Renewable Energy and Jobs

Employment Impacts of Developing Markets for Renewables in California

Environment California
Research and Policy Center

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EXECUTIVE SUMMARY

Developing California's renewable energy industry will provide a job boost for the state. Effective implementation of the recently-adopted Renewables Portfolio Standard (RPS) would create greatly increased demand for renewable energy equipment and services, which may encourage California renewable energy companies to expand their operations. The booming worldwide market for renewable energy creates further opportunities for these companies.

Full realization of the RPS targets would greatly boost renewable energy production in California.

- Considering current proposals and remaining resource potential, utilities could be expected to satisfy the RPS renewable energy requirements with 35% wind, 50% geothermal, and 15% biomass.
- This would result in the development of 3,000 MW of wind power peak capacity, 1,700 MW of geothermal power, and 800 MW of biomass power through 2017.
- This is a tripling of wind power, a 120% increase in geothermal power, and a doubling of biomass power over 14 years.

The worldwide market for renewable energy is exploding.

- The wind power industry has been growing worldwide at the rate of 40% annually from 1995-2002. Wind power is expected to more than double within five years and grow to a $60 billion industry by 2020.
- Geothermal power is projected to grow by 50% by 2010 and 230% by 2020 to a $35 billion industry.
- Production of solar panels is still small, but is growing at nearly the same rate as wind power. Manufacturing capacity of solar photovoltaics (PV) is expected to more than double by 2010 and become a $30-$40 billion industry by 2025.
- Sales of fuel cells for the large power generation sector are expected to reach $25 billion by 2020, and sales of small and portable fuel cells could reach $6 billion. In addition, sales of fuel cells for vehicles are projected at $75 billion by 2020.

California wind power and geothermal power companies are well positioned to control significant market share in their industries.

- Three globally competitive wind power companies are located in California, although they have greatly reduced their in-state manufacturing capacity.
- Three of the world's biggest geothermal power companies are located in California.

California has good potential to lead in the widespread commercialization of two key emerging technologies – solar photovoltaics (PV) and fuel cells.

- Two of the largest PV plants in the world are in California.
- The two U.S. cities most aggressively pursuing PV growth – Sacramento and San Francisco – are in California. Los Angeles has also initiated an aggressive solar rebate program that has attracted manufacturing capacity to the city.
- California is home to the world's premier R&D consortium for fuel cells for vehicles, the California Fuel Cell Partnership. This expertise will be directly useful to the budding market for fuel cells for electricity generation.
- Many of the first fuel cell demonstration projects were located in California, and direct sales of commercial fuel cells have now begun.

Developing California's capacity to capitalize on the expanding markets for renewable energy would have tremendous benefits for the state economy.

- Full realization of the RPS goals would create an estimated 119,000 person-years of employment for Californians over the lifetimes of the plants built through 2017.
- Jobs from steady growth in the use of solar panels would add 2,700 person-years of employment.
- Overseas renewable energy markets would create an estimated 4,300 jobs for Californians by 2010 and 9,700 by 2017. From 2003-2017, this would total 78,000 person-years of employment.
- Together this totals 201,000 person-years of employment. At an average salary of $40,000 per year, this job growth would have payroll benefits of $8 billion.

Policy Findings

California took a large step forward in developing the in-state market for renewable energy with passage of the Renewables Portfolio Standard. However, the RPS target of 20% renewable energy by 2017 is not certain. The California Public Utilities Commission must set a benchmark price for renewable energy, above which contracts will be subsidized by the Renewable Resource Trust Fund. If this benchmark price is too low, the fund will be depleted quickly and utilities will not have to meet their percentage requirements. It is in California's best interests to do what it takes to reach 20% renewable energy as soon as possible.

In addition, California should continue to promote an increased use of ultra-clean micropower such as solar photovoltaics and fuel cells through state and local incentive programs, building codes and requirements for existing and new buildings, and technology-forcing emission standards for dirty energy sources. It is also in the state's best interest to remove barriers to ultra-clean micropower such as interconnection rules and fees and standby charges

Full realization of the RPS goals and a large increase in the use of ultra-clean micropower would result in a significant boost to California renewable energy companies, which would more effectively springboard the industry into global market dominance.

Other programs to promote research in renewable energy and commercialization of renewable energy technologies, and to reduce subsidies and tighten regulations on fossil fuel and nuclear energy sources, are also effective in leveling the playing field and thereby promoting a strong renewables industry. Maintaining and expanding these programs could have significant long-term economic benefits for California.

INTRODUCTION

California has an advanced renewable energy industry. Many renewable energy technologies were born here. We used to have more renewables in place than anywhere else. We are still a market leader, but we have slipped from our dominant position.

Now that market is rapidly changing from the fringe to the mainstream. The use of renewable energy is booming around the world, and this growth is only going to escalate from here.

The same thing happened with personal computers twenty years ago. California manufacturers were at the head of the market, and the state economy benefited greatly. It happened with the Internet ten years ago, and California was leading the charge. Silicon Valley is world famous for its technological achievements and market dominance.

Now it's time to run with another booming market – renewable energy.

This couldn't come at a better time for the state economy. A decline in the computer industry and a sagging stock market have shriveled state revenues from capital gains and taxes on stock options. We've been making deep cuts in state programs and still face a shortfall in next year's budget one-third the size of the entire General Fund budget.[1]

Fortunately, there are ways to stimulate the renewable energy industry without dumping public money into it. Most importantly, government and industry leaders can start at home by promoting the development of California's in-state renewable energy resources. Many projects are ready to go and others are ripe for development, but most of them are awaiting the adoption of market policies that will guarantee fair treatment for renewables.

Once those market policies are in place, California-based renewable energy companies can get down to the real work of building equipment and putting it into operation. This in itself will create many jobs and increase tax revenues. Then these companies will be stronger and better able to capitalize on the booming international market. This will have further economic benefits to the state as a whole.

California's leadership in the industry is far from guaranteed. The governments of Japan, Germany, Denmark, and other countries are providing vast subsidies for renewable energy. 45% of the world's solar panels are manufactured in Japan.[2] Denmark produces more wind turbines than all other nations combined.[3] Policy makers in these countries plan to continue to aggressively pursue the development of this industry.

Given the current budget situation, California cannot meet that level of direct financial support, but policy makers here can still give the industry a major boost with cost-effective market-building policies.

Many California renewable energy companies are ready to take advantage of new opportunities and incentives to export their products and services. According to a recent survey of energy companies by the California Energy Commission, 40 percent of respondents indicated "restructuring in the U.S. is causing them to consider new project development opportunities in international markets."[4]

With the world's sixth largest economy, California has the financial might to be a world leader in this industry. We have the experience and the reputation to command the market. Effective public policies could springboard the state's renewable energy industry back to global market dominance.

California was an early leader in renewable energy technologies. Many of the first modern wind turbines were designed and built in California, and the state has gone further than any other to develop its geothermal resources. Due to uncertainties surrounding deregulation, renewable energy development stalled from roughly 1994 to 2001. In the past two years, however, the pace has quickened.

California's three investor-owned utilities – PG&E, Southern California Edison, and San Diego Gas & Electric – now acquire 14% of the electricity they sell from renewable sources. Under the Renewables Portfolio Standard, each utility must increase its percentage from renewables by one percent per year until it reaches 20%. Southern California Edison, which now sells 17% renewables, will reach 20% in 2006. San Diego Gas & Electric, whose electricity is now only 4% renewable – will not get to 20% until 2017.

Direct access suppliers – non-utility energy companies that sell electricity directly to customers within the utility service areas – must also meet the requirement for 20% renewables by 2017. Direct access suppliers currently handle about 10% of the electricity in the state, almost all of which is through contracts with large commercial and industrial users.[6] These companies currently get approximately 2% of their electricity from renewable sources.[7]

Electric service providers will most likely get all of the required increase in renewable energy from established technologies. Although new technologies may become a significant factor in the later years, this analysis assumes that all RPS-driven renewables growth will come from wind, geothermal, and biomass power. No growth in hydropower is expected.

A prediction of the exact resource mix the utilities will use to satisfy RPS requirements is inherently difficult to make. Uncertain factors include the proposed extension of the federal Production Tax Credit beyond 2003, the proposed inclusion of geothermal in the Production Tax Credit, approval of the repowering of existing wind projects that get favorable regulatory treatment, and allowance of interstate contracts within the RPS. Based on interviews with energy analysts, we use a resource mix of 35% wind, 50% geothermal, and 15% biomass for the growth projections in this report.[8]

Wind Power

California had 95% of the world's installed wind energy capacity in 1985, but this has declined as wind power projects have come online around the globe.[9] Europe and Japan now use more wind power than the U.S. Germany alone has more than twice as much wind power in operation as the entire U.S.[10]

California Market Growth

Wind power is expected to be the biggest component of renewable energy growth in the coming years, as California has immense

Table 1. Current Renewable Energy Mix of California Investor-Owned Utilities[5]

Utility	Wind	Solar Thermal	Geothermal	Biomass	Small Hydro	Total Renewables
PG&E	1%		5%	3%	3%	12%
Southern California Edison	4%	1%	9%	2%	1%	17%
San Diego Gas & Electric	1%			3%		4%
Total	2%	0.5%	6%	3%	2%	14%

untapped wind resource areas.

In 1998, scientists at the Lawrence Berkeley National Laboratory found that the state's 36 best potential wind power sites could generate 87,000 GWh/yr, 33% of current electricity needs.[11] Their economic analysis showed that most of this development could occur sooner rather than later. By 2010, 26,000 GWh/yr could be operational at less cost than other energy resources. At an added cost of just 2 ¢/kWh over conventional power, an additional 14,000 aMW of wind power could be developed by 2010, for a total of 40,000 GWh/yr of generation, including the current capacity of 3,900 GWh/yr.[12]

Since this analysis, the outlook for natural gas prices has changed dramatically. Market analysts predict a steady increase in the average price of gas, and wide price fluctuations around that average are all but certain. For this reason, these predictions should be taken as very conservative estimates. Continued high gas prices would result in no price premium for this amount of wind power development in the next decade.

Assuming that 35% of renewable energy growth will be from wind, California will have developed 13,000 GWh/yr of wind power by 2017 – 33% of the state's cost-effective potential. In this scenario, wind power would grow to 5.4% of the electricity sold within the service areas of the investor-owned utilities in 2017. (See Table 2.)

Global Market Growth

Wind has been the fastest-growing energy sector, and this trend will continue. Most of the growth in renewable energy in the next decade, measured by energy output, will come from wind power.

Globally, the wind industry has been growing at an average rate of 25%-annually since 1995.[14] In 1998, worldwide sales of wind turbines exceeded $2 billion.[15]

The cost of wind generation has dropped from 10 ¢/kWh in 1990 to 4-6 ¢/kWh in 2002, making many projects cost competitive with natural gas power plants. These

Table 2. Projected California Wind Power Development[13]

Year	New Wind Power Capacity (MW)	Total Wind Power Capacity (MW)	Wind Power Generation (GWh)	Total Electricity Generation (GWh)	Wind Pct of Total
2003		1,470	3,900	185,000	2.1%
2004	470	1,940	5,100	192,000	2.7%
2005	400	2,340	6,100	199,000	3.1%
2006	290	2,630	7,100	204,000	3.5%
2007	250	2,880	7,800	208,000	3.8%
2008	260	3,140	8,500	212,000	4.0%
2009	160	3,300	9,200	216,000	4.3%
2010	270	3,560	10,000	220,000	4.5%
2011	260	3,820	10,700	224,000	4.8%
2012	30	3,850	11,100	227,000	4.9%
2013	150	4,000	11,600	231,000	5.0%
2014	150	4,150	12,000	235,000	5.1%
2015	30	4,180	12,400	238,000	5.2%
2016	150	4,330	12,900	242,000	5.3%
2017	160	4,500	13,400	246,000	5.4%

costs are expected to continue to drop to the point where more prospective wind farms can generate electricity for about 4 ¢/kWh.

Wind capacity is forecast to continue expanding rapidly. In 2001, installed wind capacity worldwide jumped from 18,500 MW to 25,000 MW.[16] This 6,500 MW of new wind energy generating capacity was the largest increase ever in wind energy installations.[17] Many nations have set targets that will guarantee further expansion of wind power worldwide.

Figures from the World Market Research Centre indicate that international wind markets will grow at an average rate of 25% per year through 2006.[18] The World Market Research Centre is a private consulting firm with hundreds of corporate and government clients around the world.

