Arnold Schwarzenegger
Governor

CALIFORNIA ROOFTOP PHOTOVOLTAIC (PV) RESOURCE ASSESSMENT AND GROWTH POTENTIAL BY COUNTY

PIER FINAL PROJECT REPORT

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PREFACE

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (Energy Commission), conducts public interest research, development, and demonstration (RD&D) projects to benefit California.

The PIER Program strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy Innovations Small Grants
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

California Rooftop Photovoltaic (PV) Resource Assessment and Growth Potential by County is the final report for work authorization number 003-P-06 conducted by Navigant Consulting, Inc. The information from this project contributes to PIER's Renewable Energy Technologies Program. For more information about the PIER Program, please visit the Energy Commission's website at www.energy.ca.gov/pier or contact the Energy Commission at 916-654-5164.

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Abstract and Key Words

The objective of this project was to determine the potential size of the rooftop photovoltaic (PV) market in California, by county, for both residential and commercial applications for three cases: (1) current market without the California Solar Initiative incentives, (2) using the California Solar Initiative incentives, and (3) using new or improved business models. The results were further broken out by retrofit versus new construction installations. The analysis revealed that the 3,000 MW goal of the California Solar Initiative is achievable by 2016 with aggressive PV system cost reductions and new business models.

Key Words: PV Markets, solar energy, California Solar Initiative, CSI, photovoltaics, solar panels, PV panels, PIER, solar incentives. W_{pac} - peak alternating current (ac) watt.

EXECUTIVE SUMMARY

Introduction, Purpose, and Project Objectives

The objective of this project was to determine the potential size of the rooftop photovoltaic (PV) market in California, by county, for both residential and commercial applications for three cases: (1) without the California Solar Initiative incentives, (2) using the CSI incentives and (3) using improved business models. The results were also broken out by new construction versus retrofit installations. For both the commercial and residential markets, this analysis used business-as-usual PV system pricing in one scenario, and aggressive system pricing in another scenario for installations in California. County-level utility rates, solar insolation data and building stock data were also incorporated into the analysis. This assessment is expected to help the state of California in its refinement of policies to support the Senate Bill 1 (Murray) and California Solar Initiative goals and the PV industry to understand the competitiveness of PV on a county-by-county basis.

Project Outcomes

The technical potential (for examples area of roof space available for PV use, but not based on economic attractiveness) for rooftop applications in the state was calculated to be 40 giga watt in 2006 and rising to 68 giga watt in 2016. The rise is due to building stock growth and improvements in PV technology efficiency. Using the technical potential as a starting point, economic potentials were calculated for a variety of pricing scenarios using market penetration and technology adoption models. The different pricing scenarios and resulting economic potentials are shown in Figures E1 and E2. These figures do not include the approximately 180 mega watt of grid connected PV systems already installed in California.

Table E1: Economic Potential under a Business-as-Usual Pricing Scenario

		Installed System Price** ($2006/Wpac)			Market Penetration (MW)			2016 Total Market Penetration by Price Scenario
System Price Scenario	Market Segment	2006	2010	2016	2006	2010	2016	
Business-as-Usual (BAU)	Residential	$9.60/ 9.60	$8.00/ 7.70	$5.80/ 5.40	1	9	200	518 MW
	Commercial	$8.70/ 8.70	$7.50/ 7.20	$5.40/ 5.00	30	82	318	
BAU + CA Incentives	Residential	$9.60/ 9.60	$8.00/ 7.70	$5.80/ 5.40	4	43	357	844 MW
	Commercial	$8.70/ 8.70	$7.50/ 7.20	$5.40/ 5.00	58	141	487	
BAU+ New Business Models + CA Incentives*	Residential	$9.60/ 9.60	$6.90/ 6.60	$4.50/ 4.20	4	97	755	1,752 MW
	Commercial	$8.70/ 8.70	$6.40/ 6.10	$4.20/ 3.90	58	164	998	

* NCI used new business models developed with PIER in 2004/2005, as the basis for additional system price reduction. MW numbers are new additions as of 2006, so they do not include existing installations which are approximately 180 MW in CA.

** The first number is retrofit pricing and the second number is new construction pricing.

Table E2: Economic Potential under an Aggressive PV System Pricing Scenario

System Price Scenario	Market Segment	Installed System Price** ($2006/Wpac) 2006	2010	2016	Market Penetration (MW) 2006	2010	2016	2016 Total Market Penetration by Price Scenario
Aggressive (AGGR)	Residential	$9.60/ 9.60	$7.00/ 6.70	$4.00/ 3.70	1	18	663	1,550 MW
	Commercial	$8.70/ 8.70	$6.00/ 5.80	$3.50/ 3.30	30	101	903	
Aggressive + CA Incentives	Residential	$9.60/ 9.60	$7.00/ 6.70	$4.00/ 3.70	4	91	936	2,280 MW
	Commercial	$8.70/ 8.70	$6.00/ 5.80	$3.50/ 3.30	58	183	1344	
Aggressive + New Business Models + CA Incentives*	Residential	$9.60/ 9.60	$6.00/ 5.70	$3.10/ 2.90	4	135	2258	4,384 MW
	Commercial	$8.70/ 8.70	$5.10/ 5.00	$2.70/ 2.50	58	267	2126	

* NCI used new business models developed with PIER in 2004/2005, as the basis for additional system price reduction. MW numbers are new additions as of 2006, so they do not include existing installations which are approximately 180 MW in CA.

** The first number is retrofit pricing and the second number is new construction pricing

Conclusions and Recommendations

The market penetration analysis of PV in California emphasizes the importance of California incentives and further system cost reductions relative to achieving the California Solar Initiative goal of 3,000 mega watt by 2016. Without incentives, support mechanisms, and continued PV system price reductions it is unlikely that the 3,000 mega watt target can be achieved. Existing and future PIER and Energy Commission programs and policies are clearly needed to encourage the development of aggressive PV system price reductions and new business models to support more streamlined deployment and packaging of PV systems.

Benefits to California

The benefits of this report to California were twofold. The first benefit is a determination of the potential size of the PV market in California by county for both residential and commercial applications for three cases: (1) without the California Solar Initiative incentives, (2) using the California Solar Initiative incentives and (3) using new or improved business models. This analysis can help the state of California in its refinement of policies to support California Solar Initiative and will also help those in the PV industry to understand the competitiveness of PV on a county-by-county basis.

The second benefit relates to the California Solar Initiative goals. By helping to support the California Solar Initiative, this report furthers the goals of the California Solar Initiative for the development of cost-effective, clean, and reliable distributed generation.

CHAPTER 1: INTRODUCTION

Motivation

The California Energy Commission (Energy Commission) and the California Public Utilities Commission (CPUC) currently provide buy-down incentives to lower the initial cost of photovoltaic (PV) systems and grow the PV market. In theory, a robust PV market will gradually lower system costs to the point where incentives will no longer be required. However, only limited data exists on the potential size of the California PV market. In addition, there is limited data on the potential size of the PV market given different subsidy levels or use of improved business models that focus on the way a product or service is created, sold, or delivered to the customer.

Often, incentive programs globally target accelerating price reductions by providing end-user rebates or guaranteeing revenues for power sold back to the grid through special feed-in tariffs for PV power. In 2006, California established the California Solar Initiative (CSI). The CSI is a 10-year program aimed at providing a solid, but declining, incentive program to accelerate the adoption of PV in California by helping to lower installed PV system costs. In addition to California state incentives, the federal government has recently provided additional PV tax incentives through the Energy Policy Act of 2005, and the PV industry is continuing to modify business models to help reduce PV system costs.

The objective of this project was to determine the potential size of the PV market in California by county for both residential and commercial, new construction and retrofit applications for three cases: (1) without the California Solar Initiative (CSI) incentives, (2) using the CSI incentives and (3) using new or improved business models. This analysis also ran two scenarios of system pricing: one as a business-as-usual case and the other as an aggressive PV system price case. The analysis also used county-level utility rates, solar insolation data and building stock data. This assessment can help the state of California in its refinement of policies to support Senate Bill 1 (SB1) and CSI and also help those in the PV industry understand the competitiveness of PV on a county by county basis.

