Energizing Southern California's Economy:

The Economic Benefits and Potential for Geothermal Energy in Southern California

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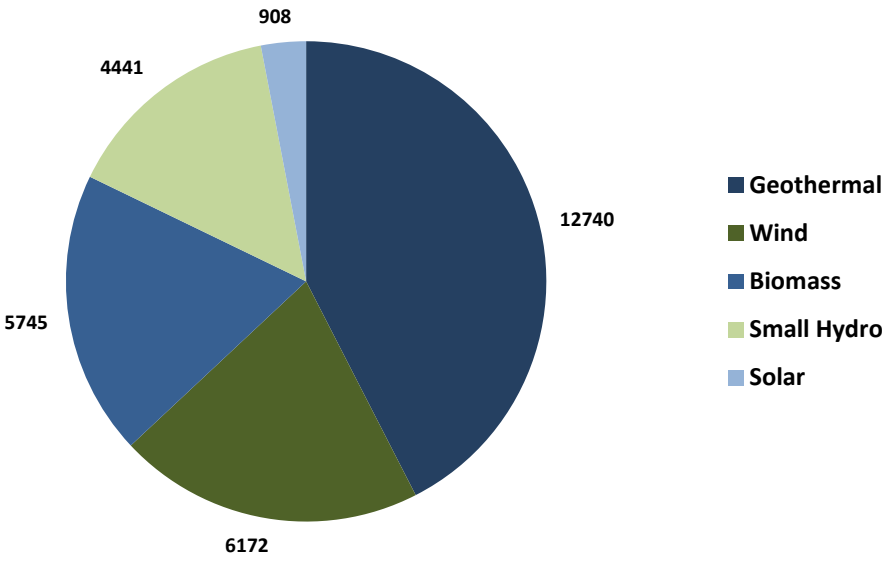
Cover Photos Courtesy of ***EnergySource***

Introduction

Geothermal energy continues to be a major provider of renewable energy to California. As the state looks forward to a future of expanded renewable energy production, geothermal energy will remain a critical part of California's energy mix. Geothermal resources provide a uniquely reliable and continuous source of clean energy, which helps to balance the state's renewable energy portfolio.

Geothermal energy provides a significant share of California's power supply. In 2010 geothermal energy provided approximately 42% of California's commercial in-state renewable electricity generation.[i] In addition to its current contribution to California's energy mix, the future potential of geothermal energy in the state is also substantial. An aggregation of various estimates provides a range of 3186 – 24750 megawatts (MW) of geothermal energy resources could be developed in California using conventional and incrementally improved technologies.[ii] This is equivalent to 10% to 90% of the estimated increases in demand for new power generation for the state.

Figure 1: In-state Renewable Energy Capacity and Generation (GWh, 2010)



Source: California Energy Commission (CEC)

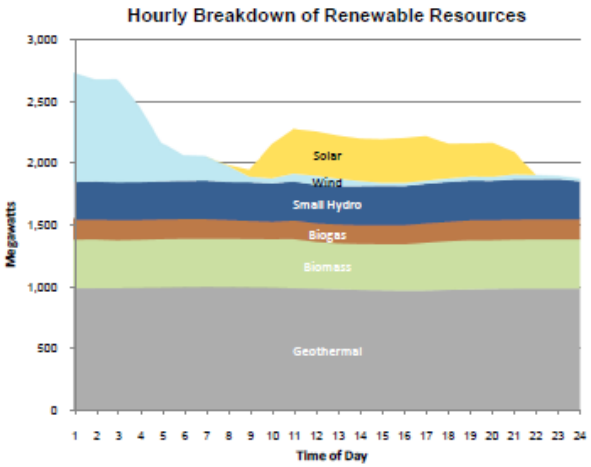
In addition to its large potential capacity, geothermal energy also offers advantages over other forms of energy: it is ideally suited to provide baseload (24/7) power that intermittent renewable resources cannot provide. As highlighted by Figure 2, the value of baseload geothermal energy to California's renewable energy portfolio cannot be overstated. Additionally, when compared to other forms of baseload thermal generation, geothermal offers major advantages in fuel price stability, since it does not require a fuel supply, significantly reduced air emissions, and a smaller footprint/installed MW.

