- Small power plant footprint and less environmental impact
- Government mandates green power and tax incentives
- Reduced exploration costs
- Development of an under utilized renewable energy source
- Reduction in electrical system congestion, and increased electrical system reliability
- Delayed construction of additional transmission and subsequent environmental impacts
- Creation of green jobs

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Questions?

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Geothermal Energy Co-Production from LA Basin Oil and Gas Fields Study 2010

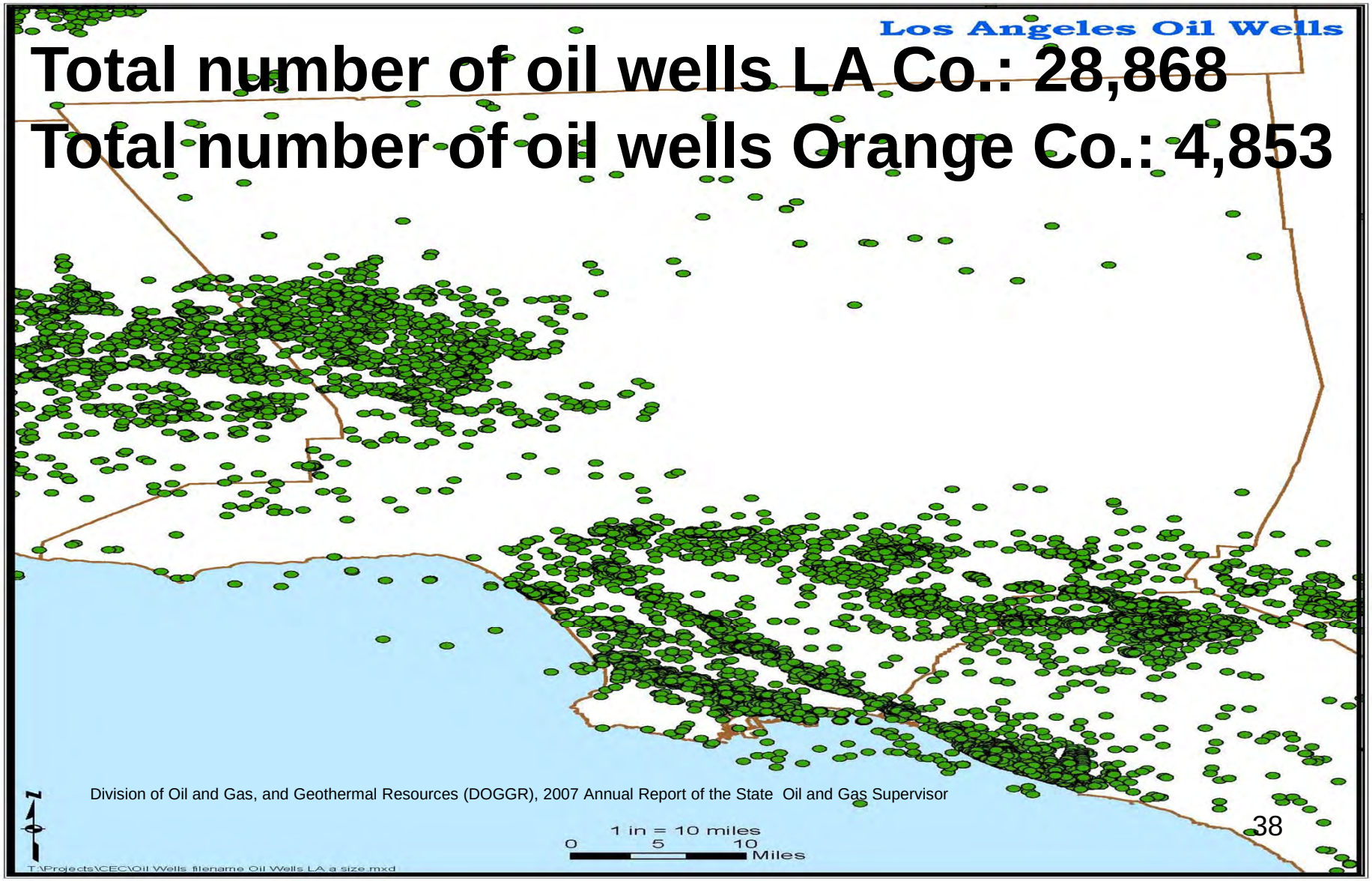
The study summarized results, where available, temperature and pressure values at known depths in reservoirs for individual pools located in Los Angeles County.