Approach

This report describes the levels of market penetration that could be achieved in California under a variety of scenarios described below and outlined in Figure 1:

- Chapter 2 estimates the potential of solar PV in MWs by county for residential and commercial solar PV systems in 2006, 2010 and 2016. This is referred to as the technical potential. The analysis screens out resources that cannot be accessed due to reasons such as shading from trees, poor building orientation, or shading from other buildings.
- Chapter 3 estimates the diffusion of solar PV (in MW) into the marketplace by county for residential and commercial solar PV systems in 2006, 2010 and 2016. Using the Chapter 2 analysis as the basis for market size, Chapter 3

considers the relative economics of solar PV (with no state subsidies or incentives) and the maturity of the technology.

- Chapter 4 discusses the resulting market penetration with the CSI rebates.
- Chapter 5 discusses new business models for PV in California and examines the market penetration with the new business models and the CSI rebates applied.
- Chapter 6 summarizes the results and provides recommendations for the Energy Commission.

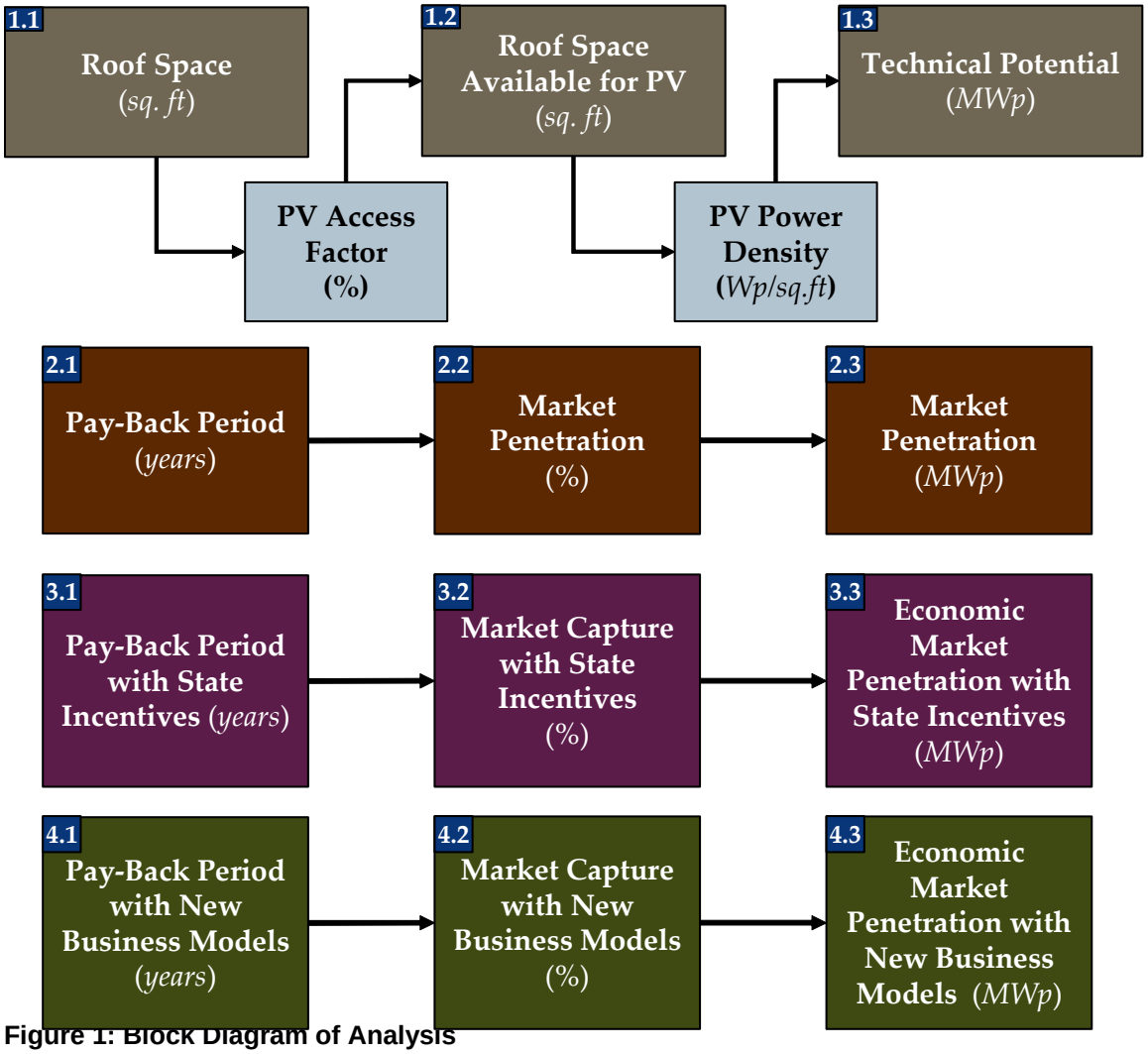

Figure 1: Block Diagram of Analysis

CHAPTER 2: TECHNICAL POTENTIAL

To calculate the market penetration of PV, the size of the available market must be known first. The current and projected total roof space in California was therefore calculated for 2006, 2010, and 2016, by county for residential and commercial buildings. A PV access factor was applied to the square footage roof space data to estimate how much roof space is actually available for PV. The PV access factor takes into account shading, building orientation, and roof structural soundness. The PV power density data is then used to calculate the potential installed capacity in California.

To calculate the total roof space, Navigant Consulting, Inc. (NCI) started with the total amount of floor space in California residential and commercial buildings, by county. The Energy Commission provided NCI with county level floor space totals and projections for 2000 through 2010. For 2010 through 2016, NCI used the compounded annual growth rate (CAGR) from 2006 through 2010. To estimate how floor space translates into roof space, NCI used data on the average number of floors per building, and the *Regional Economic Research Inc. 2002* report for residential information by climate zone. For the commercial building analysis, NCI used information from a 2003 EIA report. Climate zone definitions and county level climate zone designations are presented in Appendix A.

To estimate how much of the total roof space is available for PV, NCI developed PV access factors that were based upon a NCI study for a major U.S. utility company. The study was adjusted for California conditions based upon interviews with Ed Kern of Irradiance, who possesses years of installation experience in the industry. Separate access factors were developed for cooler climates (Energy Commission climate zones 1, 2, 3 and 16) and warmer climates (Energy Commission climate zones 4 through 15).
Figure 2 through 5 show the different analyses and Table 1 shows a summary of the results. The PV access factors were then applied to the county level roof space data to estimate the available roof area for PV.