European Wind Energy Association (EWEA) data shows that the global wind energy market could reach 60,000 MW by 2007. If this growth is achieved in equal increments over the next five years, this would translate to 7,000 MW per year in new capacity. EWEA based its estimates both on recent high growth rates and on new policies of various nations that will result in more wind power coming online in the future.[19]

The International Energy Agency (IEA), a forum for 26 member countries, presents a more cautious view using conservative assumptions about government policies. The IEA predicts that world wind capacity will reach 48,000 MW by 2007.[20] If this growth is achieved in equal increments over the next five years, this would translate to 4,500 MW per year in new capacity.

Although the projections of the World Market Research Centre are the most likely if favorable policies continue, averaging these three projections produces a more conservative estimate for the growth of wind power. Using this average through 2007 and a cautious estimate of 10% annual growth thereafter, we can expect that 16,000 MW of wind power capacity will be added in 2010 and 31,000 MW in 2017. (See Figure 1.)

In dollar terms, the wind turbine market was worth $3 billion in 1999 and will grow to $13 billion by 2005 and $43.5 billion in 2010, according to the clean energy advocacy group Clean Edge.[21] Climate Solutions, another clean energy group, predicts that the wind market will grow to approximately $60 billion by 2020.[22]

United States

There is now 4,300 MW of wind power online in the United States, and approximately 2,000 MW more is expected to be added in 2003.[23] The National Renewable Energy Laboratory projects that 80,000 MW of wind power will be online in the U.S. by 2020 – 5% of total energy production.[24]

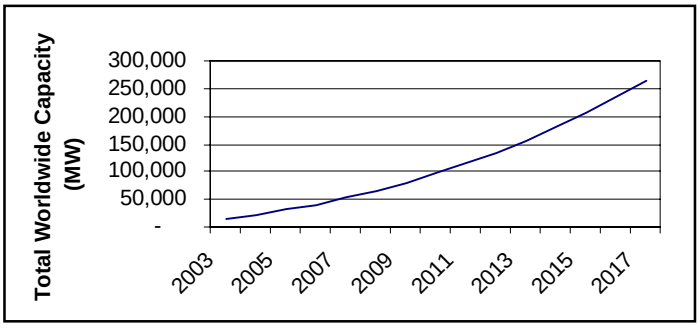
Europe

Energy analysts predict that 1,470 MW of new wind capacity will be installed annually in Europe from 2002-2005, for a total capacity of 17,000 MW in 2005.[25]

Germany currently produces half of Europe's wind power, about a third of the world total.[26] Germany's wind capacity will likely triple between 2000 and 2006.[27] Germany expects to have 25,000 MW of wind power installed by 2010.[28]

In December 2000, France announced that it would develop 5,000 MW of wind gener-

Figure 1. Wind Energy Worldwide Growth Projections



ating capacity by 2010.[29] To meet EU clean energy commitments passed since then, France will need to develop 10,000 MW of wind power by 2010.[30]

Denmark's target is to have 1,500 MW of wind power installed by 2005 and 5,500 MW by 2030.[31]

Asia

India now has 1,500 MW of capacity, and the Indian government has projected that 2,000 MW of wind capacity could be added by 2007.[32] India plans to add 6,000 MW of wind power by 2012.[33]

China will develop up to 2,500 MW of generating capacity by 2005.[34] By 2006, China's wind capacity will be seven times greater than it was in 2000.[35]

Japan added 43 MW of wind capacity in 1999. The country's 2010 goal for wind power capacity is 300 MW.[36]

Latin America

Two Spanish companies are planning to develop 3,000 MW of wind energy in Argentina that will be completed by 2010.[37]

Ameron International

Ameron International Corporation is a multinational manufacturer of highly-engineered products and materials, including large pipes for water transmission, fiberglass tubing for fuel pipelines, and specialized coatings and finishes. The company has operations and joint ventures on six continents.

Ameron's Water Transmission Group makes heavy steel fabrications for many uses, in addition to manufacturing water and wastewater piping. Currently, the main project of this division and its Fontana plant is making large steel pilings for the renovation of the San Francisco-Oakland Bay Bridge.

This expertise and capacity is well suited for part of the renewable energy industry as well – manufacturing towers for wind turbines. At the completion of the Bay Bridge project, Ameron plans to pursue the wind tower market to replace this business and maintain production at full capacity.

California Manufacturing Capacity

California is home to some of the world's leading wind energy companies, as well as smaller companies involved in the many aspects of wind energy development and production. The California Energy Commission's "Energy Technology Export Directory" lists 136 California companies in the wind energy industry.[38] Although European companies manufacture many more wind turbines than U.S. companies, California has two major integrated wind power companies, several small innovators, and many small wind energy development and operating companies. The largest players include the following.

GE Wind Energy

GE Wind Energy is the 4th largest wind turbine manufacturer in the world, according to company data.[39] Their U.S. headquarters is located in Tehachapi, California, although their turbine manufacturing facilities at that location have been closed. In the past twenty years, GE Wind has developed and installed more than 5,300 wind turbines worldwide with a combined capacity of 2,800 MW.[40]

SeaWest

SeaWest WindPower, founded in 1982, is based in San Diego. During their 20 years in business they have installed over 3,300 turbines around the world with a combined capacity of 830 MW.[41] SeaWest handles all phases of wind project development from inception through construction and generation, although they no longer manufacture their own turbines.[42] SeaWest recently modernized one of its California wind farms, the 43 MW Westwinds plant in Palm Springs, replacing 477 old turbines with 62 new turbines.[43]

Clipper Windpower

Clipper Windpower is a relatively new company on the wind market. Currently, the company is developing wind projects throughout the U.S., in addition to design-

ing a wind turbine able to generate power cost-effectively in lower wind conditions. Clipper received $13 million from the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) – the largest grant ever – to develop this new product. The prototype is in development and is expected to be complete by the end of 2003. Manufacturing will then begin in 2004.[44]

enXco

EnXco Group currently operates or is developing nearly 3,400 wind turbines in the Americas, Australia, and Europe. The turbines combine for an installed capacity of 550 MW. The company has direct ownership of 191 MW of this capacity and is under contract to develop and manage the rest. Founded in 1985, enXco is located in North Palm Springs.[45]

Geothermal Power

Geothermal energy has a smaller long-term potential capacity than other forms of renewable energy, but growth over the next decade will be significant.

Since electricity generation from geothermal energy consists of drilling wells and operating large steam turbines, the geothermal energy industry is dominated by large companies also involved in traditional energy production. Small consulting firms also play a significant role in helping these companies adopt to the unique characteristics of geothermal energy.

California Market Growth

California energy companies currently have 1,741 MW of geothermal electricity generating capacity.[46] Approximately 80% of that capacity serves customers in the service areas of the three investor-owned utilities.[47] In those areas, geothermal power constitutes 6% of electricity sold.

Energy analysts estimate that the state has the potential for an additional 4,000 MW of geothermal electricity generating capacity at a small average price premium using current technology.[48] The rate of development of this resource will increase as the technology advances. Already the best resource areas can be developed at a cost lower than the cost of natural gas plants.[49]

Most of this resource is concentrated within a few large geothermal fields.

- The Glass Mountain Area around the Medicine Lake volcano near the Oregon border. Permits are currently being issued for a 50 MW plant, and plans for another 50 MW plant are under development.
- The Geysers Geothermal Field in Lake County. Plants were first built here in the 1960s, and since the 1970s The Geysers has been the world's largest geothermal development. Plants totaling 936 MW are in operation.
- The Salton Sea Geothermal Field in the Imperial Valley. Three companies operate a total of 527 MW of geothermal power capacity. CalEnergy has plans to add a 185 MW plant, which would be the largest geothermal power plant in the world.
- The Coso Geothermal Field underlying U.S. Air Force land near China Lake, CA. Four plants produce 270 MW.[50]

Analysis by the Geothermal Energy Association has produced similar results, finding that California has the potential to boost output from existing plants in the near term by 300-600 MW and can develop up to 1,000 MW at known but undeveloped reserves at each of three locations, for a total of 3,600 MW that can be practically developed with today's technology.[51]

If California energy companies satisfy 50% of renewable energy growth with geothermal energy, they will develop 1,680 MW of geothermal power capacity over the next 14 years.

Global Market Growth

According to the European Network of Energy Agencies, worldwide geothermal deployment for electricity production is predicted to grow by 4% per year throughout this decade, increasing from 10,000 MW in 2000 to nearly 15,000 MW in 2010.[53] Assuming only half that rate of growth in the following decade, worldwide geothermal power capacity will grow to 19,000 MW by 2017. (See Figure 2.)

In dollar terms, the IEA predicts that the geothermal market will grow from $15 billion in 2000 to $35 billion in 2020.[54]

In the U.S., EIA figures predict that high capacity geothermal capacity will increase by 87% between 2000 and 2020 to 5,000 MW and will provide 35 million MWh of electricity generation.[55]

Geothermal power generation will expand most in the Philippines, Indonesia, Japan, and California.[56]

California Manufacturing Capacity

Much of the work involved in geothermal energy involves local labor for drilling and construction. The turbines and other components in a geothermal plant are not as highly specialized as in other renewable energy industries, and can thus be built by traditional manufacturers at many locations around the world. Studying potential sites for geothermal plants and developing plans for them, however, is a highly specialized activity. California has considerable expertise at these activities and is well suited to grow further into the international market.

The Geothermal Resources Council lists 20 California-based geothermal energy development and service companies.[57] The larger California-based companies in the geothermal industry include the following.

Table 3. Projected California Geothermal Power Development[52]

Year	New Geothermal Power Capacity (MW)	Total Geothermal Power Capacity (MW)	Geothermal Power Generation (GWh)	Total Electricity Generation (GWh)	Geothermal Pct of Total
2003		1,380	10,900	185,000	5.9%
2004	170	1,560	12,300	192,000	6.4%
2005	190	1,750	13,800	199,000	6.9%
2006	180	1,930	15,200	204,000	7.4%
2007	120	2,050	16,200	208,000	7.8%
2008	130	2,180	17,200	212,000	8.1%
2009	130	2,310	18,200	216,000	8.4%
2010	140	2,440	19,300	220,000	8.8%
2011	130	2,580	20,300	224,000	9.1%
2012	80	2,650	20,900	227,000	9.2%
2013	80	2,730	21,500	231,000	9.3%
2014	80	2,810	22,100	235,000	9.4%
2015	80	2,890	22,800	238,000	9.6%
2016	80	2,970	23,400	242,000	9.7%
2017	90	3,060	24,100	246,000	9.8%

Calpine

One of the world's largest geothermal companies. See box.

Bibb's Process Division

Bibb's Process Division, a multi-disciplinary architecture and engineering firm, is located in Pasadena. They are a worldwide leader in geothermal power plant development with 30 years of experience in geothermal projects. Their projects involve nearly 500 MW of power.[58]

Baker Hughes

Baker Hughes is one of the top oil and gas service companies in the world, and also is a major player in the smaller geothermal market.[59] The company's geothermal work is headquartered in Santa Rosa. Nic Nickels, Manager of Geothermal Operations Worldwide, is confident that geothermal is an up and coming market. He further says that the company is looking to expand its geothermal operations around the world.[60]

GeothermEx

GeothermEx specializes exclusively in consulting on geothermal energy. The firm is based in Richmond and has been operating since 1973.[61] GeothermEx provides technical evaluation of new projects, directs exploration activities, analyzes changing conditions, and performs financial projections for all types of geothermal energy projects. The company has been involved in more than 750 projects for 180 clients in 44 countries.

Calpine

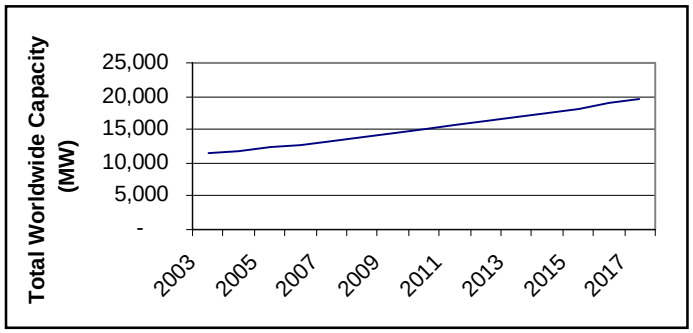
Calpine Corporation owns and operates natural gas power plants throughout North America and geothermal power plants in California. In 2001, Calpine's generating capacity grew to 11,100 MW – double the capacity of the prior year.[62] Calpine brought almost 4,000 MW of new natural gas power plants online and purchased power plants with 1,475 MW of capacity. In the same year, the company acquired its first plant outside of North America, in the United Kingdom.[63] The company was founded in 1984 and has its headquarters in San Jose.