- **Hydrothermal resources that have fluid temperatures in excess of 91ºC (195ºF). This is the minimum temperature required for small-scale binary power systems**
- **Geopressured reservoirs that have fluid pressures that exceed hydrostatic pressure by 10% at the depth at which the fluid is extracted.**

Sources:

Division of Oil and Gas, and Geothermal Resources (DOGGR), California Oil and Gas Fields, Vol. II. Report (1991)
Division of Oil and Gas, and Geothermal Resources (DOGGR), 2007 Annual Report of the State Oil and Gas Supervisor
Higgins (1981) Reconnaissance Report on the Geothermal Potential of Los Angeles County
Sanyal et al (1993) Evaluation of the Potential for Geopressured Resources

*Unpublished report and data., G. Gambirazzio, W. Glassley, P. S. Gutierrez and G. Wiggett, *California Energy Commission, 2010.*

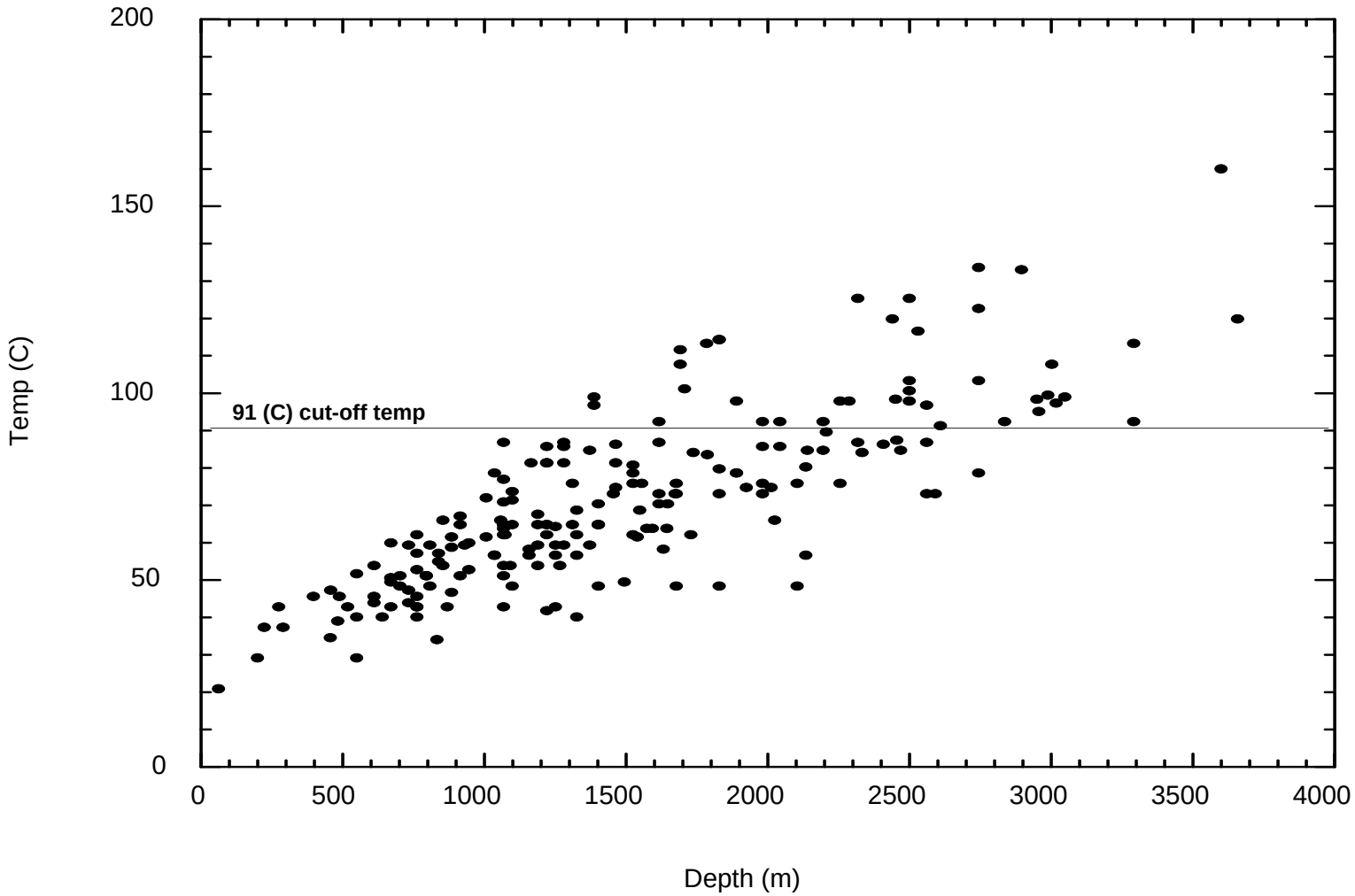


Total number of oil wells LA Co.: 28,868

Total number of oil wells Orange Co.: 4,853

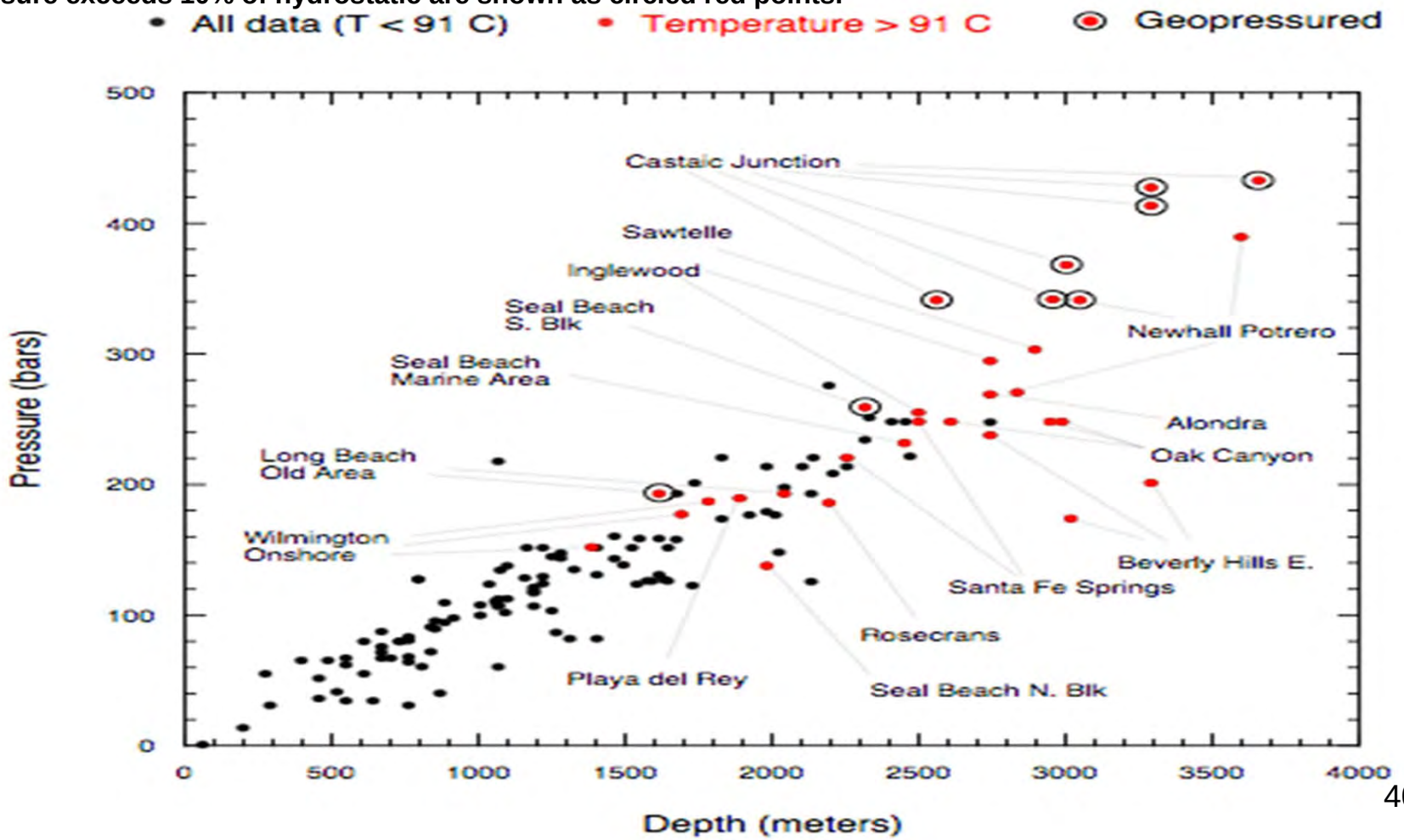
Temperature vs. depth for oil pools in the LA Basin

91 (C) is the theoretical lower limit to generate power using a binary (ORC cycle) power plant



Pressure vs. depth for oil pools in the LA Basin

Pools for which the temperature exceeds 91°C are shown in red. Pools for which the temperature exceeds 91°C and the pressure exceeds 10% of hydrostatic are shown as circled red points.



Oil Pools with Geothermal Potential

The minimum (Min.) and maximum (Max.) temperatures (°C). Pools with pressures 10% above the theoretical hydrostatic pressure are indicated (Y). Some wells within the oil pool with geopressure are show'Y/N'.

Name	Min. T (C)	Max. T (C)	Geopressured?
Castaic Junction	97	120	Y
Newhall Potrero	76	160	Y/N
Sawtelle		133	N
Alondra		134	N
Inglewood	37	101	N
Seal Beach (S. Blk.)	64	125	Y
Seal Beach (Marine Area)	73	98	N
Santa Fe Springs	54	103	N
Oak Canyon	55	100	N
Beverley Hills East	86	103	N
Long Beach (Old Area)	44	92	Y/N
Playa del Rey		98	N
Wilmington (On Shore)	51	113	N
Rosecrans	84	98	N
Seal Beach (N. Blk.)	51	92	N