generation solar electric system reduces demand for electricity from the grid during peak periods of demand, customers with time-of-use rate pricing can take advantage favorable net metering rates. Pacific Gas and Electric, for example, offers residential customers with PV installations up to 1 MW a time-of-use net metering rate that values solar energy produced during peak periods at a rate three times higher than during non peak periods.[231] Utilities support distributed generation because projects can come on line quickly, reduce peak load demand, and contribute to RPS goals. However, PV remains more expensive per MWh[232] (Figure 4.9), which is a major barrier to widespread adoption despite numerous economic incentives.

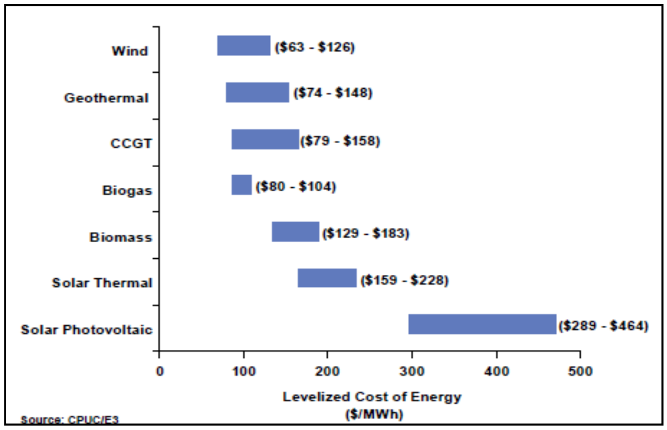

Figure 4.9 Developer Levelized Cost of Generation by Technology Type. The cost of PV for distributed generation per MWh of electricity produced is currently significantly higher than for other renewable energy resource technologies, including solar thermal used in utility-scale applications.

California's Incentives for Distributed Generation

During the period from 1990 through 1999, overall electricity demand in California increased by 11.3 percent while electric generating capacity decreased by 1.7 percent over the same period.[233] The imbalance between electricity supply and demand came to a head during California's energy crisis of 2000 to 2001, when the state endured rolling blackouts during the summer peak demand periods. Skyrocketing wholesale electricity costs forced utilities to limit supply to customers who enjoyed artificially low, regulated electricity billing rates. Wholesale electricity market prices exhibited "significant departures from competitive pricing during the high-demand summer months and near-competitive pricing during the lower-demand months" between 1998 and 1999 and increased significantly in 2000.[234] This increase was likely due to rent-seeking behaviors and inequitable market power among generators in the recently restructured market rather than to rising fuel costs or environmental costs. While an in-depth discussion of California's energy market restructure and consequences is outside the scope of this review, it is worth noting for its contribution to the energy crisis and the subsequent policies created to address market failures and increase alternative, competitively priced distributed electric generation capacity. Today, not only is distributed generation important for California's energy security, it is a boon to the state's economic development and plays a significant role in meeting renewable energy goals.

As policy measures are introduced and extended to reduce uncertainties and enable widespread adoption of solar technologies, opportunities for improvements and investment in the distributed generation solar market arise. As with utility-scale projects, the PV market creates a value chain starting with research and development, followed by investment, material supply and manufacturing, project development, labor and installation, legal, financial and environmental consulting, and ultimately, the consumer. Rapid evolution of the industry over the past decade coupled with uncertainty of policy incentives and market externalities over the extended economic life cycle of product creates points throughout the value chain that are dependent on favorable policy and incentives. The market for PV is growing rapidly in California (Figure 4.10) with the support of progressive and ambitious renewable energy goals. California's incentive programs (Table 4.4) and pricing policies (Table 4.5) for distributed generation resulted in over 24,000 distributed PV installations with a combined capacity of 459 MW between 1998 and 2008.[235] California's innovative programs targeted specifically at adoption of residential solar power also support a growing workforce of specialized distributers and installers.