Figure 2: PV Access Factor Residential Buildings in Warmer Climates

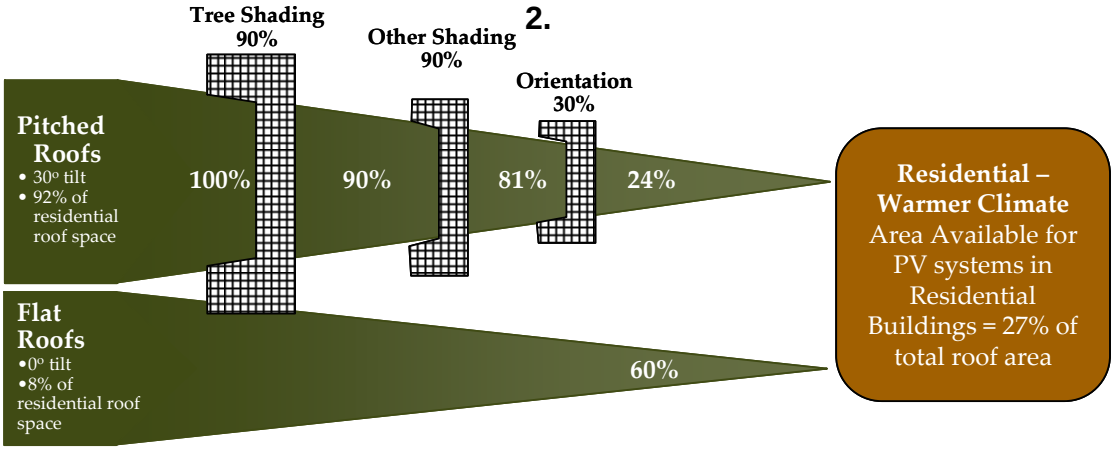

Figure 3: PV Access Factor for Residential Buildings in Cooler Climates

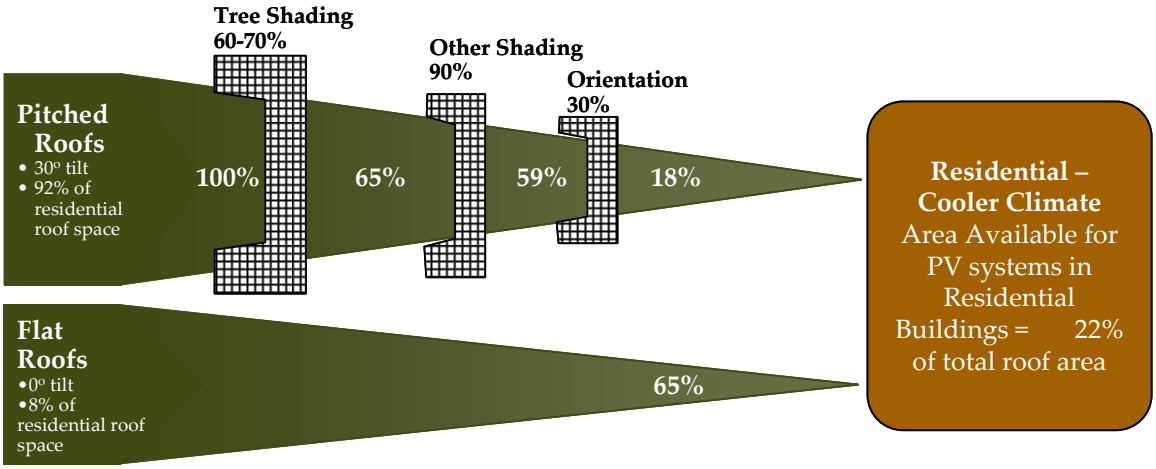

Figure 4: PV Access Factor for Commercial Buildings in Warmer Climates

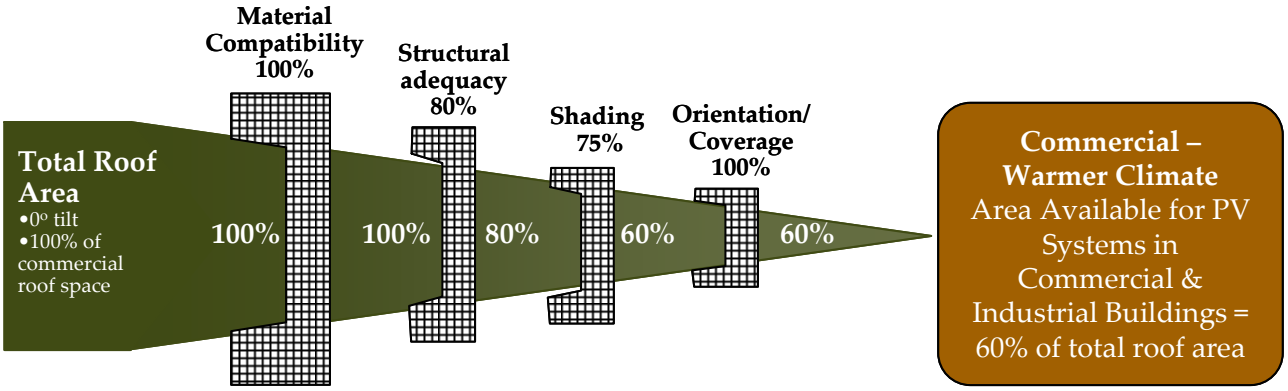

Figure 5: PV Access Factor for Commercial Buildings in Cooler Climates

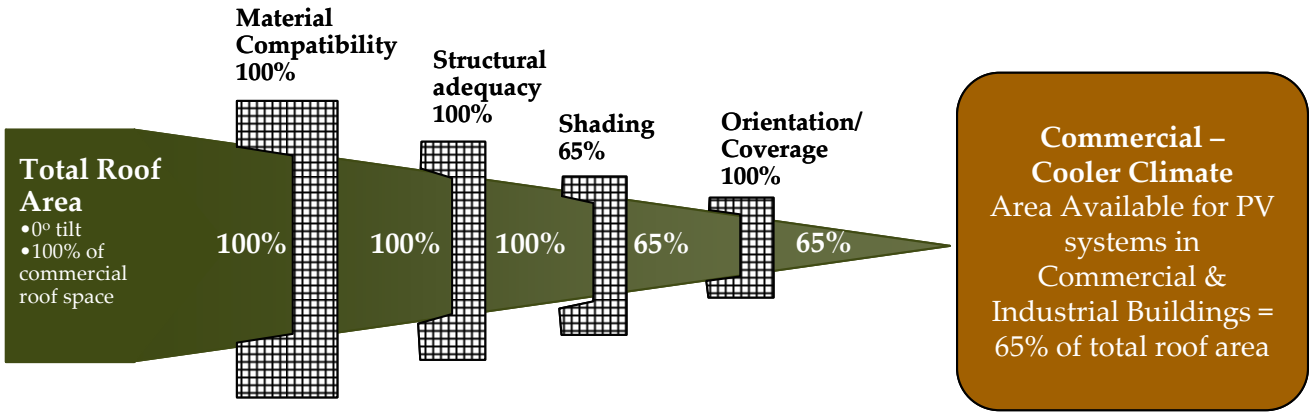

Table 1: Summary of PV Access Factors

	Summary of PV Access Factors	
	Residential	Commercial
Warmer Climates (zones 4 through 15)	27%	60%
Cooler Climates (zones 1, 2, 3 and 16)	22%	65%

NCI estimated the technical potential by using data on PV power density. PV power density is the measure of a module's efficiency in converting sunlight to energy. To calculate the power density of a solar PV system in 2006, NCI developed a weighted average module efficiency using market share for the three most prevalent technologies in California, i.e. polycrystalline silicon, monocrystalline silicon, and amorphous silicon. NCI and its PV Services program maintain current and future projections for module efficiency and market share of PV technologies in California. The power density of a module was then calculated on a square footage basis and the power density of a PV system was calculated by applying a packing factor of 1.25 for residential and commercial systems. The packing factor modifies the PV power density by taking into account space need for the system, such as space for access between modules, wiring, and inverters.

The resulting system power density is 10 MW/million sq. ft. as derived from an average module efficiency of 13.5% per Equation 1 below. For 2016, NCI assumed an average odule efficiency of 19% for all installations resulting in a packing factor of 14 MW/million sq. ft. in 2016.

System Power Density = Module Efficiency X 1000 (W/m^2) / Packing Factor ……. (1)

NCI used the Clean Power Estimator[1] to calculate county level capacity factors and used tilt angles recommended by Akeena Solar, a leading integrator/installer in the California market. Figure 6 shows the technical potentials in 2016, by county. The resulting technical potentials by county and year of nalysis are shown in Appendix B, Table B.1. The total technical potential (not factoring in economics) by 2016 will be approximately 68 GW.

[1] The Clean Power Estimator for California can be found at (http://www.consumerenergycenter.org/renewables/estimator/index.html)