Figure 2: California Renewable Electricity Production, October 12, 2011

24-Hour Renewables Production

Renewable Resources	Peak Production (MW)	Daily Production (MWh)
Solar	362	3,767
Wind	913	4,558
Small Hydro	329	7,519
Biogas	172	3,973
Biomass	407	9,401
Geothermal	992	22,470
Other Renewables *	78	1,806
Total Renewables		**53,494**
Total 24-Hour System Demand (MWh):		*695,671*

This table gives numeric values related to the production from the various types of renewable resources for the reporting day. The total renewable production in megawatt-hours is compared to the total energy demand for the ISO system for the day.



This graph shows the production of various types of renewable generation across the day.

Source: California ISO

California's geothermal power production comes largely from four areas in the state. In Northern California, The Geysers, in Sonoma and Lake Counties, represents the single largest geothermal power source in the state, and the world. Today, The Geysers represents almost one-half of the state's geothermal output, with installed capacity of over 1100 MW.

Southern California enjoys geothermal production from power plants located around Coso and the Imperial Valley. Today, Southern California provides substantial geothermal power from these regions, with enough installed capacity to meet the needs of an estimated 1 million California households. The region also has substantial undeveloped geothermal resources, which could potentially double, at least, current production using existing technology. Developing these resources would bring significant amounts of clean, renewable, reliable power to meet the state's energy, climate, emissions and renewable goals. It would also mean thousands of new jobs, and billions of dollars of economic development in some of the most economically challenged areas of the state.

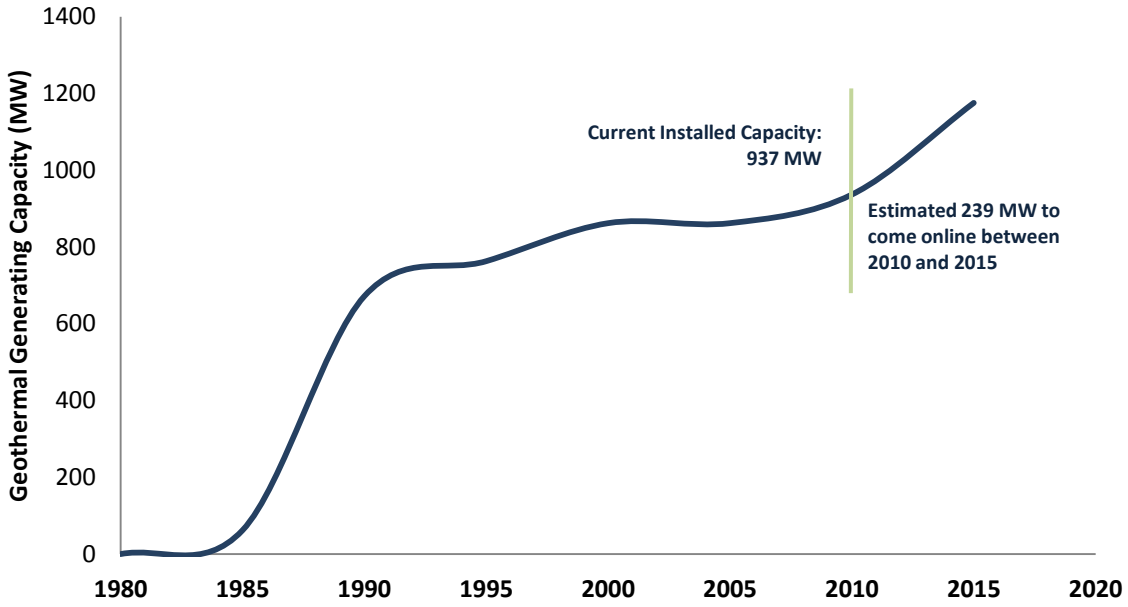
In the future, emerging technologies will expand the benefits of geothermal even further. Not only are firms in California involved in developing the geothermal technologies of the future, but the renewable power they could harness is simply enormous. This could provide direct benefits to the power needs of the California economy, and make California a world leader in a fast-growing new technology market.

