As a renewable energy source, geothermal power has several unique characteristics.

- It can produce power 24 hours per day, 7 days a week.
- The output of geothermal power plants degrades over several years, especially if the field is not properly managed.
- Geothermal development is similar to drilling for oil and gas. It has many of the same environmental consequences if not properly managed.
- Geothermal operation has potential environmental damage to air, water and soil resources.
- Geothermal resources are localized in very specific areas. Fortunately, San Diego County is close to the resources in Imperial County and in Mexico's Cerro Prieto.
- Significant potential exists for increased production of geothermal energy in areas near our Region.
- New transmission resources may be required to transport the geothermal power to our load centers from Imperial County or Baja California.

5.1 Geothermal Resource in California

California has major geothermal resources to exploit. Most of California's developed geothermal resources are located in Sonoma, Lake, Imperial, and Inyo Counties. Other geothermal resource areas in the State are found in Lassen, Mono, Siskiyou, and Modoc Counties. Figure 5.1[2] shows the locations of the resources in California. Figure 5.2[3] indicates the power produced at each location.

In total, California has 1673 MW of installed geothermal capacity that produced 12,786 million kWh of energy in 1999. Calpine Corporation has a fleet of power plants at The Geysers that have a nameplate capacity of 512 MW. CalEnergy has a fleet of power plants in Imperial County (Calipatria) that has a total nameplate capacity of 340 MW.

5.2 Geothermal Resource in the San Diego Region

Two major geothermal resource fields are located in the Region. The first is Imperial County; the second is Cerro Prieto in Mexico. There is no known technical potential for geothermal resources within San Diego County.

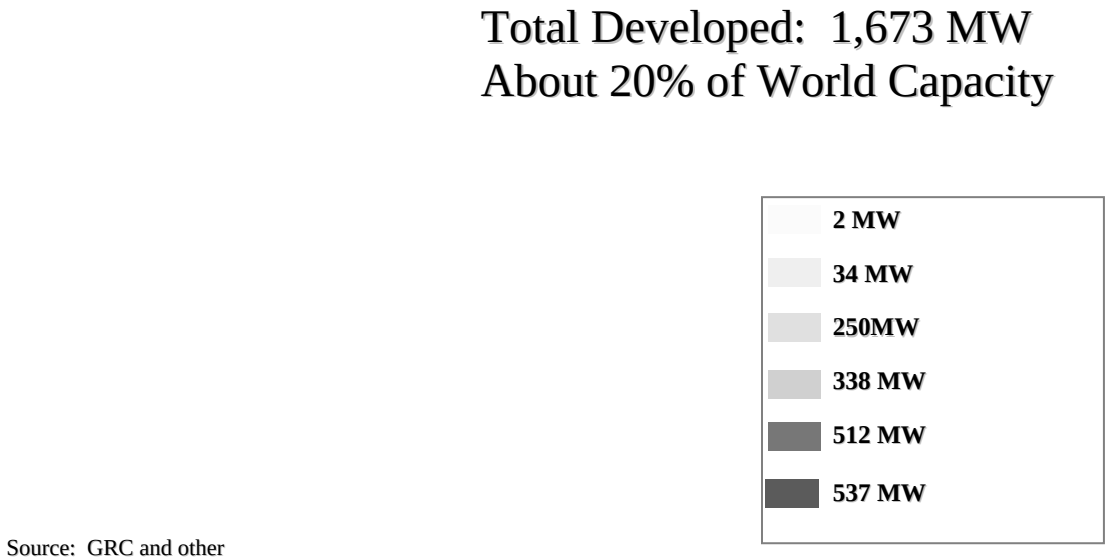
5.2.1 Imperial County

Imperial County, located directly east of San Diego County, has a large geothermal resource composed of hot brine near the Salton Sea. (Brine is water containing high concentrations of dissolved salts and minerals. Brine is highly corrosive to pipes and other power plant equipment.) This site uses flash-type power plants to produce steam from the brine; the steam is used to turn the turbine generators. Activities to produce commercial power from this resource in Imperial County have been ongoing for decades. At the time of this writing, approximately 537 MW (Gross power) of capacity is installed.

[2] www.energy.ca.gov, California Energy Commission Website.
[3] CalEnergy Presentation to CMUA-CEERT Workshop, (Burbank, CA), November 15, 2004.

Figure 5.1: Known Geothermal Resources Areas in California

Figure 5.2: Developed Geothermal Power in California



Source: GRC and other industry sources.