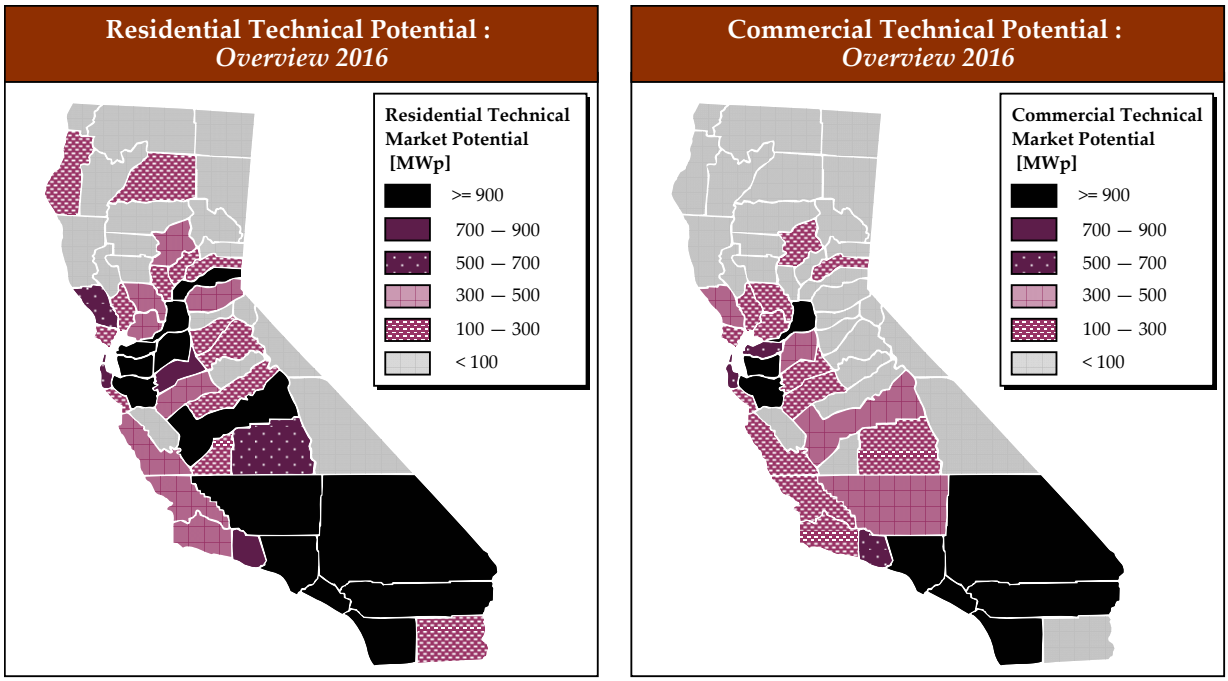

Figure 6: Technical Potential in 2016

CHAPTER 3: ECONOMIC POTENTIAL

Chapter 3 assesses the market penetration by segment (residential vs. commercial) and county in 2006, 2010, and 2016 factoring in the economic attractiveness of PV. First, NCI calculated system payback period using data on system prices, utility rates, and expected system capacity factors. The payback periods were incorporated into NCI's market penetration model to estimate economic potential. NCI then used S-Curves to estimate the percentage of the market penetration potential that can actually be captured. This first analysis assumed federal incentives and no state incentives. Refer to Appendix A for other key assumptions in the analysis.

The primary input into NCI's market penetration model is the payback period of a PV system. NCI recognizes that there are other variables that can factor in to the PV purchase decision making, but the market penetration curves used are based on the adoption of past experience of energy equipment into the building sector. Payback period is calculated by dividing the installed system price by the yearly electric bill savings achieved by using a PV system. For PV system prices over time, NCI used two different pricing scenarios:

Business-as-Usual:
The first scenario is a Business-as-Usual (BAU) case that assumes the current PV silicon supply issue is resolved in the next few years and PV system prices decline at historical rates (as tracked by NCI and other sources). New construction pricing assumes a discount relative to retrofit: 4% in 2010, 7% in 2016 because of displaced roofing costs and some reduction in installation costs as contractors are already at the site doing the home construction. However, new construction pricing does not assume volume discounts for builders who install PV in an entire subdivision. The module pricing scenarios were developed by NCI and checked against 2006 and 2010 prices from the *NCI PV Services Program* and Bill Rever at BP Solar.

Aggressive:
The second scenario is an Aggressive case that assumes accelerated annual price declines after the PV silicon supply issue is resolved. The aggressive system price reductions assume that there is a breakthrough in some of the thin film and advanced crystalline silicon PV technologies that are currently being undertaken by industry. The aggressive case also assumes the same discounts for new construction relative to retrofit as the BAU case.

Table 2 lists commercial and residential system prices for both scenarios. All prices are in 2006 dollars. Inverter replacement is assumed to occur 10 years after installation at a cost of $0.50/Wpac in 2016 and $0.25/Wpac in 2026 (i.e. ten years after a 2016 installation) for the residential market and $0.30/Wpac in 2016 and $0.15/Wpac in 2026 for the commercial market.

Table 2: Assumed Installed PV System Costs ($2006/Wpac) Over Time, under Different Pricing Scenarios

		Retrofit Installed System Price *($2006/Wpac)*			New Construction Installed System Price *($2006/Wpac)*		
System Price Scenario	Market Segment	2006	2010	2016	2006	2010	2016
Business-as-Usual (BAU)	Residential	$9.60	$8.00	$5.80	$9.60	$7.70	$5.40
	Commercial	$8.70	$7.50	$5.40	$8.70	$7.20	$5.00
Aggressive* (AGGR)	Residential	$9.60	$7.00	$4.00	$9.60	$6.70	$3.70
	Commercial	$8.70	$6.00	$3.50	$8.70	$5.80	$3.30
Aggressive + New Business Models (AGGR+NBM)	Residential	$9.60	$6.00	$3.10	$9.60	$5.70	$2.90
	Commercial	$8.70	$5.10	$2.70	$8.70	$5.00	$2.50

Source: NCI as checked against data from NCI's PV Services and Bill Rever of BP

Yearly electric bill savings were calculated differently for the residential and commercial markets. For the *residential market*, NCI used Energyguage software to develop monthly energy usage profiles for a typical home in each climate zone. Typical home statistics were taken from the *Residential New Construction Study Project Year #2* report (Regional Economic Research Inc. 2004). NCI developed baseline allowances for residential customers in each county depending on utility and utility baseline zones in that county[2]. NCI assumed standard residential rate classes (i.e. Pacific Gas & Electric's schedule E-1 or San Diego Gas &Electric's schedule DR). Effective rates were calculated using each utility's rate structure. This was done by calculating household electricity payments for the year (using the utilities tiered rate structure) and dividing by the number of kWh used. To estimate utility rates in 2010 and 2016, NCI assumed an annual real escalation rate of 3%. Given the uncertainty in estimating real escalation rates, NCI conducted a sensitivity analysis on electricity rate escalation to 7%. The results are presented in Appendix B.

Based upon discussions with utilities and PV installers, NCI considered Time-of-Use (TOU) rates for *commercial customers* of utilities that offered them. For utilities not offering TOU rates, standard commercial rates were used. NCI calculated the effective rate at which electricity purchases are being offset by using two sets of data: 365 days of hourly insolation profiles for different locations in California (NREL 1990) and TOU rate structures from each utility[3]. The percentage of PV generated power in each TOU class (i.e. summer peak, winter mid-peak, etc) was calculated

[2] Baseline allowances, baseline service areas and rate structures for IOU's was taken from the CPUC at (http://www.cpuc.ca.gov/static/energy/electric/rates+and+tariffs/index.htm). Information for MUNI's was found from each MUNI's webpage

[3] Time-of-Use rates were sourced from the CPUC at http://www.cpuc.ca.gov/static/energy/electric/rates+and+tariffs/index.htm or utility websites

using the hourly insolation data for each county with the corresponding utility and climate zone. The percentages were used to calculate the effective rate at which electricity purchases are being offset. To estimate commercial utility rates in 2010 and 2016, NCI assumed an annual real escalation of 3%. Table A.3 in Appendix A tabulates the residential and commercial utility rates assumed.

NCI incorporated the pay back periods into a market penetration model to assess the economic potential by county. NCI based market penetration upon two sets of curves. The first, by Kastovich (Kastovich 1982) calculated market penetration curves for retrofit and new construction markets of energy technologies. Also, NCI produced a curve based on field interviews, consumer surveys, and market data on adoption of efficient energy technologies in the market. The market penetration curves provide the cumulative market penetration 10-20 years after product introduction, as a function of payback in years. For this project, NCI averaged the curves to produce market penetration curves for pre-2010 and post-2010. California's SB-1 dictates that by 2010, all builders must offer PV as an option in new housing for developments over 50 homes. This will increase consumer access to PV and increase the market penetration at a given payback. Figure 7 and Figure 8 show the curves used. The calculated cumulative market penetration (in %) for a year of analysis is multiplied against that year's technical potential. This yields a market potential estimate.