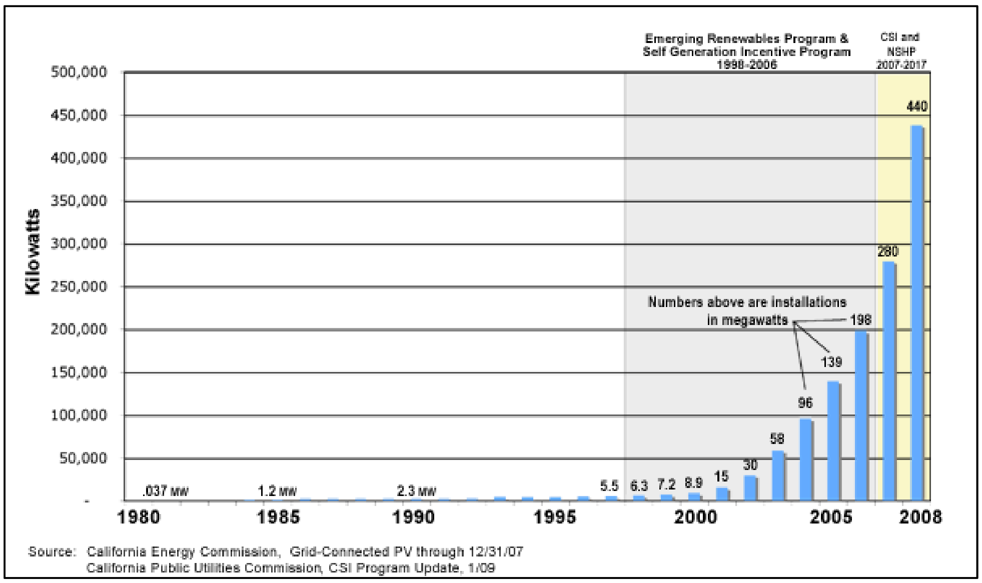

Figure 4.10 Grid-Connected Solar Photovoltaic Installed Capacity in California-Cumulative by Year, 1981to 2008. Market penetration of PV systems is rapidly accelerating. California's goal is to reach 3,000 MW of installed capacity by 2020.

Emerging Renewables Program

In 1998, the California Legislature created the Emerging Renewables Program (ERP), which established an incentive fund managed by the CEC to support installation of household-sized (less than 30 kW) photovoltaic systems, among other technologies. The program required California's major utilities to contribute a total of $540 million collected from ratepayers to an Emerging Renewable Resources Account between 1998 and 2001. The goal was to stimulate the near-term market for PV systems and "encourage manufacturers, sellers, and installers to expand their operations and reduce their costs per unit."[236] While the ERP was expanded to $135 million per year through 2011, other programs came online to support the growing market for distributed generation.

Table 4.4 California Programs Incentivizing Distributed Photovoltaic Systems.[237,238]

Emerging Renewables and Self-Generation Incentive Programs 1998 to 2006	•Provided rebates for residential installations •The CEC offered rebates for PV systems <30kW •The CPUC offered rebates for renewable energy systems >30 kW •192,792 kW of grid connected PV by 2006
California Solar Initiative 2006 to Today	•Provides an up-front Expected Performance-Based Buydown payment for smaller systems OR Performance-Based Incentive payments for larger systems •Payment values decrease over time as installed capacity increases •Includes New Solar Homes Partnership Program to incentivize installation of PV on new construction •Available to customers of IOUs •299.2 MW of grid connected PV as of February, 2010
Property Assessed Clean Energy Financing 2008 to Today	•The state adopted AB811 in 2008, which allows municipalities to sell bonds to finance a renewable energy and energy efficiency loan fund •Property Assessed Clean Energy financing allows property owners living in participating municipalities to obtain low-interest loans and repay them through a special assessment on the property •Repayment obligation stays with the property in the event of a sale

Table 4.5 Economic Incentives for Distributed PV Installation .