5.2.2 Cerro Prieto

Mexico has relatively large geothermal resources just south of the US-Mexico border and 25 miles south of Mexicali. This resource is a hot-water (280-360 ^{o}C) geothermal system at Cerro Prieto. Power plants installed by 1996 had a nameplate capacity of 620 MW and actually produced ~560 MW from reservoirs up to 4000 m (~12,000 feet) below the surface. In 2000 four additional 25 MW power plants were installed bringing the total nameplate capacity to 720 MW[4]. In 2002 Cerro Prieto produced 4934 GWh of electricity down from 5013 GWh in 2001.[5]

5.3 Technical Potential of Geothermal in the San Diego Region

Two studies have estimated the potential for additional generation capacity in the Region. The National Renewable Energy Laboratory (private communication[6]) has estimated a potential for incremental capacity of 1200 to 2300 MW. GeothermEx, Inc[7] has estimated the

[4]Jose Luis Quijano-Leon & Luis C.A. Gutierrez-Negrin, "Mexican Geothermal Development, An Unfinished Journey", GRC Bulletin Sept/Oct 2003, pp 198-203.
[5] Ibid.
[6] Private communication between Chuck Kutscher of NREL and Dr. Alan Sweedler at NREL, Oct. 2004.
[7] Jim Lovekin, "Geothermal Resources Available to California Markets", GeothermEX, Inc. presentation to the San Francisco Public Utilities Commission, May 20, 2004.

gross incremental capacity at 1350 to 1950 MW. Gross power refers to the output of the generators before deducting the power needed to operate the facility including injection pumps. Net power output can be lower.

CalEnergy is designing Salton Sea Unit 6 in Imperial County. Unit 6 will, if completed, be the largest single geothermal power plant in the United States. It was approved by the CEC in 2003 at 185 MW. CalEnergy has requested a modification to the license to allow it to produce up to 205 MW. It expects the power plant to be operational in 2007/2008. The Imperial Irrigation District Board of Directors has approved a power sales agreement for the purchase of up to 200 MW from that unit.[8,9] CalEnergy has also announced that a plan to add three more 200 MW geothermal power plants - one each in 2009, 2011, and 2013. That company has said that it could accelerate this schedule if firm 30-year power purchase agreements were offered.

The Cerro Prieto fields do not inject all of the spent geothermal brine. In 1996, only 19 percent of the brine was injected into the field. Some speculate that this low injection rate has contributed to the reduction in reservoir pressure, the reduction in power output, and the subsidence of the land. The brine that is not injected is directed toward surface holding ponds. Local ground and air contamination results from disposal of brine in this manner.

With increased environmental protection and re-injection to ensure continued power production, these fields could produce significantly more power than today's output with reduced environmental impacts. Transmission lines are in place to conduct the electricity to both Mexican and US cities. There are no known scientific estimates of incremental power potential in this region. One could guess that with proper resource management and new wells the output might be significantly increased. Current plans include the replacement of two 37.5 MW power plants with two 50 MW power plants for a net increase of 25 MW.

The numbers shown below are estimates based on the limited available information. The reader is cautioned that not all potential incremental power is available to the San Diego area. Besides transmission constraints to deliver the power, producers at both sites may have already negotiated sales arrangements with other utilities or communities. For example, power produced at Cerro Prieto may be totally consumed in Baja California. Southern California Edison and Imperial Irrigation District may be planning to purchase geothermal power produced in Imperial County. Technical potential from geothermal resources in the region is shown in Table 5.1.

[8] Press Release, Imperial Irrigation District, September 1, 2004.
[9] Press Release, Imperial Irrigation District, September 22, 2004.

Table 5.1 Technical Potential of Geothermal Energy in the San Diego Region

	2005 Capacity	2005 Energy	2020 Capacity	2020 Energy
Imperial County	537 MW	~4,700 GWh	2,500 MW	~22,000 Gwh
Cerro Prieto	720 MW	~5,000 GWh	840 MW	~6,000 GWh
Total	1,257 MW	~9,700 GWh	3,340 MW	~28,000 GWh

The technical potential in 2020 is highly significant. It represents more than half of San Diego's maximum power demand. Additionally, geothermal power costs are close to the cost of power produced by natural gas-fired combined cycle gas turbines at today's natural gas price.

5.4 Impact on the System Peaks

Geothermal power plants operate 24 hours per day, so they are operating at system peak, as well as other hours of the year. Geothermal power plants would not be economical if they were operated solely as peaking generation.

5.5 Drivers and Barriers

5.5.1 Availability

No geothermal field has been abandoned because of resource decline. However, pressure and production decline have been experienced, and research at The Geysers has focused on mitigating these effects through injecting water to maintain reservoir pressure. Most often the injected water is treated urban waste water. In addition, some of the sites for new geothermal development are located in areas characterized by sensitive cultural and environmental concerns. While geothermal development in the Imperial County region is more costly due to corrosive minerals and chemical components of the groundwater basin, developing geothermal power plants has less environmental and cultural impact since the area has already been extensively farmed. Other issues that could delay development include permitting and access to transmission.

Another factor may affect geothermal availability for power delivery. CalEnergy operates geothermal power plants in Imperial County near Calipatria. It has developed methods to extract valuable minerals from the geothermal brine that is used in the flash power plants. Prior to injecting the brine back into the ground it is processed to remove those minerals. Currently it is producing commercial quantities of zinc at one geothermal power plant. The operators have discussed also removing fine silica and manganese. The process of removing minerals from the brine is called "liquid mining" and can add significant revenue to the operator of the power plant. The downside of liquid mining is that it consumes a fraction of the electricity produced by the power plant. Thus the net electrical output of a power plant to the grid could be less than 50 percent of the gross power. Because private industry is making the decisions on how best to utilize its geothermal resources, it is not possible to predict the

penetration of liquid mining in the geothermal power business in Imperial County. This makes prediction of net electric power much less precise.