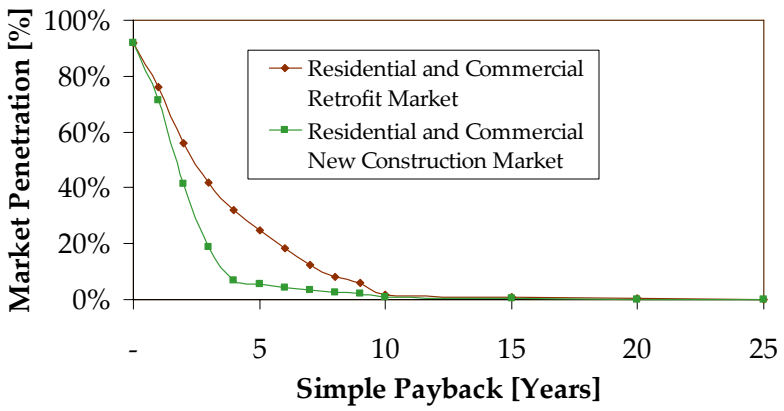

Figure 7: Market Penetration Curves, Pre-2010

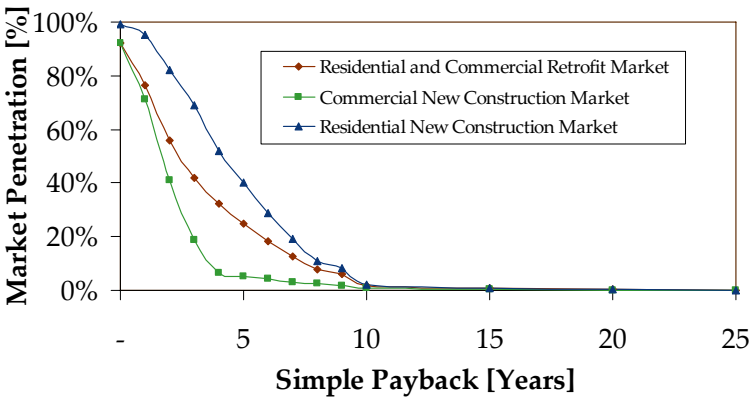

Figure 8: Market Penetration Curves, post-2010

NCI then used S-Curves to estimate the percentage of the market penetration potential that can actually be captured. The S-Curve provides the rate of adoption of technologies as a function of the technology's characteristics and market conditions. NCI gathered market data on the adoption of several electric technologies over the past 120 years and fit the data using Fisher-Pry curves. The Fisher-Pry technology substitution model predicts market adoption rates for an existing market of known size. Technologies were then identified with technology characteristics, industry characteristics, and external factors similar to PV. An average of two curves was used to balance the many factors that impact PV adoption. The S-Curve used is shown in Figure 9. Figure 9 shows that adoption within the penetrable market increases with time. An S-Curve is typically "anchored" in a base year (Year zero on the plot below). Since PV technologies have been on the market for several years in California, NCI studied where the market should be "anchored". Based on system price/installation data maintained for the Emerging Renewables Program (ERP) and Self Generation Incentive Program (SGIP) programs, NCI "anchored" the curve seven years in the past (i.e. year zero in Figure 8 corresponds to 1999).This is reasonable given that the ERP and SGIP programs started in 1998.

Applying the S-Curve to market penetration (as calculated from the market penetration curves) yielded county level economic potential for the residential and commercial market. This is done per equation 2. Figure 10 graphically shows the economic potential by county for 2016 for the Business-as-Usual case and Table 3: breaks out the results by new construction and retrofit. Appendix B shows the tabulated results by county and year. The result is 518 MW installed by 2016.

Economic Potential = Technical Potential X Market Penetration (in %) X % of Market Potential Captured …….. (2)

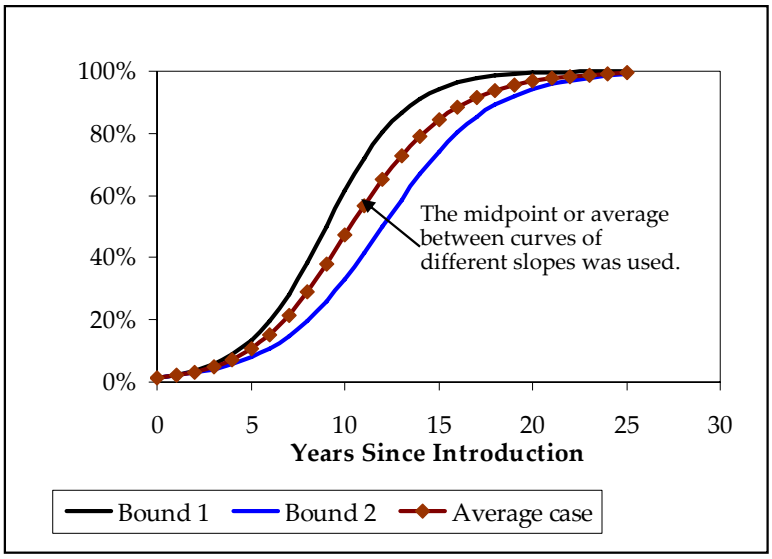

Figure 9: S-Curves Used to Model Technology Adoption

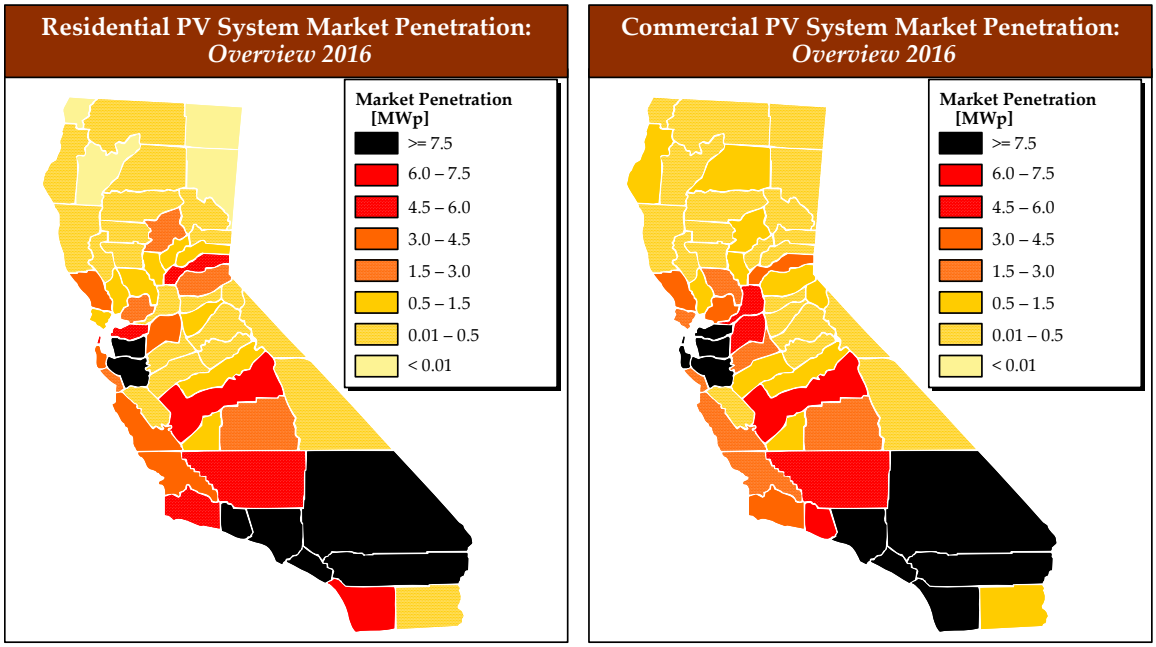

Figure 10: 2016 Economic Potential by County, under the Business-As-Usual Pricing Scenario (518 MW in 2016)

Table 3: Results of BAU System Pricing, Federal Incentives, and No CA Incentives

	Total Installations (MW)		
Cumulative Market Segment	**2006**	**2010**	**2016**
Residential	1	9	200
Total New Construction	*0*	*0*	*15*
Commercial	30	82	318
Total New Construction	*0*	*2*	*11*
Total	**30**	**91**	**518**

	Annual Installations (MW)		
Annual Market Segment	**2006**	**2010**	**2016**
Residential Retrofits	1	4	63
Residential New Construction	0	0	6
Commercial Retrofits	29	22	49
Commercial New Construction	0	1	3

Note: The 518 MWp does not include the ~180 MWp currently installed in CA.

CHAPTER 4: ECONOMIC POTENTIAL WITH CALIFORNIA INCENTIVES

Chapter 4 estimates the impact of the CSI rebates on market penetration by segment (residential vs. commercial) and county in 2006, 2010, and 2016. NCI repeated all of Chapter 3's analysis steps with the CSI rebates included. Below is a description of the CSI rebate structure and NCI's relevant assumptions, along with the resulting economic potential. The results of a sensitivity analysis are also included.

Table 4 shows the most recent (at the time of this report) CSI rebate structures. The rebate structure has trigger levels such that when a trigger is reached, the rebate is lowered according to Table 4. The structure also has separate triggers by utility service area. NCI's analysis did not consider the separate utility triggers. For 2006 incentives, the CPUC's SGIP rebates levels were used for commercial systems and the Energy Commission's ERP incentives were used for residential systems.

There are two types of rebates in the CSI structure. The EPBB, which stands for Expected Performance Based Buy-down, is an upfront payment that takes into account system capability, system design, and location. NCI assumed that average rebates over the state will be per Table 4. PBI, which stands for Performance Based Incentives, is an incentive for systems larger than 100 kWp in size. The PBI is based upon actual system performance and is paid for a five year period. The PBI rebate levels are designed such that the value (adjusted for time using an 8% discount rate) of the PBI payments over five years are equivalent to the up front EPBB payment for an equivalently sized system. Thus, NCI used the EPBB for all systems to simplify the analysis.