Net Metering	•Beginning in 1996, customers with small systems (less than 1MW) are allowed to feed excess generation back to the grid and earn credit against electricity used on site •Credit from one billing cycle is rolled into the next and the customer has the option to cash out credit balance after a 12-month period
Feed-In Tariff	•Production incentive established in 2006 for customer-generators •Currently allows owners of small systems (up to three MW) to enter into 10-, 15-, or 20-year contracts for sale of electricity to utility •Price paid is based on CPUC MPR and is adjusted for time-of-use to reflect value of electricity during peak demand periods
Residential Financing	•Lowers up-front costs and likely reduces utility bills in the future •Property Assessed Clean Energy financing enabling legislation was passed in California in 2008 and is a model for many other states •Several additional options with improved or streamlined structures are coming to market for residential PV financing

Self Generation Incentive Program

The rolling blackouts of the early 1990s occurred during the summer months, when peak demand exceeded supply. As a response, and in addition to establishing a RPS, the CPUC established the Self Generation Incentive Program (SGIP) in 2001 to bring new distributed generation capacity online. The program continues to provide up-front capital costs for ratepayer-owned, grid-connected distributed generation projects. Utilities benefit from an offset to peak demand wholesale market pricing impacts and, as a result, ratepayers benefit because utilities have less need to build new utility-scale generation capacity that would likely result in a rate increase. The SGIP complimented the ERP by providing incentives for qualifying solar PV systems with up to one MW capacity between 2001 and 2006. Although the program continues to offer incentive payments to other generation technologies, PV projects no longer qualified when California Solar Initiative was established in 2006. By 2008, completed PV projects accounted for 133 MW (40 percent) of SGIP capacity, contributed 197,178 MWh to California's statewide energy use, resulted in 65 percent of the SGIP's greenhouse gas emission reductions, and developers received a total of $454 million in incentive funding (76 percent of total).[239]

California Solar Initiative

The annual statewide production capacity for solar energy reached 1,868 MW by 2006. At this point, incentives for residential and commercial customer-owned solar PV were relocated to the new California Solar Initiative (CSI) program, established by the CPUC and the CEC, in order to better serve the needs of the market. The goal for the CSI is to install an additional 3,000 MW of distributed generation capacity and include solar PV on 50 percent of new homes built by 2020. The 10-year program was allocated $2.17 billion (2007 to 2016) to enable utilities to provide direct incentives to consumers for PV and non-PV technologies, fund low-income solar programs, pilot a solar water heating program, and stimulate research, development and deployment.[240] The diversity of rebate, grant and loan programs included in the CSI encourages growth of the solar industry in a number of market sectors and technologies for residential and commercial applications. The CSI framework encourages manufacturers to improve performance because the incentives are based on performance (kWh produced) rather than nameplate capacity. This framework benefits the industry as a whole by rewarding manufacturers that can deliver the least cost, highest performing products that are essential for creating a self-sustaining industry. In addition, the incentive payments are scaled to favor early adopters since payments decrease as the total number of MW installed increases.

Net Metering

Net metering (or co-energy metering for publicly owned utilities) laws passed in 1996 in California allow IOU and public utility customers with small PV systems (less than 1 MW) to put any excess energy generated on the electric grid and carry the net generation forward to their next energy bill. Since there are no interconnection, standby or other charges to the customer, this significantly lowers the payback period for residential and commercial PV installation and encourages property owners to install PV. The safety and manageability concerns often cited by utilities concerned about the impacts of cumulative inputs to the grid are addressed through an aggregate capacity limit of the utility's peak demand. Originally, the cap was set at 2.5 percent of a utility's peak demand and some utilities were close to reaching the cap in 2009. Solar advocacy groups lobbied the state to increase the cap to 10 percent and avoid the roadblock to reaching the 3,000 MW of new solar capacity goal set by the CSI. When a bill to raise the cap was introduced to the state assembly, Assemblyman Skinner stated "according to recent estimates by the PUC, each IOU share of the 3,000 megawatt goal represents between 4.5 to five percent of the utility's aggregate peak load. Even with the grant program created under the CSI and federal tax credits, distributed generation solar is not economical for the customer generator unless the utility participates in some form of a buy-back program such as net-metering."[241] Although Skinner's bill sought to increase the cap to 10 percent, the legislature passed a revised cap of five percent in February 2010.

Utilities and some customers resisted more significant increases to the net metering cap because, some believe, it creates a disparity among electricity customers when those who do not have renewable energy installed for net metering are effectively subsidizing the electricity use of those who do.[242] While Pacific Gas and Electric and Southern California Edison supported increasing the cap to five percent through 2010, they called for additional studies of not only the economic impacts of the program but also the impacts on grid stability, which might be impacted by voltage spikes created by multiple residential systems. Matching the feed-in-tariff caps to the desired distributed generation installed capacity is important for avoiding boom-bust cycles in the solar PV industry. Property owners are heavily incentivized by the net-metering program which drives the market for residential PV installation.