Calpine's 19 geothermal plants at The Geysers, 100 miles north of San Francisco, make it the world's largest producer of geothermal power.[64] The plants have a combined capacity of 795 MW.[65]

Calpine is also exploring new geothermal prospects. The company currently has a proposal to develop geothermal fields at Glass Mountain, near the Oregon border.[66] They already have three exploratory wells at Glass Mountain, and intend to build 50 MW of generating capacity.

Calpine has the second most improved performance among major U.S. corporations over the past five years, according to a Fortune list based on percentage growth in profits.[67] Calpine also ranks 251 on the Fortune list for annual revenues.[68]

Figure 2. Projected Worldwide Geothermal Energy Growth



Biomass Power

Many types of "waste-to-energy" technologies and energy crops used to generate electricity fall under the banner of "biomass." Some are unacceptably harmful to the environment, while others provide a net benefit to the environment.

Any material that releases air pollutants or toxins into the air upon combustion at a greater rate than the fossil fuel it is replacing should not qualify as a renewable fuel. Included in this group are municipal solid waste and construction debris, which can release dangerous toxins from the combustion of plastics and chemicals.

Burning timber wastes and agricultural wastes also have high emissions of dangerous pollutants, but can provide a net benefit over current practices. Burning organic waste in closed systems to generate electricity can result in lower emissions than disposing of it in open-air burn piles. Emissions can be further reduced with biogas digesters, although this option is not currently cost-effective. Biogas digesters utilize bacteria to transform livestock manure into fertilizer and biogas, which consists mainly of methane (the main component in natural gas). Some forms of digesters are currently employed for sewage treatment and fertilizer production, with biogas-generated electricity as a secondary benefit.

In most cases, landfill gas used as a renewable fuel has a net benefit for the environment. When large amounts of methane are emitted from landfills, operators are required to flare it; when emissions fall below limits requiring flaring, methane and other toxins escape into the atmosphere. Therefore, burning the methane to generate electricity is more desirable.

Various types of energy crops (i.e. willow, sweetgum, sycamore, switchgrass, woody crops) hold the potential for cleaner electricity production compared to traditional fossil fuels, especially coal, but their life-cycle impacts on the environment deserve further study.

California Market Growth

If California energy companies satisfy 15% of renewable energy growth with biomass energy, they will have developed 1,560 MW of capacity by 2017. The Renewable Energy Policy Project estimates that the mix of types of biomass developed in California through 2010 will be 26% agricultural residues, 43% urban waste, 16% forest trimmings, and 16% landfill gas.[69]

Table 4. Projected California Biomass Power Development[70]

Year	New Biomass Power Capacity (MW)	Total Biomass Power Capacity (MW)	Biomass Power Generation (GWh)	Total Electricity Generation (GWh)	Biomass Pct of Total
2003		770	4,000	185,000	2.2%
2004	100	870	4,500	192,000	2.3%
2005	90	960	5,000	199,000	2.5%
2006	80	1,040	5,400	204,000	2.6%
2007	60	1,100	5,700	208,000	2.7%
2008	60	1,160	6,000	212,000	2.8%
2009	60	1,210	6,300	216,000	2.9%
2010	60	1,280	6,600	220,000	3.0%
2011	60	1,340	6,900	224,000	3.1%
2012	30	1,370	7,100	227,000	3.1%
2013	40	1,410	7,300	231,000	3.2%
2014	40	1,440	7,500	235,000	3.2%
2015	40	1,480	7,700	238,000	3.2%
2016	40	1,520	7,800	242,000	3.2%
2017	40	1,560	8,100	246,000	3.3%

Solar Photovoltaics

Photovoltaic (PV) technology converts sunlight directly into electricity without using any moving parts. Although PV panels only generate electricity when the sun is shining, connection with the grid makes it possible to depend on PV, both from the consumer and the state planning perspectives. On hot days, when electricity consumption is at its peak, PV panels feed excess electricity into the grid. In the evening when the sun is down and electricity demand is lower, customers draw electricity from the grid. Recent improvements in "net metering" – in which the electricity meter runs backward when power is being fed into the grid – have made this technology much more cost-effective for consumers.

PV is a truly unique technology that is clean and renewable, and has immense overall generating potential. According to the U.S. Department of Energy, "it is easy to foresee PV's 21st century preeminence."[71]

Because each solar array adds only a small amount to statewide generating capacity, it will be years before solar PV generates as much electricity as other major sources of power. But in percentage terms, PV is the second fastest growing power source worldwide, right behind wind power.[72] The development of the industry over the coming decade will be vitally important to the eventual dominance of the technology.

California Market Growth

Because the generating cost of electricity from photovoltaics is still higher than that of other technologies, solar power will probably not be a major part of the utilities' plans to satisfy new renewable energy requirements. However, solar PV is cheaper than the retail price of electricity under good conditions, and thus makes economic sense for individuals to generate their own power rather than buying it from utilities. Also, innovative policies may be highly effective at encouraging spurts of growth in solar power among developers and municipalities.

A ballot initiative passed by voters in San Francisco in November 2001 will result in the addition of 10-12 MW of solar panels on city-owned buildings, a major jump from the estimated 15 MW of total current PV capacity statewide. Alameda County's Santa Rita Jail recently installed a 500 kW PV system.[73] A concerted push in Los Angeles will encourage the installation of 100,000 rooftop PV systems – approximately 200 MW – in that area alone, according to the California Department of Water Resources.[74]

Programs at the California Energy Commission (CEC) and the California Power Authority may also result in significant additions of solar capacity. Since the start of the Emerging Renewables Buydown Program, established by the CEC in 1996, 3,800 systems, mostly photovoltaic systems, totaling approximately 30 MW have been installed.

Solar power development in California is therefore likely to follow a path of steady, gradual growth as individuals add panels to their homes mixed with periodic jumps as regional policy packages are adopted.

From 1989-99, the growth rate of worldwide PV module shipments averaged 18%. For the same time period, the U.S. growth rate was 21%. Recently the growth rate has been much higher. The average growth rate in 1997-99 in the U.S. and worldwide was 31%. In 1999, the U.S. growth rate of PV module shipments was 52%, the highest ever, while the worldwide growth rate of shipments remained at a healthy 30%.[75]

If PV additions increase to 30 MW by 2007 and this rate grows by 10% annually thereafter, California will have 600 MW of photovoltaic capacity by 2017. Such a growth trajectory is similar to the projections of the Renewable Energy Policy Project, which estimated in 2002 that California PV capacity would grow to 700-1,300 MW by 2020.[76]

Global Market Growth

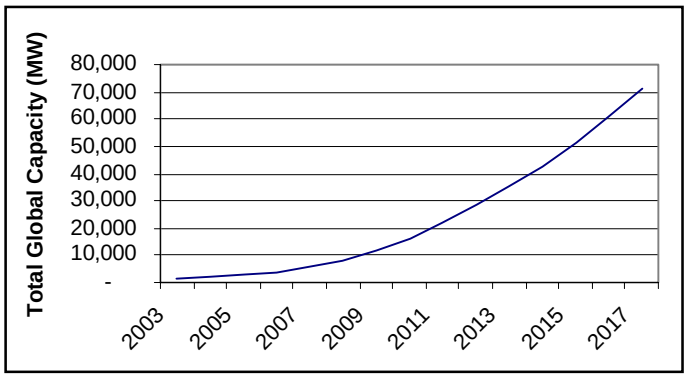
The worldwide solar PV industry is very small. Currently, the industry can only manufacture 350 MW of solar panels each year.[77] However, the industry stands to benefit greatly from economies of scale as demand grows. Increases in manufacturing capacity lead to significantly lower prices, which further expands the market and leads to more production and price reductions. Because the potential market is so large, this cycle can continue to reap benefits well into the future.

PV is already cost competitive with traditional energy sources for many buildings with moderate power needs that are not already connected to the power grid. In developing countries, solar panels are becoming widespread for remote applications. World shipments of photovoltaic modules expanded more than 30% between 1998 and 2000.[78]

An Allied Business Intelligence report predicted that global PV production will exceed 800 MW by 2005. The report found that worldwide demand for PV could be as high as 900 MW by 2005 and 5,000 MW by 2010.[79] This would require 44% annual growth in capacity additions between 2006 and 2010. Assuming just a quarter of that rate of growth for the following decade, annual solar PV installations will exceed 10,000 MW in 2017.

In dollar terms, the PV industry worldwide will be worth $30-$40 billion by 2025, according to the National Renewable Energy Laboratory.[81] Clean Edge sees the photovoltaics market growing from $2.5 billion in 2000 to $7.5 billion in 2005 and $23.5 billion in 2010.[82] The GAO has reported that world sales of photovoltaic technology increased by 16% every year between 1985 and 1997 to exceed $1 billion in 1997.[83] ABI has determined that PV sales are likely to increase tenfold by 2010.[84]

Figure 3. Projected Worldwide PV Growth[80]



United States

By 2020, the photovoltaics industry is expected to reach $15 billion in the U.S.[85] The U.S. plans to achieve more than 2 GW of PV peak capacity by 2010 and 3 GW of capacity by 2020.[86] NREL predicts that at least 10% of U.S. power-generation capacity will be PV by 2030.[87]

According to the California Energy Commission, California could meet 100% of its daytime electricity needs with PV if all available commercial and industrial rooftop space were used for solar panels.[88]

Europe

The European Photovoltaic Industry Association projects that the PV industry could directly employ 294,000 people in Europe by 2010.[89] The EU plans to add 3 MW of photovoltaic capacity by 2010.[90]

Some 20,000 solar arrays were installed in Germany in 2001 – twice as many as the previous year – for a combined capacity of 77 MW. This brings Germany's total PV capacity to 170 MW. An additional 80 MW was planned in 2002 and 95 MW more in 2003. As the country does not have a significant PV manufacturing base, it is the world's biggest importer of solar panels.[91]

Asia

Japan had 200 MW of installed PV capacity at the beginning of 2000.[92] The country's PV capacity target is 5 GW by 2010.[93]

California Manufacturing Capacity

U.S. solar cell manufacturing capacity has not kept pace with the growth of the PV market. Six years ago, the U.S. was manufacturing 44% of the world's solar panels, but market share rapidly fell to 27% by 2001.[94] However, California still has several strong PV companies that could maintain this market share as the size of the market increases.

PowerLight

PowerLight is the largest designer, manufacturer, and installer of grid-connected solar photovoltaic systems in the country, with operations in Berkeley and Oakland. The company has its own line of patented PV products. *Inc* magazine has called PowerLight "one of the fastest growing privately-held businesses." The company was founded in 1991, and annual revenues have doubled each year since 1997.[95]

Shell Solar

Shell Solar, part of the Royal Dutch Shell group of companies, is one of the world's largest manufacturers of PV modules and systems, and has its main PV manufacturing plant in Camarillo, in Ventura County. The company sold 44 MW of solar panels in 2001.[96] Shell Solar is involved in all stages of PV system manufacturing and recently announced an increase in sales and marketing efforts.[97]

AstroPower

AstroPower was founded in 1989 as a division of Astrosystems Inc., a developer of semiconductor products. AstroPower has been growing at a rate of 50% annually. The company recently established AstroPower West, in Concord, as a division specifically focused on developing on-grid residential, commercial, and utility business.[98] AstroPower was named one of the 200 best small companies by *Forbes* magazine in 2002. AstroPower was ranked 19th for annual sales growth.[99]

Xantrex

A developer and manufacturer of power inverters. See box.

Schott Applied Power

Schott Applied Power, the world's largest independent distributor of solar energy systems, has moved its headquarters from Lacey, WA to Rocklin, CA.[100] Schott occupies 23,000 square feet in its new home and employs 32 staff.[101]

Sharp Electronics

Sharp Electronics, the U.S. subsidiary of Sharp Corporation in Osaka, Japan, has established a new division in Huntington Beach. This branch will make Sharp's solar cells, modules, and systems available in North America. Sharp is one of the world's

Xantrex

Xantrex Technology, established in 1983, develops, manufactures, and markets power electronic products for various applications. The company's products convert raw energy into household electricity. While they produce products for other energy applications, 40% of their business is in the renewables market. The company's Livermore staff spends 90% of its efforts on renewable energy products.[106]

Xantrex has a global presence. The company has an office in Barcelona and has a strong market presence in Central and South America. In Europe, Xantrex works with companies like BP Solar and AstroPower on solar projects. The company's international business accounts for 20% of its overall revenues. Xantrex equipment is in use in more than 3,000 MW of power systems worldwide.[107]

Xantrex's was named to the 2002 Deloitte and Touche Technology Fast 500 List, a list of the fastest-growing technology companies in the United States and Canada based on a percentage increase in revenues over a five-year period. Xantrex experienced a 1,190 percent increase in revenue from 1997 to 2001. The company also made the list in 1998. Ray Hudson, Vice-President of Emerging Markets, has stated that the company intends to find markets to continue such strong growth trends.[108]

largest solar manufacturers, with a 19% share of the market, and plans to increase its solar production capacity from 94 MW to 200 MW in 2002.[102] Sharp's Huntington Beach office is also responsible for Canada and Latin America.