Current Production and Near Term Development

The majority of Southern California's geothermal capacity is concentrated in the vicinity of the Salton Sea in Imperial County, and on Department of Defense land in Inyo County. Geothermal power plants have been operating in Southern California since the early 1980's. Currently, 25 geothermal power plants provide approximately 937 MW of clean geothermal energy to demand centers throughout

Southern California, enough electricity to power approximately 1 million households. Additionally, operating geothermal plants bring a variety of job opportunities to the region. For example, geothermal power plants in the Imperial Valley directly employ 391 professionals to support geothermal power plant operations.

Figure 3: Geothermal Installed and Estimated Capacity Through 2015



Source: GEA

Geothermal companies are developing additional geothermal resources for electricity production in Imperial County. Currently, five geothermal projects–with a combined estimated installed capacity of 239 MW–are being developed by CalEnergy, Energy Source, and Ormat Technologies in the area around the Salton Sea. These projects are in advanced stages of development and are expected to begin coming online in 2012. In addition to providing clean energy to Southern California's power markets, the development and operation of these geothermal power plants will also provide an economic boost to the region. According to CalEnergy, the development of its Black Rock geothermal projects will employ up to 642 workers during the peak of construction. Once online, these power plants will permanently employ approximately 57 operations, maintenance, engineering, and administrative professionals.

The construction of EnergySource's Hudson Ranch I geothermal plant supports up to 230 full time construction jobs, and will permanently employ approximately 34 plant operations and maintenance professionals when complete. Additional development of the Hudson Ranch resource is expected to support the permanent employment of 19 geothermal professionals. For the construction of its Hudson Ranch I geothermal power plant, EnergySource awarded a contract with an approximate value of $85M to Performance Mechanical Contractors, a local contractor.[iii] This is just one example of how the development of geothermal resources brings added value to the local economies of Southern California in the form of clean and renewable electricity, improved infrastructure, and added jobs.

Future Geothermal Development: What's Possible

While the geothermal industry has been producing clean energy in Southern California for decades, and also has advanced stage projects slated to come online in the near future, geothermal resources in the region are large enough to drive long-term development for decades to come. In fact, it has been estimated that 65% of the state's incremental geothermal capacity exists in Southern California.[iv] Seven known geothermal resource areas (KGRA) have been identified in Imperial County by the USGS. Various sources estimate these KGRA's have approximately 1800 – 2900 MW of geothermal energy potential.[v] In addition to the KGRA's around the Salton Sea other areas in Southern California with geothermal potential have been identified, specifically the Truckhaven/Superstition Mountain Leasing Project[vi]

Table 1: KGRA MW Potential Estimates

	Geothermal Potential (MW)		
KGRA	**Western Governors Association**	**CEC**	**Imperial County**
Brawley (North)	463	135	100
Brawley (East)	50	129	0
Brawley (South)	0	62	100
Dunes	10	11	0
East Mesa	100	148	50
Glamis	10	6.4	0
Heber	50	142	140
Mount Signal	25	19	0
Niland	150	76	0
Salton Sea	2000	1750	1400
Superstition Mt.	25	9.5	0
Total	**2883**	**2488**	**1790**

Source: IID, CEC, WGA

Geothermal developers are keen to capitalize on Southern California's abundant geothermal resources for the foreseeable future. In addition to advanced stage projects that are expected to bring approximately 239 MW of geothermal energy online in the next few years, geothermal companies are developing six early stage geothermal projects, and are exploring another six prospective geothermal sites for possible future development.