NCI applied the incentives and repeated the analysis steps in Chapter 3. Figure 11 graphically shows the economic potential by county for 2016 for the Business-as-Usual case and Table 5 breaks out the results by new construction and retrofits. Appendix B breaks the results out by county. The result is ~800 MW installed by 2016. To assess the effect of the Aggressive pricing scenario (shown if Table 2) and other key variables, NCI conducted a sensitivity analysis. The variables analyzed and their levels of variation are shown in
Table 6. The results of the sensitivity analysis are shown in Figure 12. Figure 12 shows that the installed system cost and electricity price escalation have large impacts on market penetration.

Table 4: CSI Rebates and Trigger Levels

Proposed CSI Rates and Trigger Levels							
Step	Statewide MW in Step	EPBB Payments (per watt) for systems under 100-kWp[1]			PBI payments (per kWh) for systems 100-kWp and above[2],[3],[4]		
		Residential	Non-Residential	Non-Tax	Residential	Non-Residential	Non-Tax
1	50	$2.80	$2.80	$2.80	N/A[5]	N/A[5]	N/A[5]
2	70	$2.50	$2.50	$3.25	$0.39	$0.39	$0.50
3[6]	100	$2.20	$2.20	$2.95	$0.34	$0.34	$0.46
4	130	$1.90	$1.90	$2.65	$0.26	$0.26	$0.37
5	170	$1.55	$1.55	$2.30	$0.22	$0.22	$0.32
6	230	$1.10	$1.10	$1.85	$0.15	$0.15	$0.26
7	300	$0.65	$0.65	$1.40	$0.09	$0.09	$0.19
8	400	$0.35	$0.35	$1.10	$0.05	$0.05	$0.15
9	500	$0.25	$0.25	$0.90	$0.03	$0.03	$0.12
10	650	$0.20	$0.20	$0.70	$0.03	$0.03	$0.10

(1) Regardless of size all new construction receives EPBB

(2) If Customers otherwise classify for the EPBB they may opt to receive PBI payments

(3) Regardless of size all building integrated systems receive the PBI

(4) All PBI payments incorporate an 8% discount rate

(5) The First 50-MWp incentives are disbursed under the 2006 SGIP program; PBI payments do not apply

(6) For PBI Calculations, the first three steps assume a capacity factor (CF) of 0.18; Steps 4-10 assume a CF of 0.20.

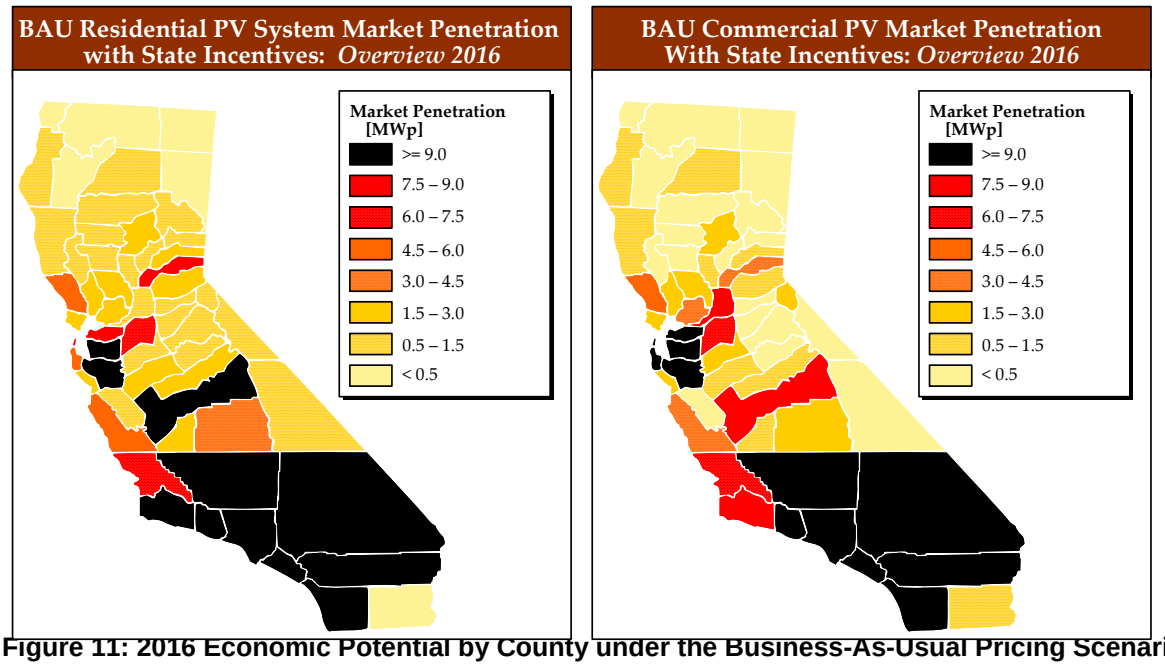

Figure 11: 2016 Economic Potential by County under the Business-As-Usual Pricing Scenario with California Incentives (844 MW)

Table 5: Results of BAU System Pricing, Federal Incentives, and CA Incentives

	Total Installations (MW)		
Cumulative Market Segment	**2006**	**2010**	**2016**
Residential	4	43	357
Total New Construction	0	2	39
Commercial	58	141	487
Total New Construction	*0*	*4*	*20*
Total	**62**	**184**	**844**

	Annual Installations (MW)		
Annual Market Segment	**2006**	**2010**	**2016**
Residential Retrofits	4	16	108
Residential New Construction	0	1	14
Commercial Retrofits	58	29	147
Commercial New Construction	0	1	5

Note: The 844 MWp does not include the ~180 MWp currently installed in CA.

Table 6: Sensitivity Analysis Variables

Parameter	Baseline Setting	Range Tested
Installed System Cost	BAU	Aggressive
Electricity Rate Escalation	3% per year	0% to 7%
REC Market	Only Commercial Market	Residential/ Commercial Market
REC Price Escalation	0% / year, Only Commercial Market	0 to 3% / year in Residential and Commercial Market
Market Penetration	Average of Kastovich and NCI	Kastovich only

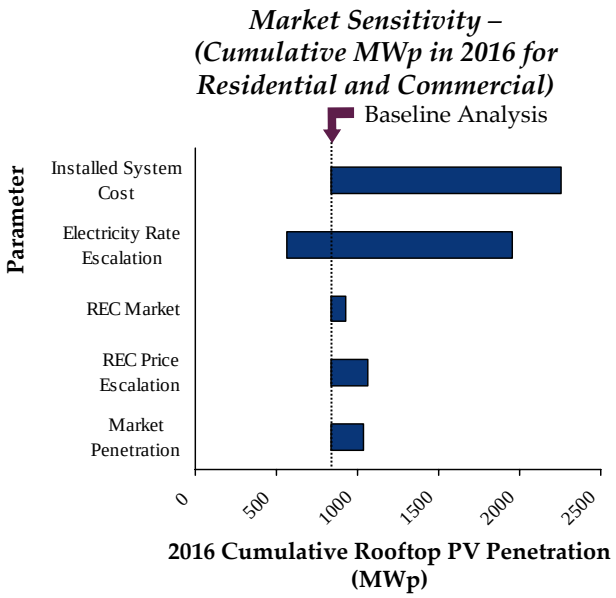

Figure 12: Results of the Sensitivity Analysis

CHAPTER 5: ECONOMIC POTENTIAL WITH NEW BUSINESS MODELS

Chapter 5 examines the effects of new business models (NBM) on the market penetration of PV in California. Below, NCI's previous work on NBMs is described along with the effects of new business models on PV prices. The resulting market penetration is calculated.

In 2004, NCI conducted a study (Frantzis and Graham, 2004) for CEC's Public Interest Energy Research (PIER) program to assess major barriers with current new home business models in the PV industry. Cost barriers included high initial system costs and negligible reductions in electric bills. Other PV barriers were: customers perceived limited value to homeowner and utility, and additional hassle and risk for builders with little value added. Based upon the barriers, PIER and NCI developed seven improved business models to overcome the barriers: *PV as an Appliance, No Hassle PV, True-Value Electric Roof, PV Enhanced Multi-family, PV Consumer Finance, PV Enhanced Mortgage, and Utility in PV Subdivision.* NCI then analyzed the effect of the new business models on installed system price and found that the new business models could reduce price by a factor of 1.5 to 2. The results were reviewed by the PV industry for concurrence.