Amonix

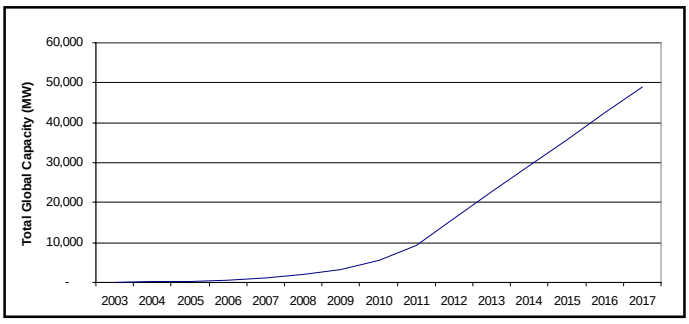
Amonix designs and manufacturers high-performance PV cells and PV power generation systems, and is the world leader in integrated high-concentration photovoltaic systems.[103] In 1994, Amonix received *R&D* magazine's 100 award.[104] The company was also selected for a California Technology Investment Partnership (CalTIP) grant in 2001, a matching grant program that supports commercial growth of up and coming technology-based companies.[105] Amonix, along with 24 other companies, will share $24 million in matching grants. The company was established in 1989 and is located in Torrance.

Fuel Cells

Fuel cells currently have the smallest market share of the generating technologies examined in this report, but have perhaps the largest potential for capacity development and for economic benefits.

Although they now use fossil fuels to create hydrogen, fuel cells emit far less pollution than most other fossil fuel generators. Emissions from current cells are primarily CO_2 and water. With further development, energy companies will be able to use renewable energy to produce the hydrogen fuel. This will give the U.S. the potential to meet all of its energy needs with renewable energy by processing hydrogen in places with the most intense sun, wind, and geothermal fields and using it to power fuel cells in places with less renewable energy potential.

Figure 4. Projected Worldwide Stationary Fuel Cell Growth[110]



Most of the work in fuel cell development has been for vehicle use. Fuel cell cars are widely seen as the technology that will eventually replace internal combustion engines powered by fossil fuels. Less attention has been paid to the development of stationary fuel cells for electricity generation, but the commercial market for stationary fuel cells has also been taking its first steps in the past few years. Like fuel cells for vehicles, the stationary fuel cell market promises to expand rapidly.

Global Market Growth

Fuel cells have the advantages of high reliability and high output in modular formations. They can generate lots of power right where the power is used, and can be scaled to virtually any size. Remote locations with large power needs can therefore already find fuel cells more cost effective than building transmission lines to faraway power plants. Such places can develop the market for fuel cells, which will come down in cost as more units become commercialized, creating a more general market.

Current global fuel cell generating capacity is 45 MW. Most of the units already in place were prototypes from R&D labs, but the industry is now producing commercial units from standardized manufacturing plants. Although there is still only one type of product commercially available, the existence of several competitors in the marketplace promises to produce a variety of products soon. Global fuel cell generating capacity is projected to reach 16,000 MW by 2012, a 70% annual rate of growth.[109] Assuming only linear growth thereafter, worldwide fuel cell capacity will grow to 49,000 MW by 2017.

In dollar terms, sales of fuel cells for the

large power generation sector are expected to reach $25 billion by 2020, and sales of small and portable fuel cells could reach $6 billion. In addition, sales of fuel cells for vehicles are projected at $75 billion by 2020.[111] Others have made more aggressive projections of a $20 billion market for stationary fuel cells by 2010, and $10 billion for commercial buildings alone.[112]

Stationary fuel cells will increasingly be used in applications that now use large batteries. The market for large batteries and fuel cells in the U.S. is expected to grow from $1.4 billion in 2001 to $2.4 billion in 2006. A growing portion of this market will go to new technologies. Sales of non-lead battery materials are expected to grow 66% per year through 2006.[113]

The market for micro fuel cells that power items like cell phones and laptop computers will also expand rapidly in the coming years. The industry is projected to ship 117,000 units in 2003, rising to 4 million units in 2008.[114] Another study estimates that as many as 200 million portable fuel cells could be shipped in 2008.[115]

Including vehicle, stationary power, and micro applications, the market for fuel cells is projected to grow to $3 billion by 2005.[116]

California Manufacturing Capacity

California is home to two of the world's premier fuel cell R&D facilities. The knowledge and experience of people involved in those projects could greatly benefit startup firms that choose to locate in California once the market for stationary fuel cells grows. Several small fuel cell manufacturers have already appeared in the state.

H2Economy

H2Economy currently has three types of fuel cell products on the market – fuel cell testing stations, AC/DC converters that allow fuel cells to operate with higher voltage capacities, and 5 to 50 watt fuel cells for demonstrations. They are also working on other prototype fuel cells they hope to have ready sometime in 2003. They expect their first commercial fuel cell to be available in mid-2004.[117] H2Economy is initially targeting smaller scale markets such as scooters and stationary/portable applications like wheelchairs.[118] The company has its headquarters in Glendale.

Metallic Power

Metallic Power concentrates it efforts on

California Fuel Cell Partnership

The California Fuel Cell Partnership was founded in January 1999 when two California state agencies joined forces with six private companies. Today there are 19 full partners, plus 9 associate partners that provide expertise in specific program areas.[121] The partners share facilities to conduct their research and product development more effectively and take part in joint public education activities.

The stated goals of the Partnership are the following:

1. Demonstrate fuel cell technology by operating and testing vehicles on California's roads;
2. Demonstrate alternative fuel infrastructure technology;
3. Explore the path to commercialization; and,
4. Increase public awareness through a coordinated outreach plan.[122]

In November 2000, the California Fuel Cell Partnership opened a 55,000-square-foot headquarters in West Sacramento that houses electric vehicles, a hydrogen fueling station, and a methanol fuel station. The complex also serves as an educational facility with a public gallery to highlight fuel cell technology.[123]

Government partners include the California Air Resources Board, the California Energy Commission, the South Coast Air Quality Management District, the U.S. Department of Energy, the U.S. Department of Transportation, and the U.S. EPA. Energy partners, among others, include BP, ChevronTexaco, and ExxonMobil. Auto partners include Ford, DaimlerChrysler, and Honda. Industry partners include Ballard, International UTC Fuel Cells, and XCELLSiS.[124]

The project is scheduled to run through the end of 2003. The partners are currently negotiating plans to continue the arrangement through 2007.

regenerative zinc/air fuel cells and began shipping its first products this year.[119] In 2001, Metallic Power won a "Best of Show" award from *Computer Telephony* magazine for technological development in long-term back-up power.[120] Metallic Power was founded in 1995, and is located in Carlsbad.

Coval

Coval Partners is a developer of fuel cell vehicles and stationary power systems. Some of Coval's products contain hybrid power systems that use fuel cells to charge batteries. The company has built prototype fuel cell trucks and heavy construction equipment, and also manufactures fuel cell testing equipment. The company was founded in 1995, and is located in Desert Hot Springs.

California Fuel Cell Partnership

The California Fuel Cell Partnership is the world's foremost research and development center for fuel cell vehicles. See box.

National Fuel Cell Research Center

The National Fuel Cell Research Center was established by Southern California Edison in 1992 and moved to the University of California-Irvine in 1997. The mission of the research center is to develop fuel cell technology and partner with private companies to commercialize fuel cell products. The center specialized in stationary fuel cell products, and has been involved with developing hybrid solid oxide fuel cells capable of operating much more efficiently than the current generation of phosphoric acid-based fuel cells.

Market Growth Summary

According to the estimates outlined in the preceding sections, wind energy will constitute an estimated 79% of all worldwide peak capacity additions throughout this decade. Solar PV will make up 13%, fuel cells 4%, and geothermal 4% of new capacity. The growth projections in Tables 2-4 are summarized in Table 5.

Table 5. Projected Annual Worldwide Capacity Additions by Technology (MW)

Year	Wind	Geothermal	Solar PV	Fuel Cells	Total
2002	6,500	420	350	32	7,302
2003	7,200	440	500	53	8,193
2004	8,100	450	650	90	9,290
2005	9,100	470	800	150	10,520
2006	10,400	490	1,200	260	12,350
2007	12,100	510	1,700	470	14,780
2008	13,300	530	2,400	800	17,030
2009	14,600	550	3,500	1,300	19,950
2010	16,100	570	5,000	2,300	23,970
2011	17,700	600	5,600	3,900	27,800
2012	19,500	620	6,200	6,600	32,920
2013	21,400	650	6,900	6,600	35,550
2014	23,600	670	7,700	6,600	38,570
2015	25,900	700	8,500	6,600	41,700
2016	28,500	730	9,400	6,600	45,230
2017	31,400	760	10,400	6,600	49,160
Total	97,400	4,430	16,100	5,455	123,385

Solar Thermal Power

There is theoretically enough sunlight in a 100-mile-square patch of desert in the southwestern U.S. to generate enough electricity for the entire country.[125] 100% of current fossil fuel-based electricity production could be replaced by solar thermal plants on 1% of the earth's desert area.[126]

Solar thermal power plants use reflectors to concentrate sunlight on a receiver that uses the sun's heat to generate electricity. Parabolic troughs, power towers, and dish/engines are the three technologies either in use or in development for solar thermal power plants, differing mainly in the shape and configuration of the reflectors.

Concentrating solar thermal power plants using parabolic troughs have been operating successfully in southern California since the mid-1980s. In this system, trough-shaped mirrors, arranged in row after row, concentrate the sun's heat on a receiver tube containing fluid. Using a series of heat exchangers, steam is produced that drives a conventional turbine to generate electricity. The plants in operation today are hybridized with gas so that the turbines can be driven by gas when solar energy is not available.

California currently has nine parabolic trough solar thermal power plants, all in San Bernardino County, operated by three separate companies. The plants range in size from 4 to 80 MW, with a combined capacity of 354 MW. This constitutes over 90% of the solar thermal electricity generation in the world.[127]

In April 1999, a pilot test in the Mojave Desert of a concentrating solar thermal power plant using a power tower configuration successfully completed its operations. Solar Two, as it was called, had a capacity of 10 MW and stored energy in molten salt for use beyond daylight hours. This storage system replaced the fossil fuel hybridization of the trough system, although it could also be designed as a hybrid system. The mirrors in a power tower system, called heliostats, are arranged in a circular field. They move individually, tracking the sun and concentrating the sun's heat on a single central receiver located on top of a tower situated in the center of the circle of mirrors. Solar Two met all of its objectives, demonstrating the ability to collect and store solar energy efficiently and to generate electricity when needed by the utility and its customers.[128]

With the performance and reliability of this technology proven, Solar Tres, a molten-salt power tower project, is currently under construction in Spain. Nexant, a subsidiary of Bechtel Corporation, and Ghersa, a Spanish company, have formed a partnership to execute this project.[129]

It appears that this research and development is soon to result in new commercial projects in the U.S. A newly signed long-term contract with a Nevada utility involves the construction of a 50 MW solar thermal power plant. And Solargenix (formerly Duke Solar) recently announced plans for a new plant near Barstow that would use a combination of solar thermal and biogas digester technologies. If these plants are successful, another 100-250 MW of solar thermal plants are likely to follow soon thereafter.[130]

EMPLOYMENT BENEFITS

Encouraging renewable energy development in California will do more than provide the state with a reliable and clean electricity supply. It will benefit the economy as well by supporting many jobs in the construction and operation of renewable energy facilities.