Economic Benefit of Geothermal Development to the Region

In addition to providing jobs, geothermal power sales provide a significant source of tax revenues for local jurisdictions. Imperial County received more than $12 million in 2008 from geothermal power producers, accounting for 25% of its revenue base. Through the Geothermal Steam Act Amendments (2005), geothermal leases on federal lands also result in revenue that is passed back to the states in which geothermal power is produced. In 2008, California received $9.9 million in returned revenues. Of that revenue, 40% is provided to the counties (including Imperial and Mono Counties) in which geothermal power is produced.[vii] Another portion of those funds is made available by the California Energy Commission through its Geothermal Resources Development Account (GRDA). The GRDA program supports projects intended to increase the availability and use of geothermal energy through

research, planning and project development. In 2011, the California Energy Commission awarded 2 GRDA grants for projects in the Imperial Valley that totaled more than $3.7 million.[viii]

Although often viewed exclusively as a source for generating electrical power, geothermal resources can also be employed in a variety of applications in which the heat from geothermal waters is directly used. One example of such an application is aquaculture, in which phytoplankton, zooplankton, aquatic plants and fish are grown in warm, nutrient-rich waters that can be heated by geothermal fluids. Imperial County has a long history of employing geothermal heat to support its $10.9 million aquatic products industry[ix].

Geothermal fluids are complex solutions that may have significant economic value themselves. For example, the Imperial Valley/Salton Sea region has geothermal fluids rich in many economically valuable metals, including lithium, manganese and zinc. Simbol Mining, Inc. has recently been conducting research into methods for extracting these elements from geothermal brines in the region. If successful, it is likely that many millions of dollars will be generated in revenues and a new source of jobs will be created.

State Incentives and AB 32 Goals

California has a Renewable Portfolio Standard (RPS) mandating that 33% of its electrical power be provided from renewable energy resources by 2020. To support the RPS targets, Governor Brown's Clean Energy Jobs Plan calls for adding 20,000 megawatts of new renewable capacity by 2020, including 8,000 megawatts of large-scale wind, solar, and geothermal as well as 12,000 megawatts of localized generation close to consumer loads and transmission and distribution lines.[x]

The Southern California region, as noted above, has extensive, untapped geothermal resources. When considered as a whole, this renewable energy resource has the potential to provide nearly half of the renewable generating capacity required by the 33% by 2020 RPS goal.

California has also implemented ambitious greenhouse gas (GHG) reduction goals, requiring that emissions of those gases be reduced to 1990 levels by 2020. This mandate was codified in Assembly Bill 32 (AB 32) in 2006. Replacing fossil-fuel power plants with geothermal plants can dramatically reduce GHG emissions, since modern geothermal power plants have GHG emissions that are 10-10,000 times less than fossil-fueled power plants[xi]. New geothermal power plants in the Southern California region can thus play an important role in helping the state meet its AB 32 goals.

Accessing California's Geothermal Resources with New Transmission Lines

One of the major barriers to expanding development of geothermal resources in Southern California has been the capacity of the state's electricity grid to access and deliver power to major load centers. As part of the state's commitment to the 33% by 2020 RPS goal, California utilities and state regulators have made a concerted effort in the past 5 years to overcome transmission barriers to access what are commonly called "location constrained" resources. This term refers to the fact that most of the

geothermal, solar and wind resources that will meet our renewable energy resources are geographically removed from large urban areas where most of California's electricity demand is located.

In 2007, the U.S. Department of Energy in a nationwide study concluded that San Diego sits in one of the weakest and most vulnerable energy corridors in the country. This situation is being remedied by the construction of the Sunrise Powerlink transmission line, and the availability of reliable, baseload power in the Imperial Valley is one of the main economic and environmental justifications for building the line. This 500-kilovolt electric "superhighway" will have the capacity to carry up to 1,000 megawatts of clean power. As SDG&E has stated, "Geothermal energy has a long history in the Imperial Valley and could begin to play an even bigger role in California once the Sunrise Powerlink is completed."