For this analysis, NCI chose to model the following three New Business Models that could be applied to new homes as well as retrofit systems for existing homes:

PV as an Appliance, where PV systems can be sold to a homeowner and incorporated into the home like an appliance as "plug and play".
No Hassle PV, where a single entity bundles the system design, purchase, permitting, rebate application, installation, maintenance, and financing into one transaction for the customer.
PV Consumer Finance, in which initial PV system costs are financed using standard consumer finance models.

The application of these models results in lower system prices, as shown in Table 7, for the following reasons:

Market consolidation leads to larger players with more power in relationships with suppliers.
Development of highly standardized pre-packaged systems with plug and play features makes them easier to install.
Market evolution, sophistication of company, and plug and play features lead to highly streamlined installation.
Standardized components lead to reduction in sales and marketing costs.
Consumer finance (as with other appliances) keeps products moving, resulting in more predictable inventory and sales cycles reducing overall operating costs.

Table 7 shows what system prices could result if the three aforementioned NBM's are implemented in the Business-as-Usual and Aggressive pricing scenarios. The corresponding reduction in system prices were calculated using the 2004 NCI study. The market penetration resulting from NBMs and state incentives are shown in Figure 13 for the Business-as-Usual pricing scenario and Table 8 breaks out the results for new construction and retrofits. Appendix B tabulates the results by county. The results show that 1,752 MW of PV could be installed by 2016. To assess the effect of the Aggressive PV system pricing scenario (shown in Table 2) and other key variables, NCI conducted another sensitivity analysis. The variables analyzed and their levels of variation are shown in Table 9. The results of the sensitivity analysis are shown in Figure 14. Comparing Figure 12 to Figure 14 shows that the baseline is shifted by 300 MW because of the New Business Models. Figure 14 shows that the CSI target of 3,000 MW is achievable by 2016 with either aggressive PV system pricing and new business models or with high real electricity escalation rates and NBMs.

Table 7: Installed System Costs Resulting from the Implementation of New Business Models

	New Business Model Installed System Price Assumptions (Starting with Base Case System Prices for CA)					
	Retrofit Installed System Price *($2006/Wpac)*			New Construction Installed System Price *($2006/Wpac)*		
Market Segment	2006	2010	2016	2006	2010	2016
Residential	$9.60	$6.90	$4.50	$9.60	$6.60	$4.20
Commercial	$8.70	$6.40	$4.20	$8.70	$6.10	$3.90

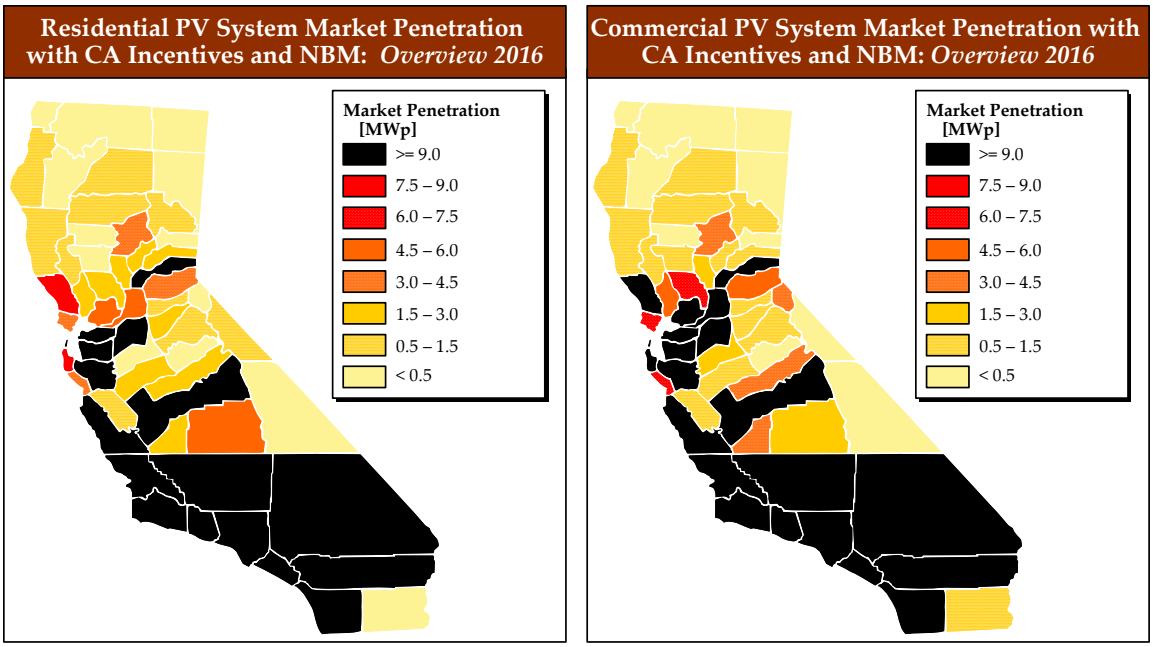

Figure 13: 2016 Economic Potential by County With New Business Models and California Incentives (1,752 MW)

Table 8: Results of BAU System Pricing, Federal Incentives, CA Incentives and NBMs

	Total Installations (MW)		
Cumulative Market Segment	**2006**	**2010**	**2016**
Residential	4	97	755
Total New Construction	*0*	*3*	*75*
Commercial	58	164	998
Total New Construction	*0*	*4*	*26*
Total	**62**	**261**	**1,752***

	Annual Installations (MW)		
Annual Market Segment	**2006**	**2010**	**2016**
Residential Retrofits	4	42	299
Residential New Construction	0	3	27
Commercial Retrofits	58	39	479
Commercial New Construction	0	1	7

*Note: The 1,752 MWp does not include the ~180 MWp currently installed in CA

Table 9: Sensitivity Analysis Variables for New Business Model Analysis

Parameter	Baseline Setting	Range Tested
Installed System Cost	New Business Models	New Business Models applied to the Aggressive Pricing Scenario
Electricity Rate Escalation	3% per year	0% to 7%
Market Penetration	Average of Kastovich and NCI	Kastovich only

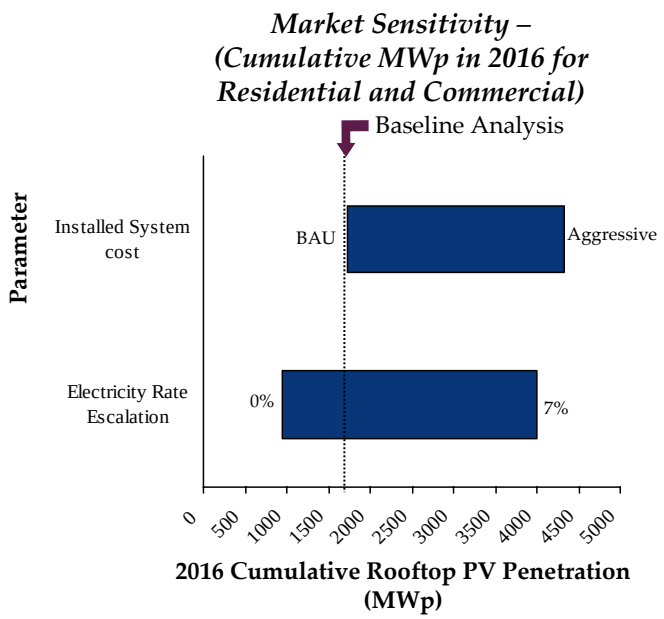

Figure 14: Results of the Sensitivity Analysis

It should be noted that there are other factors that could increase market penetration. These include:

Inclusion of the non-roof top applications of PV (note: only roof-top applications were considered in this study);
Utility rates could escalate at a rate higher than 3%, which would increase market penetration by reducing pay back periods;

The value for Renewable Energy Certificate (RECs) was assumed to be $0.015/kWh in 2010. A higher REC value due to greater demand could improve the economics; and
The Federal Tax Incentives could be extended beyond 2007, with the residential credit changing from $2,000/system to $2,000/kW (as quoted by Rhone Resch of the Solar Energy Industries Association). This analysis assumed these incentives would not be extended beyond 2007.

To assess the impact of the last three items, NCI did further sensitivity analysis around these variables. Table 10 shows the levels of variation of these variables. The results are tabulated in Table 11 and shown in Figure 15.

Table 10: Additional Factors That Could Increase Market Penetration

Parameter	Baseline Setting	Range Tested
Federal Tax Incentives	Expire in 2008, $2,000/system residential credit	Extended through 2015, $2,000/kW residential credit
Electricity Rate Escalation	3% per year	0% to 7%
RECs	0% per year escalation at $.015/kWh, only commercial market	0% to 13% per year escalation in residential and commercial market

3.