Employment Rates

The California Energy Commission's Public Interest Energy Research program sponsored a study in 2001 from the Electric Power Research Institute (EPRI), a nonprofit energy research consortium founded and supported by electric utilities. The report "characterizes the status and prospects of each renewable energy resource in the state and estimates the current and potential economic and environmental benefits they provide." The report concludes that renewable energy technologies "can make California's electricity more reliable, affordable, and cleaner."[131]

The EPRI report includes estimates of job creation from renewable energy development based on existing and planned projects in California and the market outlook of project developers and equipment manufacturers. The construction employment rate in the report ranges from 2.57 jobs/MW for wind to 7.14 jobs/MW for PV. EPRI's operating employment rate ranges from 0.12 jobs/MW for PV to 2.28 jobs/MW for landfill/digester gas. These figures include direct jobs at the generating facilities as well as indirect jobs from component manufacturing.

The EPRI study did not attempt to measure employment rates for fuel cell manufacturing. Since fuel cells are still not mass produced, there is no hard data to determine what manufacturing job rates will be in the fuel cell industry once mass production begins. This report assumes a rate equivalent to that of solar PV. Since this rate has only been achieved after decades of production in that industry, this is sure to be a conservative estimate for the fuel cell industry.

EPRI states in its report that these employment projections are "likely characteristics for the next 5-10 years." However, to be more conservative, one can assume a steadily decreasing employment rate over the next decade due to economies of scale and increasing experience of renewable energy companies. Although it is difficult to quantify this decrease based on historical precedent, it is likely that there would be much more efficient use of manufacturing personnel and service technicians at the end of a

Table 6. EPRI Employment Rates with Annual Reduction (jobs/MW)

	Wind		Geothermal		Solar PV		Biomass	
	Constr. Jobs	O&M Jobs	Constr. Jobs	O&M Jobs	Constr. Jobs	O&M Jobs	Constr. Jobs	O&M Jobs
EPRI estimates	**2.57**	**0.29**	**4.00**	**1.67**	**7.14**	**0.12**	**3.71**	**2.28**
2003	2.31	0.28	3.60	1.59	6.43	0.11	3.34	2.17
2004	2.08	0.26	3.24	1.51	5.78	0.11	3.01	2.06
2005	1.87	0.25	2.92	1.43	5.21	0.10	2.70	1.95
2006	1.69	0.24	2.62	1.36	4.68	0.10	2.43	1.86
2007	1.52	0.22	2.36	1.29	4.22	0.09	2.19	1.76
2008	1.37	0.21	2.13	1.23	3.79	0.09	1.97	1.68
2009	1.23	0.20	1.91	1.17	3.42	0.08	1.77	1.59
2010	1.11	0.19	1.72	1.11	3.07	0.08	1.60	1.51

period of rapid renewable energy market growth. A decline of 10% per year in the construction employment rate and 5% per year in the operating and maintenance employment rate through 2010 leads to very conservative job growth estimates. (See Table 6.)

Job Growth from the California Market

A strong in-state market for renewable energy would provide an incentive for renewable energy companies to expand their operations in California. Wind turbine manufacturers that have built more facilities elsewhere than they have in California recently will be encouraged to increase capacity here. PV manufacturers that have gradually ramped up production would have more reason to increase that rate of growth. Companies that service renewable energy facilities will need more staff.

There is no way to know the extent to which manufacturers respond to this incentive, but the incentive will exist and we can safely predict some amount of response.

Assuming that just 30% of manufacturing activity associated with California renewable energy development occurs in-state, full realization of the targets in the Renewables Portfolio Standard would result in 1,500 person-years of construction employment in the wind power industry, 1,200 in geothermal, and 540 in biomass, according to EPRI's employment rate estimates. Assuming that 90% of operating employment is California-based, the RPS would create 19,000 person-years of O&M work for wind, 59,000 for geothermal, and 38,000 for biomass over

Table 7. Job Growth from Wind Power Development

Year	New Wind Capacity (MW)	New Construction Jobs	New Operating Jobs	Total New Employment (person-years)
2004	470	330	120	3,900
2005	400	250	94	3,100
2006	290	160	65	2,100
2007	250	130	53	1,700
2008	260	120	53	1,700
2009	160	64	30	960
2010	270	98	49	1,600
2011	260	96	48	1,500
2012	30	10	5	160
2013	150	55	27	860
2014	150	56	28	880
2015	30	10	5	160
2016	150	57	28	900
2017	160	60	30	960

Table 8. Job Growth from Geothermal Power Development

Year	New Geothermal Capacity (MW)	New Construction Jobs	New Operating Jobs	Total New Employment (person-years)
2004	170	190	250	7,600
2005	190	180	260	7,900
2006	180	160	230	7,100
2007	120	97	150	4,600
2008	130	91	150	4,600
2009	130	82	140	4,400
2010	140	78	140	4,300
2011	130	76	140	4,300
2012	75	43	79	2,400
2013	77	44	81	2,500
2014	79	45	83	2,500
2015	81	47	85	2,600
2016	83	48	87	2,700
2017	88	51	93	2,800

the 30-year lifetimes of the facilities.

With the same 30% in-state manufacturing assumption for solar panels, the PV growth projections outlined earlier would create 2,700 person-years of employment over the lifetimes of the panels installed between now and 2017.

Because this report only models the California market effects of the RPS and solar energy development, it does not count impacts from likely additional renewable energy development. Southern California Edison and PG&E, which will reach 20% renewables by 2006 and 2011, respectively, are likely to surpass 20% by 2017. Benefits from all renewable energy development beyond that mark, and from renewable energy sold outside the service areas of the investor-owned utilities, are not included in this analysis.

Table 9. Job Growth from Biomass Power Development

Year	New Biomass Capacity (MW)	New Construction Jobs	New Operating Jobs	Total New Employment (person-years)
2004	99	99	190	5,900
2005	87	78	160	4,900
2006	82	67	140	4,400
2007	57	41	95	2,900
2008	59	39	93	2,800
2009	59	35	89	2,700
2010	62	33	89	2,700
2011	61	32	87	2,600
2012	34	18	49	1,500
2013	35	19	51	1,500
2014	36	19	52	1,600
2015	37	20	53	1,600
2016	38	20	54	1,700
2017	40	22	58	1,800

Table 10. Job Growth from PV Development in California

Year	Added Capacity (MW)	Total Capacity (MW)	New Construction Jobs	New Operating Jobs	Total New Employment (person-years)
2003		15			
2004	5	20	10	1	27
2005	10	30	19	1	52
2006	20	50	39	2	100
2007	30	80	58	3	146
2008	33	113	64	3	156
2009	36	149	70	3	166
2010	40	190	77	3	180
2011	44	230	85	4	200
2012	48	280	93	4	210
2013	53	330	100	4	230
2014	58	390	110	5	260
2015	64	450	120	5	280
2016	70	520	130	6	310
2017	80	600	150	7	350

Job Growth from the International Market

Developing renewable energy business activity in California would have the further benefit of providing a springboard into the worldwide renewable energy market. As California companies grow to satisfy in-state demand, they will be better able to gain market share in foreign markets.

EPRI determined that an average of 80% of manufacturing activity involves the manufacturing of components and other activities not necessarily located at the construction site. With only a few competitors currently with significant production, California could gain a major portion of this non-local employment from renewable energy projects around the world. To be conservative, we look at a scenario in which California has a 5% market share for geothermal and 10% for the other technologies.[132]

Using the EPRI employment rate estimates and projections for the international market, overseas renewable energy markets would create an estimated 4,300 jobs for Californians by 2010 and 9,800 by 2017. From 2003-2017, this would total 78,000 person-years of employment. (See Table 11.)

These employment benefits would come on top of the job growth created by developing California's in-state renewable energy resources. Adding in employment from the domestic market, California renewable energy employment can be projected to grow by 201,000 person-years over the lifetimes of the plants built from 2003-2017. (See Table 12.) At an average salary of $40,000 per year, this job growth would have payroll benefits of $8 billion.

Table 11. Construction Jobs from Foreign Markets for Renewable Energy Technologies (person-years)

Year	Wind	Geothermal	Solar PV	Fuel Cells	Total
2003	1,500	70	290	30	1,900
2004	1,500	65	330	51	1,900
2005	1,500	61	370	86	2,000
2006	1,600	57	500	150	2,300
2007	1,600	54	640	270	2,600
2008	1,600	50	810	460	2,900
2009	1,600	47	1,100	740	3,400
2010	1,600	44	1,400	1,300	4,300
2011	1,700	46	1,500	2,200	5,500
2012	1,900	47	1,700	3,800	7,400
2013	2,100	50	1,900	3,800	7,800
2014	2,300	51	2,100	3,800	8,200
2015	2,500	54	2,300	3,800	8,700
2016	2,800	56	2,600	3,800	9,200
2017	3,100	58	2,800	3,800	9,800
Total	28,900	809	20,340	28,088	78,100

Table 12. Total California Employment Growth from Renewable Energy Development (person-years)[133]

Technology	Construction Employment for International Market	Construction Employment for In-State Market	Operating Employment for In-State Market	Total
Wind	28,900	1,490	18,930	49,320
Geothermal	800	1,230	59,030	61,070
Biomass	na	540	38,070	38,610
Solar PV	20,300	1,120	1,540	23,000
Fuel Cells	28,100	na	na	28,100
Solar Thermal	na	390	550	940
Total	78,100	4,770	118,120	201,040

POLICY FINDINGS

Government actions to attract businesses often result in a race to the bottom, where states and municipalities compete with each other to court companies with direct subsidies that can greatly diminish the region's economic benefits from the new business activity. However, state and local governments in California can help develop the renewable energy industry in several ways that avoid this problem.

Economic development authorities and other public agencies can provide tax-exempt financing to qualifying companies. The state can also continue its coordination and funding of research and development programs. The business activity associated with the commercialization of new products can provide a large payback for these efforts.

Because of strict guidelines on eligibility for tax-exempt financing and because there is no guarantee that the commercialization of new technology will stay within the state, however, these two approaches are not enough to give the California renewable energy industry the boost that is warranted to help it reach its full potential. The most effective assistance the state government can give to this industry is to: 1) commit to reaching the full goals of the Renewables Portfolio Standard through proper implementation of the law; and 2) expand solar installations on new and existing buildings.

Examples of Successful Policies

Policies adopted in Europe and elsewhere are instructive. In Germany, Denmark, Spain, and Japan, national policies have been put in place in recent years with great success at increasing the use of renewable energy and expanding the domestic renewable energy industry.

- In 1990, Germany enacted a law requiring utilities to purchase renewable energy at a guaranteed minimum price. Since then, the country's wind capacity has grown from 56 MW to 12,000 MW in 2002, more than a third of wind capacity worldwide. The German wind industry now employs 40,000 people.[134]
- Germany started the 1,000 Roofs program in 1991 and expanded it to 100,000 Roofs in 1998. The program offers 10-year, low-interest loans for individuals and businesses to install PV panels. Largely as a result of these programs, Germany is expected to have 440 MW of solar power in operation by the end of 2003, more than twice as much as the entire U.S. German PV manufacturers are greatly expanding their capacity in response to this demand. In one decade, Germany has built an industry with billions of dollars in revenue.[135]
- Spain passed a law in 1994 guaranteeing access to the electric grid and establishing purchase requirements for renewable energy, and is now adding wind turbines at the third highest rate in the world. Spain's Gamesa Eolica has become the world's second-largest wind turbine manufacturer.[136]
- Denmark has long had a policy of guaranteeing a market for producers of wind energy, stimulating manufacturing activity that has made the country the world's largest producer of turbines.[137]
- The Japanese government invests $200 million per year in a program that provides a rebate on solar panels in exchange for the right to collect performance data. The program has resulted in 41% annual growth in total installed PV capacity since 1992, and manufacturers have expanded their operations to keep pace with this growth. Japan is now the world leader in both the use and production of solar panels.[138]

Implementation of the Renewables Portfolio Standard

Benchmark Price

California took a large step forward in developing the in-state market for renewable energy with passage of the Renewables Portfolio Standard (RPS). If properly implemented, the California RPS will be the biggest policy stimulus for renewable energy in the country. However, the RPS goal of 20% renewable energy by 2017 is not certain. Whether that goal is met may depend on some key decisions at the California Public Utilities Commission (PUC).

Most importantly, the PUC must set a benchmark price for renewable energy, above which contracts will be subsidized by the Renewable Resource Trust Fund. If this benchmark price is too low, the fund will be depleted quickly and utilities will not have to meet their percentage requirements. It is in California's best interests to do what it takes to reach 20% renewable energy as soon as possible. Market policies that ensure full attainment of the RPS goals would provide economic benefits for the entire state.