Additionally, the Imperial Irrigation District (IID) and Southern California Edison (SCE) are making major strides to increase the capacity of the transmission system to bring Imperial Valley geothermal energy resources to the Los Angeles basin, the largest power market in the state. " In August 2011, the IID Board of Directors approved a 20-mile transmission upgrade project that will double the capacity of the existing 230 kilovolt, "Path 42" line that runs from Coachella to Thousand Palms in California's Coachella Valley. Path 42 connects IID with neighboring utility Southern California Edison (SCE) and subsequently allows for power that is generated in the Imperial Valley to be delivered to the coastal regions of California "This upgrade will add flexibility to our system and achieve the goals of IID and renewable energy generators, alike—to help deliver renewable energy generation to markets within the California Independent System Operator (CAISO) grid," said Juan Carlos Sandoval, IID transmission expansion manager. When construction is completed in December 2013 the new line will have the capability to deliver an additional 700 MW of power from renewable energy projects to CAISO, which serves 80% of California's electricity users.

In August IID signed transmission and generator interconnection agreements with two major geothermal developers, CalEnergy Generation and Ormat Technologies. In order to service these new contracts and further prepare the utility's readiness for renewable energy growth in the Imperial Valley, IID launched a transmission expansion plan connecting the 500-kV Southwest Powerlink with Path 42. The estimated cost of constructing the expansion is $200 million, which will include several projects in addition to the Path 42 upgrade.[xii]

Local R&D and Industry

In addition to being home to some of the country's best geothermal resources, Southern California education institutions and companies are fashioning the region into a potential hub of geothermal R&D and manufacturing. The University of Southern California's (USC) Energy Institute recently received close to $1.5M in federal funding via the American Recovery and Reinvestment Act (ARRA) to improve fracture characterization methods used in the development of Enhanced Geothermal Systems (EGS). Researchers at Science Applications International Corporation's (SAIC) San Diego offices were awarded approximately $1M in ARRA funding to develop models that will help to predict the sustainability and commercial viability of potential EGS operations. Lastly, California based Simbol Materials was awarded

$3M to develop and implement a cost effective and environmentally friendly method for extracting lithium and other valuable minerals from brine utilized in geothermal power plants in Imperial Valley.[xiii]

Table 2: Southern California Federal and State Funded Geothermal R&D

Organization	Source	Amount ($)	Cost Share	Expenditure
California State University, Long Beach	Federal	433,560	156,420	76,347
Power Environmental and Energy Research Institute	Federal	1,840,000	460,000	395,113
Science Applications International Corporation (SAIC)	Federal	1,025,953	256,489	336,652
Simbol Materials	Federal	3,000,000	6,633,543	1,241,263
University of Southern California	Federal	1,483,189	440,824	424,697
Simbol Materials	State	949,545	1,393,508	NA
Imageair	State	672,234	732,293	NA
Total:		**7,782,702**	**7,947,276**	**2,474,072**

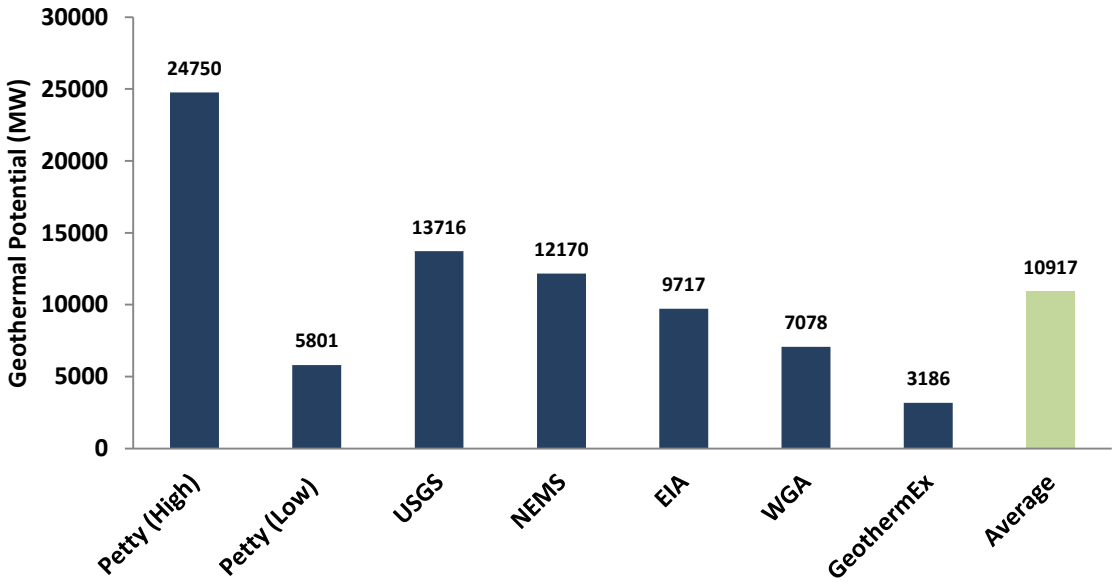
Source: DOE Geothermal Technologies Program, CEC