5.5.2 Economics

The cost of generating power from geothermal resources has decreased about 25 percent over the past two decades. A geothermal power plant built today requires 5 to 7 cents per kilowatt-hour (kWh) in revenue to cover costs.[10] Natural gas-fired combined cycle power plants require revenue between 4 and 7 cents per kWh at today's price for natural gas. Therefore the total cost of producing geothermal energy is close to that produced by conventional power plants. The specific cost components are quite different. Based on actual project costs, Jim Lovekin[11] calculates the average capital cost to build a geothermal power plant in California at $2950/kW. Combined cycle power plants cost about $800/kW to construct. Fuel for the geothermal plant is essentially free once the facilities are in place. Fuel cost for a combined cycle is a major component of the total cost. Lovekin's capital cost number for geothermal power plants includes the incremental transmission to connect with the grid. The same author speculates that only power plant projects with projected costs of less than $2400/kW can be competitive with other renewable energy projects. With the restriction of $2400/kW, he estimates that only 1700 MW of gross incremental capacity could be in installed in all of California. Although Lovekin does not specifically address the Imperial County site, his data shows that the cost to drill in Imperial County is considerably higher than the cost to drill at The Geysers in Northern California.

5.5.3 Environmental

5.5.3.1 Sulfur Emissions

Steam geothermal power plants vent the spent steam into the atmosphere. While this effluent is primarily water vapor, measurable amounts of sulfur are also present. The released sulfur has had a pronounced negative effect on local vegetation at The Geysers. To solve this problem, modern geothermal plants are equipped with sulfur scrubbers that capture the sulfur and concentrate it prior to removal from the site for sale or disposal.

5.5.3.2 Spent Brine

Geothermal power plants in Imperial County use the flash process, producing steam from very hot geothermal brine that is brought to the surface. The steam is used to turn steam turbines. The spent brine becomes an environmental hazard if not properly disposed of. In Imperial County the power plant owners have drilled injection wells and pump the spent brine back into the earth. This solves the problem of brine disposal and helps maintain the water inventory in the geothermal resource.

5.5.3.3 Other Environmental Effects

Deep wells (~12,000 feet) are drilled to bring geothermal hot water, brine, or steam to the surface. Geothermal well drilling is very similar to drilling for oil and gas. Massive equipment must be brought to the location. Often new roads are built to bring in the equipment. Large quantities of drilling fluids are utilized and significant amounts of tailings must be disposed of. This activity, if not properly managed, can have significantly negative

[10] The Center for Energy Efficiency and Renewable Technologies.
[11] Jim Lovekin, "Geothermal Resources Available to California Markets", GeothermEX, Inc. presentation to the San Francisco Public Utilities Commission, May 20, 2004.

effects on the local environment. The effects are more pronounced in The Geysers region of Northern California due to the rugged nature of the site. In Imperial County the land is predominately flat and has been farmed for several decades. The effect on natural habitat in Imperial County can be minimal.

Extracting geothermal fluids can also lead to subsidence of the surface, destruction of natural habitats, and reduction of local water quality for aquatic wildlife in the area. These potential problems can be dealt with and are usually addressed in the Environmental Impact Assessment that is required prior to the construction of a new facility. The CEC environmental review process is very thorough and addresses all of these potential problems.

5.5.4 Maintenance

The geothermal fluids in Imperial County and in northern Baja California are highly corrosive brines. Not only must the equipment be constructed with corrosion resistant alloys, but the operators must also perform regular maintenance to ensure reliable output. The geothermal fields in the region are professionally managed and maintenance is scheduled and routinely performed. The cost of the maintenance procedures is included in the estimated cost of the geothermal energy. Full-time plant operators monitor the condition of equipment and are authorized to take a power plant out of operation for unscheduled maintenance if necessary.

5.5.5 Legislative and Regulatory

The California Energy Commission (CEC) must license all “thermal power plants” over 50MW. Geothermal is classified as a “thermal power plant”. For this reason, many power plants have been built with nameplate output of 49 MW or less, avoiding the CEC’s complex siting process. As developers see the potential for selling larger quantities of geothermal power, they are approaching the CEC to discuss licensing procedures. The licensing process at the CEC requires a year of biological studies at the site prior to the formal application. State law requires that the formal application process be completed in one year or less. Typically the process can exceed that time limit. A developer must figure at least two years to obtain a license to construct and the CEC can require project changes that increase cost or cause additional time delays as part of the license to construct.

5.5.6 Transmission

The CEC has recognized the need to license and build new transmission lines to deliver renewable electricity to California markets. One transmission line to deliver wind energy from the Tehachapi mountain region has been licensed. On April 11, 2005, the CEC held a workshop to discuss the need for new transmission capacity to bring additional geothermal energy to market.

San Diego County has limited transmission capacity for importing electricity from any source. The overall transmission problem must be solved to allow both conventional and renewable resources to serve our area.