Municipal Utilities

The RPS should be expanded to include municipal utilities. Currently, the RPS only covers the service areas of the state's three investor-owned utilities – PG&E, Southern California Edison, and San Diego Gas & Electric. The most glaring omission in this policy is the Los Angeles Department of Water and Power (LADWP), a city-owned utility that handles 9% of the state's electricity demand.[139] LADWP currently acquires only 3% of its electricity from renewable sources.[140] Other large public utilities that could be covered under an RPS include the municipal utilities in Sacramento, Anaheim, Silicon Valley, and Riverside, and the Imperial, Modesto, and Turlock Irrigation Districts.

Cross-Border Flexibility

Another issue in RPS implementation is whether to allow utilities to purchase their required renewable energy from out of state. Because there is great potential in Nevada and elsewhere, much of which can be imported into California without causing transmission line bottlenecks, cross-border contracts should be allowed. This flexibility would help California utilities meet their requirements at the lowest available cost.

Minimum Solar Requirements for New Construction

Given California's peak energy shortages, booming development, and abundant solar resources, California should maintain incentive programs for retrofitting existing buildings with solar photovoltaic systems and establish statewide building requirements to integrate solar photovoltaic systems into new construction.

Currently, less than 1% of California's electricity comes from solar photovoltaic systems. Less than 2% of new single-family homes built in California come equipped with solar systems.

To bring about a self-sustaining solar energy market, reduce peak energy demand, reduce air pollution and dependence on natural gas and other unsustainable energy resources, and save consumer and taxpayer dollars, California should establish a minimum solar photovoltaic requirement for new construction.

In addition, to reduce dependence on natural gas, California should also take steps to promote solar thermal systems, such as solar hot water heaters, on new and existing construction.

Subsidy Shifting

Oil Subsidies

Subsidies, at their best, are a government tool to encourage business activity that is in the best interests of the public at large. California's policies toward the oil industry involve subsidies at their worst – unneces-

sary for the success of the industry, damaging to the environment and public health, and wasteful of taxpayer dollars.

The State of California subsidizes oil exploration and production in three principal ways. The percentage depletion allowance permits oil companies to make business expense deductions above their actual expenses by allowing them to use a generous formula rather than an actual statement of expenses. The state allows oil refineries to exploit the manufacturers' investment credit, despite the fact that their business does not fall within the fundamental purpose of the credit. And oil companies are allowed to deduct certain investments before their value has depreciated, contrary to standard accounting practice.

These three subsidies total at least $78 million per year.[141] Each of these subsidies could be eliminated immediately with negligible effect on the oil industry's activities. The money saved could be used to increase funding for renewable energy business development.

Energy Technology Export Program

Since 1988, the CEC has had a program to assist California companies win contracts for foreign energy projects called the Energy Technology Export Program. The program has been involved in energy export sales worth hundreds of millions of dollars, with a 37-to-1 return on investments in export-stimulating activities.

The program's activities include:

- Pre-investment seed funding for qualified companies.
- Market and trade analyses.
- Overseas trade missions.
- Orientation visits for foreign energy officials and briefings with experts.
- Energy project development.

Despite the proven success of this program, it is severely limited by a lack of funding. Only $250,000 was available for all grants in 2002-03, and each applicant is limited to $25,000 for pre-construction activity.[142]

Ten other states have industrial recruitment subsidies targeting renewable energy companies. Nine of those ten programs offer more money to developing companies than California's program.[143]

With such a high rate of return, money spent on this program is a good investment in California's economic well being. The state could increase the benefits of this program by increasing its funding with money made available through the elimination of subsidies to the oil and gas industry.

Additional Policy Recommendations

Emission Standards for Micropower

Clean micropower technologies, such as solar and wind, have the potential to replace dirtier forms of distributed generation such as fossil fuel generators. To ensure that new, ultra-clean technologies are encouraged, distributed generation policy should be based on the following principles:

- Distributed generation must be as clean as or cleaner than the cleanest central power plant technology.
- Rules and incentives should promote the cleanest energy industry for the future of California.
- Regulations should be as simple as possible so manufacturers can anticipate changes and comply with new technology requirements.
- Transmission grid operators should be required to draw on clean, efficient micropower before similarly priced dirty installations.

To protect the health of Californians and the air quality of the state while helping to assure reliable local power generation, California's regional air districts should help move distributed generation in the right direction by adopting uniform emissions standards, through a rule-making process, for units smaller than 50 megawatts and larger than 70 kilowatts. Specifically, we recom-

mend the Districts follow the California Air Resources Board guidelines requiring all new distributed generation to be as clean as the cleanest central station power plant by 2007.

Participation in the Kyoto Protocol

The Kyoto Protocol contains a system for tradable credits for activities that reduce carbon emissions. These credits can cover as much as 75% of the capital costs of new renewable energy facilities.[144] Because the U.S. is not a signatory to the Kyoto Protocol, U.S. companies do not currently qualify for the credits. However, the State of California could establish a contractual agreement with the signatories to participate in the process. To do so, the state would establish a baseline of carbon emissions and a target reduction, and abide by the same conventions as full signatories. California companies could then trade credits for renewable energy development in California and elsewhere.

Research and Development

The Public Interest Energy Research (PIER) program of the California Energy Commission (CEC) was created in 1996 as part of the deregulation of California's electric utility industry to ensure that research continues on clean energy and reliable transmission. In its first years, PIER has focused largely on encouraging small-scale generation of electricity near the place where it is used. In the next five years, PIER intends to focus more on demand-side management.

The CEC should maintain its commitment to this vitally important program.

Industrial Development Bonds

The California Consumer Power and Conservation Financing Authority (California Power Authority, CPA) offered $30 million in industrial development bonds (IDBs) in 2002. This program offers tax-exempt bond financing to California manufacturers to install clean energy equipment or increase production of renewable energy components or systems.

Federal eligibility requirements for IDBs are strict. Large companies are excluded by caps on total investment, since they can usually afford standard commercial financing or issue their own bonds. New companies are excluded as a credit risk. Nevertheless, many manufacturing facilities potentially qualify for IDBs, and the spread between tax-exempt rates and conventional interest rates, typically about 3%, can add up to substantial savings for a growing company.

California Statewide Communities Development Authority (California Communities) has also issued industrial development bonds, although to date there have been no participants from the renewable energy industry. California Communities is made up of 340 members, mostly local governments. It has facilitated $12 billion in investment since inception in 1988.

Both the CPA and California Communities IDB programs have enjoyed less activity than was hoped for in setting up the programs, but they have potential to expand as the availability of this type of financing becomes more widely known.

California Technology, Trade and Commerce Agency Coordination

The California Technology, Trade and Commerce Agency (TTCA) serves as a catalyst for growth in business activity in the state. While the TTCA provides assistance to renewable energy companies, alongside of businesses from many other industries, it has no program specifically targeting renewables. Given the diversity of programs available, the renewable energy industry could benefit greatly from a study detailing opportunities for:

- Taking advantage of the Manufacturers Investment Credit.
- Siting operations in enterprise zones.
- Receiving industrial development bonds.
- Getting support from small business incubators.
- Getting support from local economic development agencies.

Appendix. California Companies Involved in Renewable Energy Industries

California renewable energy companies responding to a 2000 survey by the California Energy Commission's Energy Technology Export Program. These companies are currently exporting renewable energy products and services or intend to begin doing so. Arranged by county.

Company	City	County	Resource	Year Founded	Employees	Annual Revenue	Currently Exporting	Description
A & E International Services	Oakland	Alameda	S, W	2001	10	1-5M		Installs, maintains, and services solar and wind equipment.
California Hydronics Corp.	Hayward	Alameda	G	1957	82	25-100M		Manufacturer representatives, and manufacturor of plumbing, heating and air conditioning equipment.
Custom Power Engineering	Dublin	Alameda	S, W		5	<1M		Electrical engineering, design and consulting for emergency, back-up, stand-by, and normal power systems. Electrical power quality survey and trouble shooting.
Distributed Utility Associates	Livermore	Alameda	S, W	1993		25-100M	Yes	
Diversified Services For Africa	Berkeley	Alameda	S, W, G	1991	2	<$1M	Yes	Marketing of solar-powered lighting systems to Africa. Development of joint ventures in mineral exploration and agribusiness. Environmental consulting and training.
Environmental Development Consultants Network International	Berkeley	Alameda	S, W, G	1995		>$100M		International consultants in specialized fields relating to the regional environmental development of renewable energy resources.
Exergy, Inc.	Hayward	Alameda	G	1988	12	$5-10M	Yes	Developed and owns all patents to the Kalina cycle, a new highly efficient thermal cycle for thermal power generation.
Full Circle Solar	Oakland	Alameda	S, W	1984	3	<1M		Passive solar architecture, alternative energy production, and portable power units.
H-ION Solar Inc.	Richmond	Alameda	S, W	1983	7	$1M	Yes	Designs, installs, and services renewable energy systems based on PV, wind, and small hydro electric sources. We offer consulting and prototype development services.
Intellergy Corp.	Berkeley	Alameda	S	1985	10	<1M	Yes	Developed proprietary steam reforming to convert waste of all types into hydrogen-rich syngas that can be used to power fuel cells for electricity and heat.
International Connection	Oakland	Alameda	S	1981	6	<$1M	Yes	An energy efficiency company providing solar electric systems and products and alternative energy products.
Lawrence Berkeley National Lab./Earth Sciences Division	Berkeley	Alameda	G	1931	4,000	>$100M		A leader in science and engineering technology for more than 65 years, serving as a powerful resource for the nation's scientific enterprise.

MRW & Associates, Inc.	Oakland	Alameda	S, W, G	1986	20	1-5M		Economic and technical analysis to assess market opportunities.
Onsite Energy Services	Alameda	Alameda	S, W, G	1983	10,000	>100M		Provides technical personnel in the areas of operations, transmission, distribution, maintenance, training and other associated engineering areas.
Pleas	Oakland	Alameda	S, W	2001		1-5M		
Power Engineers, Inc.	Point Richmond	Alameda	W, G	1976	730	25-100M	Yes	A geothermal plant design specialist with expertise in transmission and distribution design, cogeneration plant design, and hydro.
Schiller Associates	Oakland	Alameda	S, W	1986	46	$1-5M		An energy consulting, engineering, and technology firm providing management and technical services for the energy industry.
Smith and Sun	Berkeley	Alameda	W	1985	2	<$1M		Large single-phase high efficiency motors, solar designs: cooking, space heating, industrial hot water, solar-thermal-electric power plants, high efficiency motors.
Sun Light & Power Company	Berkeley	Alameda	S, W	1976	20	<1M		A design/build firm with 25 years of leadership in alternative energy systems and innovative designs for homes and businesses.
Renewable Technologies, Inc.	Sutter Creek	Amador	S, W		15-25	5-10M		Design, engineering, and installation of electrical power generating systems, Alternate Energy Systems, that are connected to the electrical power grid or can stand alone.
Chico Electric	Chico	Butte	S, W	1960	54	5-10M		An electrical contractor for construction, commercial, agricultural, residential repair, and control panels.
Black & Veatch Corp	Concord	Contra Costa	S, W, G	1925	8,000	>100M	Yes	An engineering & construction contractor for electric power plants of all sizes and types.
Diablo Executive Group, Inc.	Diablo	Contra Costa	W, G	1984	6	<$1M	Yes	Project management, financing and business consulting services for all types of international energy development projects.
Energy Solutions Group, Inc.	San Ramon	Contra Costa	S, W, G	1998	5	$1-5M	Yes	Provides energy services including facility and equipment analysis, energy management, and assessment of alternative energy sources.
Environmental Resources Management (ERM)	Walnut Creek	Contra Costa	G	1977	2,500	$1M		A global environmental engineering, consulting and management organization of 2,400 specialists at more than 120 locations worldwide.
ESI Engineering Services	Walnut Creek	Contra Costa	S, W	1979	50	$5-10M		A full-service engineering and design consulting firm with extensive experience in all aspects of energy engineering.
Euro American Industries, Inc.	Alamo	Contra Costa	S, W	1995	250	25-100M	Yes	Independent power producer, developer, builder, and operator.
Global Energy Partners, LLC	Lafayette	Contra Costa	S, W, G	1998	21	1-5M		Energy consulting.
Lafayette Engineers, Inc.	Lafayette	Contra Costa	S, W, G	1980	5	$1M		Energy conservation specialists with concentration on industrial sites, including schools and hospitals.