Feed-In Tariffs

Feed-in tariffs (FIT) are used around the world to incentivize and streamline incorporation of renewable energy in existing electricity grid networks. In the United States, the basic requirements include a requirement for a utility to purchase electricity from renewable energy generators, payment guarantees and assurance of access to the grid.[243] California adopted FIT legislation in 2006 and starting in 2010 it will include all IOUs and publicly-owned utilities serving more than 75,000 customers. Customers with solar thermal electric or photovoltaic systems (among other eligible renewable technologies) may enter into 10-, 15-, or 20-year contracts to sell the electricity and associated Renewable Energy Credits to the utility. The 2009 amendments to the 2006 legislation increased the maximum generation capacity of the customer-owned systems from 1.5 MW to three MW and also allows for the system to be located off-site from the customer's property as long as the system is within the service area of the contracted utility. The tariff rate is based on market prices with time-of-use adjustments which provide a higher rate during peak demand periods. The mechanism is specifically directed towards assisting utilities with meeting RPS goals and will be available until the statewide cumulative capacity installed equals 750 MW.[244]

The provisions of California's amended FIT expand solar market opportunities by increasing the number of potential projects and, because of the certainty afforded by a sales contract, provide leverage for capital by developers. The FIT compliments California's RPS goal by offering alternatives to utility-scale developments that face project financing uncertainty, high contract failure rates, permitting delays, and market concentration. In addition, RPS policy alone limits the potential for renewable energy development because utilities employ a competitive bidding process for projects that "increase the return on investment requirement, which ultimately increases the required payment price. These high transaction costs also make it difficult for smaller investors to participate."[245] However, the payment structure in California may not be sufficient for attaining the desired market results. California's FIT payment structure is based on the utility's avoided cost rather than the actual cost of the project. As a result, the returns are based on market electricity prices and the variability increases the uncertainty for investors.

Residential financing programs

The California legislature AB 811 in 2008 and gave local municipalities the authority to establish Property Assessed Clean Energy financing districts. This innovative financing mechanism allows municipalities to sell bonds and create a lending fund for property owners who wish to install energy efficiency measures or renewable energy technologies. The money borrowed from the local government is paid back through a special tax assessment and the loan is senior to any other debts, including the mortgage. One advantage of this kind of lending is that the 20-year payback obligation can be transferred to a new owner in the event of a property sale, which incentivizes investment in systems with a long payback period such as PV and solar hot water heaters. The financing also helps property owners overcome the high up-front costs associated with installing PV systems.

Private sector start-ups are beginning to enter the market for residential financing and will offer homeowners additional options and structures for obtaining low-cost capital for PV systems. One alternative recently offered by SunRun, Inc. in California is third-party ownership of the solar PV system. The structure involves establishing a power purchase agreement whereby the homeowner provides a down payment and agrees to purchase electricity produced by the system at a locked-in rate over 18 years.[246] SunRun installs, owns, and maintains the system, thus reducing overall costs for the homeowner. This approach may prove to be an attractive complement or alternative to PACE financing. Additional financing structures are summarized in Table 4.6.

Table 4.6 Advantages and Disadvantages of Residential PV Financing Structures.[247]

Residential PV Matrix from Homeowners' Perspective	Purchase with Cash	Home Equity Loan	Solar Lease	Residential PPA- SunRun Power Plan	Property Tax Model- PACE	PSE&G Solar REC Loan Program
Up-front cost to homeowner	36-70%	None/Low	0-20%	5-25%	None/Low	36%
Homeowner has maintenance responsibilities	Yes	Yes	Depends on program	No	Yes	Yes
Homeowner Pays for Inverter Replacement	Yes	Yes	Depends on program	No	Yes	Yes
Likely impact on future utility bills*	Lower	Lower	Lower	Lower**	Lower	Lower
Required cash payments (above utility bills)	No	Yes- loan payment	Yes- lease payment	Yes- electricity payment	Yes- property tax payment	No- although annual true-ups possible
Ownership of PV system in Year 1	Yes	Yes	No	No	Yes	Yes
Take residential federal tax credit	Yes	Yes	No	No	Yes***	Yes***