In addition to being a center of higher education based geothermal R&D, Southern California is also home to more than 15 companies operating in the geothermal industry. Geothermal companies with operations in Southern California reflect almost all aspects of geothermal development from geothermal exploration and drilling, logistics and transportation, construction, financing, and R&D. Additionally, $3.7M in GRDA funds provided by the state support additional research efforts in California. The presence of industry and higher education institutions combined with an abundant geothermal resource ensures that geothermal energy will continue to play an increasingly important role in the development of Southern California's clean energy economy for years to come.

Longer Term Geothermal Potential/Advanced Technologies

While the benefits of expanded geothermal production in the near-term are significant, the long-term potential holds even greater promise. As shown in Figure 4, a variety of sources estimates the state's untapped geothermal energy potential to be in the range of 3186 – 24750 MW, with an average of ~10,917 MW. These potential generation estimates assume geothermal resource development with relatively conventional technology or incremental improvements.

Figure 4: Comparison of Potential Geothermal Supply Estimates for CA



Source: CGEC, GEA

In the long-term, geothermal resources have the potential to expand by means of various technological innovations. For example, geothermal technologies could be implemented in distributed generation applications in addition to utility-scale production. Small power units that can utilize medium and low-temperature resources are being applied in several areas of the nation, and have potentially widespread application in the state. One expert estimated that as much as 7,000MW of distributed generation could be produced by geothermal resources in the state.[xiv]

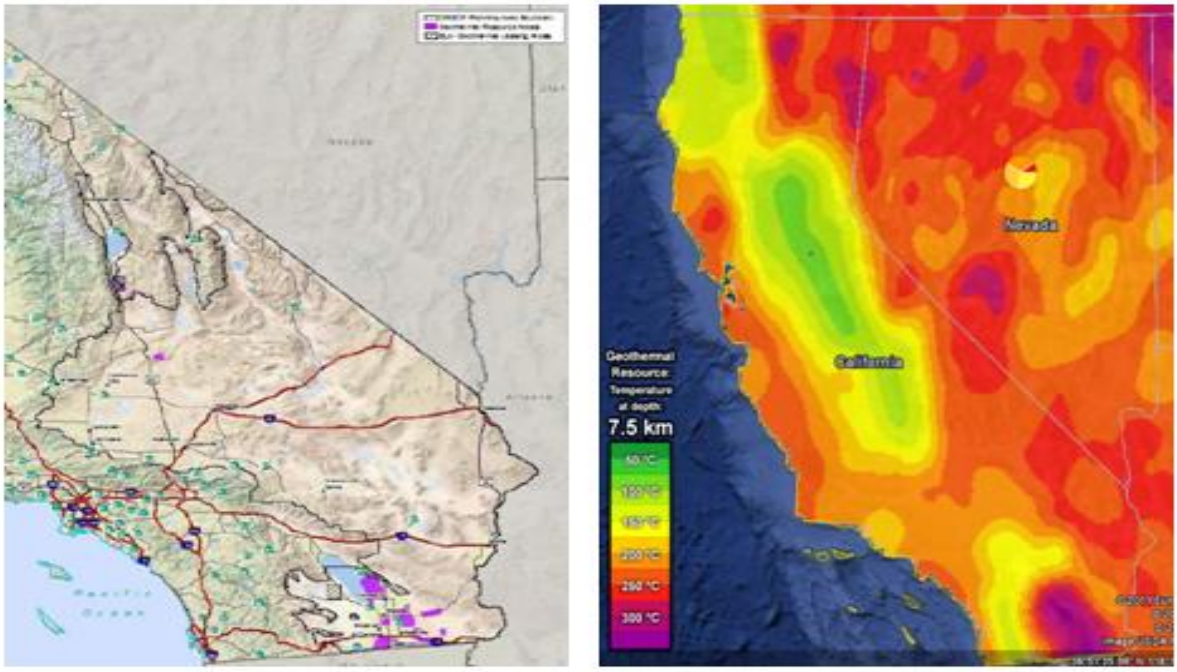
In addition to distributed generation, utilizing geothermal resources for innovative commercial purposes is expected to become more common in the future. This includes both direct-uses of geothermal resources, and geothermal heat-pump applications to provide high-efficiency heating and cooling in residential and commercial buildings. As mentioned previously, efforts to produce valuable minerals from geothermal reservoirs as a by-product of electricity production could potentially drive further industry development and innovation in Southern California in the future.