Locus Technologies	Walnut Creek	Contra Costa	G	1997	60	10-25M	Yes	Provides comprehensive consulting, design, information management, automation, and construction services for the remediation of sites contaminated by hazardous wastes.
Nu-Tech Energy Products	Walnut Creek	Contra Costa	S, W	1985	3	<1M	Yes	Designs, engineers and furnishes equipment for low-voltage lighting solutions.
Power Quality & Electrical Systems (PQES), Inc.	San Ramon	Contra Costa	S, W, G	1990		$5-10M	Yes	A full service engineering company with skills and expertise in gas, electric, water utilities and their industrial and commercial end use customers.
TechKnowsion, Inc.	Pleasant Hill	Contra Costa	G	1995	2	<1M		Industrial automation and control systems integration, software development, SCADA.
TECO BGA	Lafayette	Contra Costa	S, W	1986	150	25-100M		An engineering and energy services company that provides design and analysis expertise for a variety of industries.
Bruce R Biau & Associates	Fresno	Fresno	S	1999	3	1-5M		Specializes in filing for energy rebate & incentives resulting from energy efficient products being installed into existing commercial and agricultural facilities.
Pistacchio Pump Co.	Sanger	Fresno	S	1932	8	<1M		Water pumps of all types sold and installed, including solar (photovoltaic) powered pumps.
Premier Control & Electric	Tollhouse	Fresno	W	1992	1	1M		Electrical contractor involved in energy management and solar electric sales and installation.
Servi-Tech Controls, Inc.	Fresno	Fresno	S	1978	65	5-10M		Energy services company and contractor.
Unlimited Energy	Fresno	Fresno	S, W	1984	3	<$1M		Designers and installers of all types of solar energy systems.
GeoEngineers, Inc.	Eureka	Humboldt	W, G	1981	200+	10-25M		An engineering and geology firm.
Six Rivers Solar, Inc.	Eureka	Humboldt	S, W	1979	12	1-5M		A design/install energy company specializing in solar hydronics, PV electrical generation, and wind systems.
Sun Frost	Arcata	Humboldt	S	1984	20	1-5M	Yes	Primarily manufactures energy efficient refrigerators that make powering a home with photovoltaics or other low output energy sources both feasible and affordable.
Sun Works	Niland	Imperial	S, W	1986	0	<1M	Yes	Provides photovoltaic/wind energy to remote sites where energy is not available or is in short supply.
Perlman & Duncan	Bakersfield	Kern	S, W, G	1997	3	<1M		Provides legal services in environmental law.
Sharpe Solar Energy Systems	Bakersfield	Kern	S	1976	12	1-5M		
AeroVironment, Inc.	Monrovia	Los Angeles	S, W	1971	165		Yes	Engineers in alternative energy project development. Includes pre-feasibility studies, due diligence, environmental permitting, bid preparation, construction management, and consulting.
Astro Pak Corporation	Downey	Los Angeles	W, G	1959	120	$10-25M	Yes	Provides cleaning & surface treatments to high purity stainless steel utility systems for cogeneration and solar.
AT Engineering Services	Long Beach	Los Angeles	S, G	1993	10	<1M		An engineering and consulting firm providing design and engineering of heat transfer and process equipment for power.
Bartin and Dell Industries	North Hollywood	Los Angeles	G	1995			Yes	Specializes in brokerage, sale, and acquisition of power plant equipment, including turbines, generators and transformers.
BIBB and Associates, Inc.	Pasadena	Los Angeles	G		45	$5-10M	Yes	A leading engineering firm in geothermal power plant design and other geothermal applications.

California Manufacturing Technology Center (CMTC)	Gardena	Los Angeles	S, W, G	1992	159	$10-25M		Non-profit consulting firm providing services to California's small and medium size manufacturers.
E.P. Industries, Inc.	El Segundo	Los Angeles	W, G	1970	12	<1M	Yes	General purpose machinery manufacturing and engineering services.
Eurorient Investment Grp./Merchant Banking Grp.	Encino	Los Angeles	S, W, G	1988	75	$25-100M		Funds infrastructure projects worldwide.
Evans Hydro	Rancho Dominguez	Los Angeles	G	1987	22	5-10M	Yes	Distributor of pumps, sales and service.
Fruchtman & Associates Consulting	Los Angeles	Los Angeles	G	1986	6	<$1M		Design, HVAC, plumbing and fire protection systems for buildings.
GEI, Inc.	Pomona	Los Angeles	S	1997		5-10M		Design, manufacture, and sales of energy efficient displays and lighting; LED's & CFL's.
ICF Consulting	Sherman Oaks	Los Angeles	S, W, G	1969	800	>100M	Yes	A management and policy consulting firm that addresses energy, environmental, community development, emergency management, and transportation concerns.
James B. Greene & Company (TransPacific Capital, LLC)	Palos Verdes	Los Angeles	S, W, G			1 M		Provides financial advisory services in the independent power and marketing areas with a particular focus on renewable resources.
Law Offices of David M. Zeligs	Long Beach	Los Angeles	S, W, G	1990	3	$1M	Yes	Law firm specializing in international trade and business.
Ledtronics, Inc.	Torrance	Los Angeles	S	1983	180	$10-25M	Yes	Designs, manufactures and packages state-of-the-art LEDs.
Los Angeles Department of Water and Power	Los Angeles	Los Angeles	S, W, G			>100M	yes	Municipal Utility; provides international knowledge transfer.
Meridian Finance Group	Los Angeles	Los Angeles	S, W, G	1993				Export financing and insurance alternatives for U.S. exporters selling into emerging and developed international markets.
Paragon Consulting Service, LLC	La Verne	Los Angeles	S, W	1996	< 50	<1M		Serves the communications, control and energy management business sectors in the electric utility industry.
Paragon Consulting Services	La Verne	Los Angeles	S, W, G	1996	9	<1M		Provides consulting services, plus performance monitoring, data collection and analysis, reporting, project management, tech assessment, business plans.
Resource Recovery Research	La Verne	Los Angeles	G	1972	5	$10-25M	Yes	Consultation and design of biodigesters for organic solids in a container.
Solar Webb, Inc.	Arcadia	Los Angeles	S, W, G	1995	6	<1M	Yes	Photovoltaic and small wind generator system design, sales, service, and installation. Utility connected systems, lighting, back-up power systems, and off-grid applications.
Specialty Lamp, Inc.	Carson	Los Angeles	S	1972	24	>100M		One of the largest lamp and ballast wholesalers.
TradeWind Insurance Brokerage	Claremont	Los Angeles	S, W, G	1998	5	1-5M	Yes	Insurance and financial risk mitigation services for renewable and alternative energy projects worldwide.
U.S. Hybrid Corporation	Torrance	Los Angeles	S, W	1999	6	$1M	Yes	Design and development of power conversion and system controls for electric and hybrid vehicles and renewable energy generation.

Asociados PanAmericanos	Sausalito	Marin	S, W	1995	20	$10-25M	Yes	
Genesis Power, LLC	Mill Valley	Marin	S, W	1998	1	<1M		Develops renewable energy projects throughout the Americas. Conduct market assessments, performs due diligence, and prepares business plans.
Kuhn & Kuhn	Fairfax	Marin	S, W, G	1980		<1M	Yes	Provides independent reviews of conservation, cogeneration and alternative energy technology projects at all stages of project development.
Princeton Energy Group	Sausalito	Marin	S, W	1992	20	$10-25M	Yes	Development of environmentally favorable energy resources, including wind, cogeneration, energy efficiency, and natural gas. Associated with Asociados Panamericanos.
Solar Works, Inc. / Princeton Energy Systems	Sausalito	Marin	S, W	1980	17			Provides complete turnkey solar electric and solar hot water systems for commercial and industrial clients. Offers systems design, contract engineering and installation services.
Taber Chaitin Associates	Sausalito	Marin	S, W	1982	20	$10-25M	Yes	
Sun Electronics, Inc.	Cathey's Valley	Mariposa	S, W	1988	20	5-10M	Yes	Distributes alternative energy systems including inverters, batteries, solar, photovoltaic, generators and wind.
Advanced Solar, Hydro, Wind Power Co.	Calpella	Mendocino	S, W	1978	6	5-10M	Yes	Design, sales, and installation of solar, hydro, wind & fuel cell, electric and thermal systems worldwide.
Cheapestsolar.com	Calpella	Mendocino	S, W	1998	5	<1M		Solar, hydro, wind, and fuel cell electrical systems & components.
Real Goods Trading Corp.	Ukiah	Mendocino	S, W	1978	80	$10-25M	Yes	Environmental products, energy efficiency water conservation, renewable energy design, consulting, sales and installation infrastructure development.
Zapsucker.com	Calpella	Mendocino	S, W	1998	5	1-5M		Solar, hydro, wind, fuel cell electrical systems & components for utility inter-tie systems. Systems up to 200 kW.
R.T. Maher Construction	Merced	Merced	S	1988	10	<1M		Solar thermal heating and solar electric installations, residential and commercial.
Clean Power Research, LLC	Napa	Napa	S, W					Designs analytical methods to evaluate clean energy investments and builds software programs based on these methods. The tools are used for marketing and market analysis.
Sierra Solar Systems	Nevada City	Nevada	S, W	1980	6	$1-5M	Yes	Full line solar, wind, and hydropower. System design and supply.
Ameren Data & Metering Specialties	Huntington Beach	Orange	W, G	1999	20	$1-5M		Meter Service Provider, including testing and certification, sales, installation and service of all types of electric meters.
C3 Technology Transfer Specialists, Inc.	Anaheim Hills	Orange	S, W, G	1997	15	$25-100M		Designs & builds solar power systems; designs & produces solar products and inverters.
Dana Technologies Inc	San Juan Capistrano	Orange	G	1984	5	<1M		Energy systems engineers: performance studies, analysis, plant design; data acquisition, monitoring, control systems; economic studies, fluid flow, heat & mass balance studies.
George M. Stevens & Associates	Newport Beach	Orange	S, G	1986	1	$1M		Manufacturers' representative for equipment suppliers to electric power generation companies who build combined cycle, peaking, and utility plants.

Global Tradelinks Corp.	Fullerton	Orange	S, W, G	1995			Yes	Energy consultants and exporters of equipment for power and other industrial plants.
Lam Lighting Systems, Inc	Santa Ana	Orange	S	1974	110	10-25M	Yes	Indirect lighting, energy efficient ballasts & lamps.
Pulizzi Engineering, Inc.	Santa Ana	Orange	W	1973	47	$5-10M	Yes	AC power distribution and control systems for mainframe computer systems.
Solartrope Supply Corporation	Orange	Orange	S, W	1981	6	$1-5M	Yes	Wholesaler of all solar energy equipment and conservation devices.
SPEC Services, Inc.	Fountain Valley	Orange	S, W, G	1981	150	10-25M		Environmental, mechanical, and electrical engineering and design services.
Team China/USA, Inc.	Tustin	Orange	S, W	1995	7	$1-5M	yes	Provides project management, financial services, engineering supervision, government relations and approval guidance for power plant development in China.
Technology Transfer Ltd.	Fullerton	Orange	S, W, G	1992	1	<$1M	Yes	Technology transfer, supply, erect and fast run of wind and solar power plants.
Ultra-Research, Inc.	Atwood	Orange	S	1985	5	<$1M		Provides business intelligence and market research services for high technology products and processes with a particular emphasis on energy and pollution control technologies.
WEECO	Santa Ana	Orange	S, W, G	1984	10	10-25M	Yes	Energy system design, energy audits, environmental system design, environmental assessment and audits.
World Energy, Inc.	Mission Viejo	Orange	W, G	1997	10	$1-5M	Yes	Provides consulting to energy related products and services.
Theroux Environmental	Auburn	Placer	S, G	1994	1	<1M		Renewable resource utilization & process integration. Regulatory pathway development & permitting. Early commercialization & tech transfer assistance.
Vermeulen (Philip M.), Governmental Relations	Roseville	Placer	S, W	1994	2	<$1M		Conservation, biomass, geothermal, cogeneration and photovoltaic, with an emphasis on governmental relations.
AAA SolAar, Inc.	Hemet	Riverside	S, W	1991	2	<$1M		Sales & services in PV, solar thermal and wind.
ASC	Temecula	Riverside	S, W, G	1989	11	1-5M		An executive search firm specializing in identifying key personnel for executives in the energy related and regulated utility field.
Holt Group	Blythe	Riverside	G	1983	25	1-5M		A general practice civil engineering firm.
Mohr Power Solar	Corona	Riverside	S, W	1982	10	$1-5M		A full service energy provider. Designs, engineers, installs and serves a wide variety of solar electric, pool and hotwater systems.
Transnational Environmental Corporation	Corona	Riverside	G	1979	20	$10-25M	Yes	Environmental projects for recycled material processed into energy. Brownfield development projects.
WECS Electric Supply, Inc.	Banning	Riverside	S, W	1989	2	1-5M		An engineering company and supplier of components and systems for maintenance, service, retrofit and construction of domestic and international windfarms and wind turbines.
AnuPower Corporation	Carmichael	Sacramento	S	2000	10	<$1M		Renewable energy & fuel integration company.
Oscar Larson & Associates	Sacramento	Sacramento	W	1945	20	$1-5M	Yes	Provides project planning services, civil engineering, consulting and design services, and comprehensive land surveying services.