*** Compared to buying 100% of the electricity from the local utility. This does not mean that other costs, such as a loan or lease payment will be 100% offset by retail utility bill savings.**
**** The third-party PPA ownership model assumes that retail electricity prices will exceed the PPA price. While likely unless structured as a fixed discount to retail prices, it is not guaranteed.**
***** Based on the proposed changes to the subsidized energy financing concept in the stimulus bill.**

The Future of Utility-Scale Solar Development in California

After a promising year in 2008, developers have been stalled by delays over permits and siting decisions by the BLM, which has created uncertainty in project timelines for developers and investors. Pressure has grown as developers try to bring power on line in time to take advantage of the December 31, 2010 deadline for production tax credits. Pressure also grew among IOUs to secure their target RPS, which led to a record number of new power purchase agreements, some of which had contract prices above the MPR, with facilities located on public lands throughout the desert. Once the policies regarding permitting of solar project development on public lands are established, it is likely that a secondary push for utility-scale development on public land will ensue if conditions are favorable and result in a lower LCOE compared to private land development. Key factors in determining project costs, and by

[221] Department of Interior. 2009. Creating a New Energy Frontier. Retrieved 17 February 2010. <http://www.doi.gov/budget/2010/10Hilites/DH025.pdf>
[222] Department of Interior. 2009. Secretarial Order 3285: Renewable Energy Development by the Department of Interior. Retrieved 17 February 2010. <http://doi.gov/news/pressreleases/loader.cfm?csModule=security/getfile&pageID=5759>
[223] Department of Interior. 2010. New Energy Frontier. Retrieved 17 February 2010. <http://www.doi.gov/budget/2011/11Hilites/DH003.pdf>
[224] California Department of Conservation. 2007. Williamson Act Program. Retrieved 17 February 2010. <http://www.conservation.ca.gov/DLRP/lca/Pages/Index.aspx>.
[225] California Department of Conservation. 2007. Williamson Act Program. Retrieved 17 February 2010. <http://www.conservation.ca.gov/dlrp/lca/basic_contract_provisions/Pages/Index.aspx>.
[226] California Department of Conservation. 2007. Williamson Act Program. Retrieved 17 February 2010. <http://www.conservation.ca.gov/dlrp/lca/basic_contract_provisions/Pages/Index.aspx>.
[227] Woody, Todd. 2009. Desert Vistas vs. Solar Power. The New York Times. 21 December 2009. Retrieved 21 December 2009. <http://www.nytimes.com/2009/12/22/business/energy-environment/22solar.html?_r=1>.
[228] State of California Public Utilities Commission, 33% *Renewables Portfolio Standard Implementation Analysis Preliminary Results*, 2009, http://www.cpuc.ca.gov/NR/rdonlyres/1865C207-FEB5-43CF-99EB-A212B78467F6/0/33PercentRPSImplementationAnalysisInterimReport.pdf, 20.
[229] State of California Public Utilities Commission, 33% *Renewables Portfolio Standard Implementation Analysis Preliminary Results*, 2009, http://www.cpuc.ca.gov/NR/rdonlyres/1865C207-FEB5-43CF-99EB-A212B78467F6/0/33PercentRPSImplementationAnalysisInterimReport.pdf, 1.
[230] State of California Public Utilities Commission, 33% *Renewables Portfolio Standard Implementation Analysis Preliminary Results*, 2009, http://www.cpuc.ca.gov/NR/rdonlyres/1865C207-FEB5-43CF-99EB-A212B78467F6/0/33PercentRPSImplementationAnalysisInterimReport.pdf, 1.
[231] Pacific Gas and Electric, "E-6 Electric Schedule," http://www.pge.com/tariffs/tm2/pdf/ELEC_SCHEDS_E-6.pdf (accessed March 29 2010).