Further geothermal technology developments will allow production of geothermal energy from the expansive heat available in the rock systems underlying the state. The advancement of EGS

technologies has the potential to stimulate electricity production from an even greater geothermal resource base. EGS technologies "enhance" and/or create geothermal resources in hot dry rock through hydraulic stimulation. Both federal and state initiatives are working to develop EGS technologies that will help California's geothermal industry realize its ultimate potential.

According to Google.org, the potential amount of power that could be produced using advanced EGS technology could dwarf the total power production today from all power sources. At a 2% recovery rate, EGS potential in California is over 140,000 MW. Today, total power generation capacity in the state is just over 63,000MW.[xv] Additionally, some of the most promising areas for EGS potential are located in Southern California, as shown in Figure 5.

Figure 5: Identified Geothermal Resources and Extent of Resource Potential



Source: California Desert Renewable Action Plan, Google.org

Conclusion

If California were a separate country, it would be the world leader in geothermal power production with over 2500 MW of installed geothermal capacity. Southern California alone would rank fifth in installed geothermal capacity behind Mexico (958 MW), and ahead of Italy (843 MW).[xvi]

California's role as a leader in the development of geothermal resources is very likely to continue. Among the US states, California leads the nation in geothermal power production and has the potential

to significantly expand its production in the future. Southern California's abundant geothermal resource is the key to that expansion.

Millions more California homes and businesses could have their energy needs met through geothermal power waiting to be tapped in Southern California. Developing these resources would be a major step towards achieving the state's goals to reduce greenhouse gas emissions by reducing the need for electricity generation from fossil fuels. Geothermal energy is a consumer and environmentally friendly product, which also enhances the reliability of the power system. Further development would provide an increase in geothermal royalty revenues to both the state of California and local counties. Additionally, the development of geothermal resources will generate a large number of construction jobs and support an increased number of permanent operations and maintenance jobs in the region. The continued development of Southern California's geothermal resources will strengthen the region's robust network of industry and higher education institutions working to develop the geothermal technologies of tomorrow. Geothermal innovations in geothermal heat pumps and distributed generation technologies can help meet the energy needs of Southern California's homes and business. As the development of improved geothermal technology advances, the possibilities for further development in the region will continue to grow.

To achieve a renewable, clean energy future California needs to look no further than its own back yard. The state's geothermal resources are available and plentiful. With investment in transmission development and expedited but careful planning, geothermal energy in Southern California will continue to provide clean energy to future generations.

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