Solar Depot - Sacramento	Sacramento	Sacramento	S, W	1983	7	$1-5M	Yes	A wholesale distributor, system designer and system integrator for solar electric and solar thermal systems we offer.
Automated Systems Technologies	Rancho Cucamonga	San Bernardino	S, W	1985		1-5M		
Innovative Engineering, Inc.	Chino	San Bernardino	S, W, G	1965	11	1-5M		A control system engineering firm.
Lighting Resources, Inc.	Ontario	San Bernardino	S	1990	12	$1-5M		Lamp and ballast recycler. Also recycles CPUs, batteries and liquid mercury.
Solartech3000	Redlands	San Bernardino	S, W	1998			Yes	Provider of news, education, solar services, free consultation and windpower.
United States Solar Corp - South West Solar Corp.	Joshuatree	San Bernardino	S, W	1994	12	1-5M	Yes	Residential, commerical, industrial solar energy products and systems. Exports to Latin America.
AAPS Alternative Power Systems	Carlsbad	San Diego	S, W	1996	150	$5-10M	Yes	Serves businesses, electrical contractors, municipalities, and science communities; participates in direct contract manufacturing energy-related products; provides funding.
Alternative Energy Systems Consulting, Inc.	Carlsbad	San Diego	S, W, G	1994	16	$1-5M	Yes	An engineering and project development firm devoted to providing technical services to government agencies, energy service providers and end-users.
Alturdyne	San Diego	San Diego	W	1971	85	10-25M	Yes	Custom assembler of engine power units. Manufactures micro turbines and rotary engines. Package a hybrid engine/electric motor chiller.
Antoni International, Inc.	San Diego	San Diego	G		3	1-5M		
ASAP Power	Oceanside	San Diego	S, W	1997	69	<1M	Yes	Products and services for most renewable energy and sustainable power industries, energy trading markets, and efficient power delivery schemes.
Captain Voltage Electric	San Diego	San Diego	W	1992	5			Installs photovoltaic solar systems. Complete residential, commercial and industrial applications.
Divpower, Inc.	Santee	San Diego	S, W	1999	1	$1M	Yes	Design and engineering of solar power systems and all other solar products, lights and inverters.
Environment Business Int'l, Inc.	San Diego	San Diego	S, W	1987	14	1-5M		Conducts market research and management consulting for companies in the environmental, renewable energy and resource productivity industries.
Eskinder Berhanu & Associates (EBA)	San Diego	San Diego	G	1994	2	1M		
Hi-Z Technology, Inc.	San Diego	San Diego	S, G	1986	20	1-5M	Yes	Develops, manufactures, and sells commercial thermoelectric generating modulesy.
Horizon Industries	Escondido	San Diego	S, W	1984	10	$1M-5M		Solar thermal collector and active hot water system components. Active and passive solar heating. Photovoltaic component and design catalog for mail order complete systems.
Hyspan Precision Products, Inc.	Chula Vista	San Diego	G	1968	300	$25-100M	Yes	Manufacturer of metal bellows, metal hose, pipe expansion joints, ball joints, and ventures.

International Thermal Instrument Co.	Del Mar	San Diego	G	1969		$1M	Yes	Supplier of "K" Factor equipment for testing building walls, thermal conductivity testers for insulation, heat loss measuring instruments, and thermoelectric calorimeters.
Kleinfelder, Inc.	San Diego	San Diego	G	1961	1,400	>100M		An environmental and geotechnical engineering, material testing and construction management firm.
Leading Edge Engineering, Inc.	Poway	San Diego	W, G	1993	3			Provides engineering and technical expertise to help industrial and small businesses solve complex technical problems and develop/improve their products.
Mark Snyder Electeric	Escondido	San Diego	S	1979	15-35	1-5M	yes	A full service contractor providing service to both residential and commercial customers. Provides and installs solar panels, wind generators and standby generators.
Reotemp Instrument Corporation	San Diego	San Diego	G	1965	35	5-10M	Yes	Manufacturer of bimetal thermometers and supplier of pressure gauges, diaphragm seals, pressure switches, thermowells, vapor & gas actuated thermometers, and other accessories.
Science Applications International Corporation	San Diego	San Diego	S	1969	41,000	>100M	Yes	A high technology engineering consulting company working in the fields of energy, environment, transportation, communications and information technology.
Brown, Vence & Associates	San Francisco	San Francisco	S	1979	22	$1-5M	Yes	An energy and waste management consulting firm providing both energy efficiency and energy supply-side services.
Eley Associates	San Francisco	San Francisco	S	1976		1-5M	Yes	
Glumac International	San Francisco	San Francisco	S, W	1971	175	10-25M	Yes	Provides consulting engineering services to a wide range of commercial, institutional and industrial clients.
Latham & Watkins	San Francisco	San Francisco	S, W, G	1934	2,656	>100M	yes	Law firm serving all aspects of fossil and renewable energy industries.
Nexant, Inc.	San Francisco	San Francisco	S, W	2000	180	25-100M	Yes	Delivers targeted services to the energy sector "both onsite and online" in the areas of strategy, economics, engineering and advanced energy.
URS Corporation	San Francisco	San Francisco	S, W, G	1904	15,600	>$100M		Planners, engineers, architects, scientists and program and construction managers.
Servamatic Solar (Hydro Magic)	Lodi	San Joaquin	S, G	1986	9	<1M		Service and installation of solar energy equipment, photovoltaics, solarthermal, energy efficiency and water pumping by solar electric vehicle.
Fisher Electric	Creston	San Luis Obispo	S, W	1981	6	>100M		Electrical designs and installation for industrial and residential systems. Specializes in complex design in solar.
San Luis Sustainability Group	Santa Margarita	San Luis Obispo	S	1976	5	$1M	Yes	Architects practicing sustainable planning of green architecture.
Solar Cell Sales.com	San Miguel	San Luis Obispo	S, W	1998	2	<1M	Yes	Distributes products from numerous manufacturers.
Source California Energy Services, Inc.	San Luis Obispo	San Luis Obispo	W, G	1997	25	$10-25M		Identifies and implements facility upgrade and modernization projects in power generating facilities for power providers, government agencies and major power consumers.

TransTech Controls, LLC	San Luis Obispo	San Luis Obispo	S, W	1	5	<1M	Yes	Provides wireless control and energy management solutions for small business and residential users.
HSQ Technology	South San Francisco	San Mateo	S	1979	102	$25-100M	Yes	Develops and implements information, control, and communication systems for resource management in public facilities, including large complexes, utility systems and transit systems.
Independent Power Associates, Inc.	South San Francisco	San Mateo	W	1991		1-5M	Yes	
Noresco	South San Francisco	San Mateo	S, W, G	1984	300+	>100M	Yes	An energy services company.
SDV-SCC, Inc.	San Mateo	San Mateo	G	1992	7	<$1-5M		Services, commodities and consulting to prime contractors requiring DVBE assistance.
Environmental Co., Inc., The	Santa Barbara	Santa Barbara	W, G	1991		10-25M	Yes	
Logan Capital Corporation	Santa Barbara	Santa Barbara	W, G	1991	1			Provides investment banking services, including debt and equity placement, to landfill gas, wind and energy conservation developers in domestic and international markets.
Ecoenergies / P.V.I.	Sunnyvale	Santa Clara	S, W	2000	20	$1-5M	Yes	Sales of renewable energy systems (wind, mini-hydro, solar, hybrids), their component parts, and installation for residential, commercial, government and rural/village applications.
Energy Savers International	Mountain View	Santa Clara	W	1999	2	$1M		Develops and markets intelligent controllers to improve energy efficiency of air conditioners and heat pumps.
Enertron Consultants	Los Altos	Santa Clara	S, W, G	1987	1	<$1M		Renewable energy consulting, marketing and economic analysis. System integration of photovoltaic systems.
Fluid Industrial Systems, Inc.	San Jose	Santa Clara	G	1989	89	$10-25M	yes	Designs, engineers, manufactures, installs and services custom chillers and heat exchangers for the biotech, electronic, and pharmaceutical industries.
International Energy Systems Corp. (IESC)	San Jose	Santa Clara	S, W, G	1976		<1M		
ML Consulting Group	Sunnyvale	Santa Clara	S, W	1988	1	<$1M	Yes	Provides independent consulting services in energy efficiency, renewable resources and conventional resources in the context of power system planning and operations.
Preferred Energy Services, Inc.	San Jose	Santa Clara	S, W	1988		5-10M	Yes	
SFA Pacific, Inc.	Mountain View	Santa Clara	W	1980	10	1-5M	Yes	Consulting firm providing services in energy and fuel technology evalution and evaluation of economic markets. Services provided in strategic energy and fuels planning.
TASCO Energy Solutions	Los Altos	Santa Clara	S, W	1997	4	<$1M	Yes	Specializes in chiller and air conditioning system optimization
U.S. Energy Controls	San Jose	Santa Clara	S	1992	7	$1M	Yes	Engineering firm focused on energy production and conservation.
Electron Connection	Hornbrook	Siskiyou	S, W	1976		<$1M	Yes	Load analysis, site survey, system design, sales, installation, user training and tech support for renewable energy systems.

Katabatic Farm Co., The	Vallejo	Solano	W	2001	1	<1M		Planning the development and construction of ultra-highspeed wind turbines and electrolysis infrastructure for the use on the continent of Antarctica to harvest the Katabatic winds.
Another Planet	Forestville	Sonoma	S	1987		<1M		Lighting designer / manufacturer.
Custom Lightstyles	Santa Rosa	Sonoma	S	1996	2		Yes	Lighting designers and manufacturers.
Hollysolar Products Suntronics	Petaluma	Sonoma	S, W	1974		1-5M	yes	Solar electric manufacturers. Specializing in low voltage white LED lighting and complete solar integration.
RAES (Rhodes Alternative Energy Solutions)	Sebastopol	Sonoma	S, W	3	4	<1M		Consulting, design and installation of emerging renewable energy systems for residential and commercial projects.
Sebastopol Heat & Cool	Sebastopol	Sonoma	S	1998	5	<1M	Yes	Provides energy savings via HVAC equipment and photovoltaic power generation.
Pacific Energy Products	Tulare	Tulare	S, W	1991		<1M		Retail sales of renewable energy products. Manufacturing of related products. Package and system design.
California Trade Development Association	Jamestown	Tuolumne	S, W	2000			Yes	Association of manufacturers/businesses in California that supply pollution control/reduction equipment products and professional services to export to the Pacific Rim.
Gary W Danielson & Associates, L.P.	Jamestown	Tuolumne	S, W	1985	6	1-5M	Yes	Exporters and joint-venturers of pollution control equipment, water & wastewater package plants using alternative energy sources and waste-to-energy facilities using new technologies.
Sonora Solar Systems, Inc.	Sonora	Tuolumne	S	1977	35	1-5M		Supplier of solar equipment and services, including solar pool heating systems.
Building Industries Solar, Inc.	Simi Valley	Ventura	S	1989	49	$1-5M		The largest volume distributor and installer of solar hot water systems in the nation. Also installs "in-deck", photovoltaic and heliocol solar pool systems.
Day Light Control Systems	Moorpark	Ventura	S	1995	5	$1M	Yes	Engineers and designs photo diode light sensors and controls for lighting.
Solar Electrical Systems	Thousand Oaks	Ventura	S	1989	8	$1-5M	Yes	Design, sales and installation of grid-tied PV systems.
California Environmental Consulting Associates, Inc.	West Sacramento	Yolo	S, W, G	1998	10	<$1M	Yes	Provides environmental/energy consulting services and export marketing of U.S. manufactured products.
Davis Energy Group, Inc.	Davis	Yolo	S, W	1981	15	$1-5M	Yes	A mechanical engineering firm specializing in energy-efficiency design, product development and testing, market transformation, and energy analysis.
Paco Pumps	West Sacramento	Yolo	G	1907	250	25-100M	Yes	Manufacturer of high efficiency pumps.

Resource key: S = solar PV, W = wind, G = geothermal.

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