[232] State of California Public Utilities Commission, 33% *Renewables Portfolio Standard Implementation Analysis Preliminary Results*, 2009, http://www.cpuc.ca.gov/NR/rdonlyres/1865C207-FEB5-43CF-99EB-A212B78467F6/0/33PercentRPSImplementationAnalysisInterimReport.pdf, 73.
[233] Energy Information Administration, "Status of the California Electricity Situation Background," http://www.eia.doe.gov/cneaf/electricity/california/background.html.
[234] Severin Borenstein, James B. Bushnell, and Frank A. Wolak, "Measuring Market Inefficiencies in California's Restructured Wholesale Electricity Market," *The American Economic Review* 92, no.5 (2002): 1376-1405.
[235] Ryan Wiser and others,, *Tracking the Sun II: The Installed Cost of Photovoltaics in the U.S. from 1998-2008*, Lawrence Berkeley National Laboratory, http://eetd.lbl.gov/ea/emp/reports/lbnl-2674e.pdf, 7.
[236] California Energy Commission, "More Info about the Emerging Renewables Program," http://www.energy.ca.gov/renewables/emerging_renewables/more_info.html.
[237] California Solar Statistics, http://www.californiasolarstatistics.ca.gov/reports/2-03-2010/Dashboard.html (accessed Februar 5 2010).
[238] State of California, "California Energy Almanac," http://www.energyalmanac.ca.gov/ (accessed February 5 2010).
[239] Itron, Inc., *CPUC Self-Generation Incentive Program Eighth-Year Impact Evaluation Revised Final Report*, 2009, 5-28.
[240] Go Solar California, The California Solar Initiative, http://www.gosolarcalifornia.ca.gov/csi/index.html.
[241] California State Assembly, Assembly Bill 560 (Skinner), April 20 2009.
[242] California State Assembly, Assembly Bill 560 (Skinner) Bill Analysis, April 20 2009. http://info.sen.ca.gov/pub/09-10/bill/asm/ab_0551-0600/ab_560_cfa_20090417_124445_asm_comm.html.
[243] Cory Karlynn, Toby Couture, Claire Kreycik, *Feed-in Tariff Policy: Design, Implementation and RPS Policy Interactions*, National Renewable Energy Laboratory, 2009.
[244] Database of State Incentives for Renewables and Efficiency, California Feed-In Tariff. http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=CA167F&re=1&ee=1 (accessed 28 February, 2010).
[245] Cory Karlynn, Toby Couture, Claire Kreycik, *Feed-in Tariff Policy: Design, Implementation and RPS Policy Interactions*, National Renewable Energy Laboratory, 2009.
[246] Jason Coughlin and Karlynn Cory, *Solar Photovoltaic Financing: Residential Sector Deployment*, National Renewable Energy Laboratory, 2009.
[247] Jason Coughlin and Karlynn Cory, *Solar Photovoltaic Financing: Residential Sector Deployment*, National Renewable Energy Laboratory, 2009.
[248] Greentech Media Solar Summit, "The Future of Utility-Scale Solar Development," Conference panel presentation, March 31, 2010.
[249] Solar Energy Industry Association, "Major Solar Projects," http://www.seia.org/galleries/pdf/Major%20Solar%20Projects.pdf (accessed March 6, 2010).
[250] National Renewable Energy Laboratory. *Economic, Energy, and Environmental Benefits of Concentrating Solar Power in California*, 2006, http://www.nrel.gov/docs/fy06osti/39291.pdf
[251] Mark Crowley, "Concentrator Photovoltaics: Utility Scale Solar Technology for Rapid Deployment, Scalability, Light Footprint," Greentech Media Solar Summit presentation, March 31, 2010.
[252] B. Kelly, *Nexant Parabolic Trough Solar Power Plant Systems Analysis Task 1: Preferred Plant Size January 20, 2005-December 31, 2005*, 2006, National Renewable Energy Lab, http://www.nrel.gov/csp/troughnet/pdfs/40162.pdf, 13.
[253] B. Kelly, *Nexant Parabolic Trough Solar Power Plant Systems Analysis Task 3: Preferred Plant Size January 20, 2005-December 31, 2005*, 2006, National Renewable Energy Lab, http://www.nrel.gov/csp/troughnet/pdfs/40164.pdf, 25.