Table 11: Sensitivity Analysis of Other Factors That Could Increase Market Penetration

	Utility Rate Escalation			REC Escalation		Federal Tax Credit Extension	
Pricing Scenario	0%/ Yr	3%/ Yr	7%/ Yr	0%/ Yr	13%/ Yr	No	Yes
Business-as-Usual	562	711	1,952	615	1,280	832	1,207
Aggressive	1,661	2,256	6,179	1,833	3,615	2,256	5,670
Aggressive + New Business Models	2,603	4,335	10,899	3,884	7,659	4,335	12,541

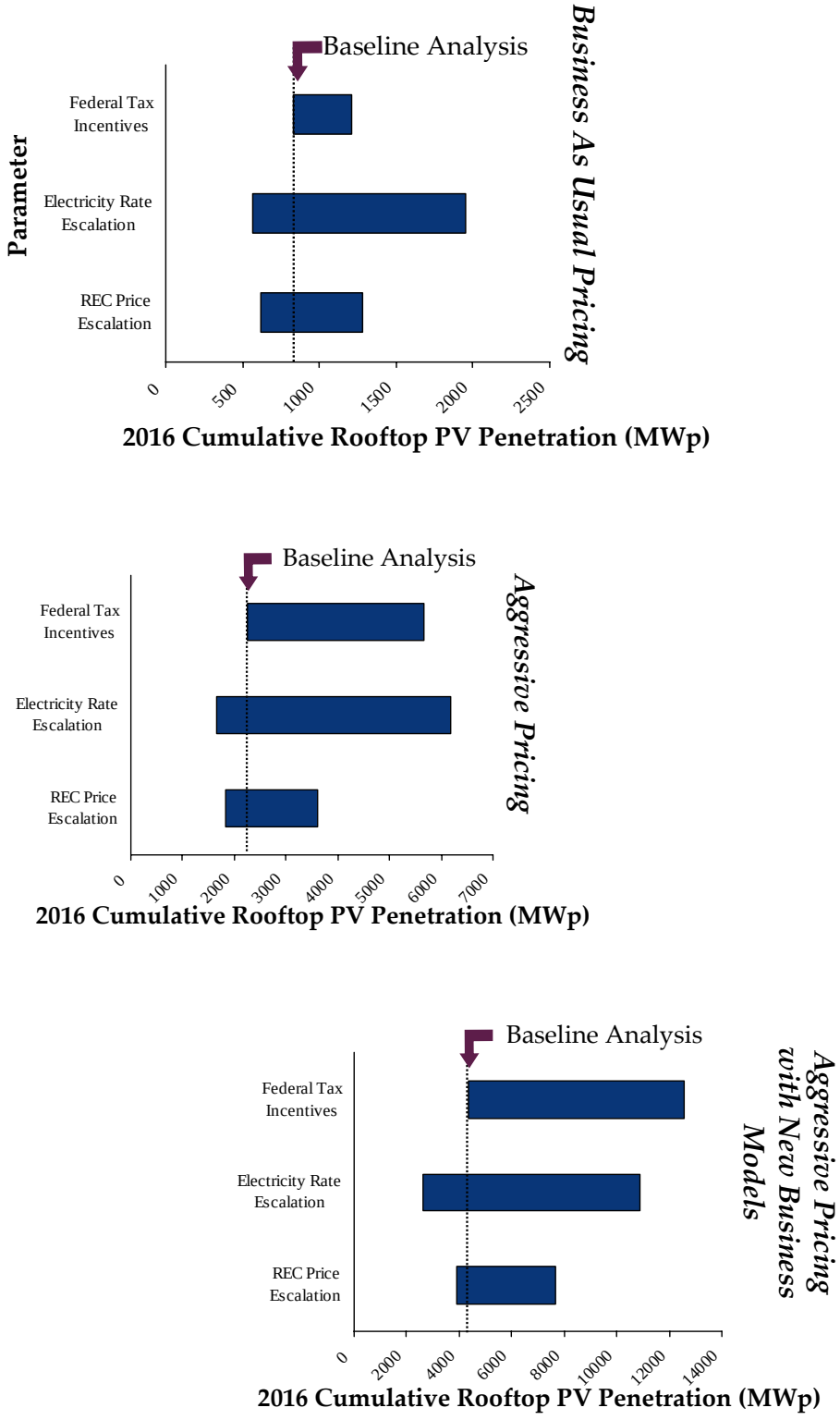

Figure 15: Sensitivity Analysis of Other Factors That Could Increase Market Penetration

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

Table 12 and Table 13 summarize the analysis results. The market penetration analysis of PV in California emphasizes the importance of California incentives and the other factors relative to achieving the CSI goal of 3,000 MW by 2016. Without these incentives and support mechanisms, it is unlikely that the 3,000 MW target can be achieved. In fact, additional programs and policies are needed to encourage the development of aggressive system price reductions and new business models to support more streamlined deployment and packaging of PV systems. As shown in Table 12 and Table 13, the combination of California incentives, more aggressive PV system price reductions and new business models can have a significant impact on market adoptions. Without these, PV economics are still too costly relative to conventional electricity to stimulate significant market adoption. Existing and future PIER and CEC programs and policies are clearly needed to encourage the development of aggressive system price reductions and NBMs to support more streamlined deployment and packaging of PV systems.

Table 12: Business-as-Usual Scenario Results (assuming 3% real electricity price escalation.)

		Installed System Price** ($2006/Wpac)			Market Penetration (MW)			2016 Total Market Penetration by Price Scenario
System Price Scenario	Market Segment	2006	2010	2016	2006	2010	2016	
Business-as-Usual (BAU)	Residential	$9.60/ 9.60	$8.00/ 7.70	$5.80/ 5.40	1	9	200	518 MW
	Commercial	$8.70/ 8.70	$7.50/ 7.20	$5.40/ 5.00	30	82	318	
BAU + CA Incentives	Residential	$9.60/ 9.60	$8.00/ 7.70	$5.80/ 5.40	4	43	357	844 MW
	Commercial	$8.70/ 8.70	$7.50/ 7.20	$5.40/ 5.00	58	141	487	
BAU+ New Business Models + CA Incentives*	Residential	$9.60/ 9.60	$6.90/ 6.60	$4.50/ 4.20	4	97	755	1,752 MW
	Commercial	$8.70/ 8.70	$6.40/ 6.10	$4.20/ 3.90	58	164	998	

* NCI used new business models developed with PIER in 2004/2005, as the basis for additional system price reduction. MW numbers are new additions as of 2006, so they do not include existing installations which are approximately 180 MW in CA.

** The first number is retrofit pricing and the second number is new construction pricing.

Table 13: Aggressive Scenario Results (assuming 3% real electricity price escalation).

System Price Scenario	Market Segment	Installed System Price** ($2006/Wpac) 2006	2010	2016	Market Penetration (MW) 2006	2010	2016	2016 Total Market Penetration by Price Scenario
Aggressive (AGGR)	Residential	$9.60/ 9.60	$7.00/ 6.70	$4.00/ 3.70	1	18	663	1,550 MW
	Commercial	$8.70/ 8.70	$6.00/ 5.80	$3.50/ 3.30	30	101	903	
Aggressive + CA Incentives	Residential	$9.60/ 9.60	$7.00/ 6.70	$4.00/ 3.70	4	91	936	2,280 MW
	Commercial	$8.70/ 8.70	$6.00/ 5.80	$3.50/ 3.30	58	183	1,344	
Aggressive + New Business Models + CA Incentives*	Residential	$9.60/ 9.60	$6.00/ 5.70	$3.10/ 2.90	4	135	2,258	4,384 MW
	Commercial	$8.70/ 8.70	$5.10/ 5.00	$2.70/ 2.50	58	267	2,126	

* NCI used new business models developed with PIER in 2004/2005, as the basis for additional system price reduction. MW numbers are new additions as of 2006, so they do not include existing installations which are approximately 180 MW in CA.

** The first number is retrofit pricing and the second number is new construction pricing

The benefits of this report to California were two folds: First it is a determination of the potential size of the PV market in California by county for both residential and commercial applications for three cases: (1) without the California Solar Initiative (CSI) incentives, (2) using the CSI incentives and (3) using new or improved business models. This analysis can help the state of California in its refinement of policies to support CSI and will also help those in the PV industry understand the competitiveness of PV on a county by county basis.

The second benefit relates to the CSI goals. By helping to support the CSI, this report furthers the goals of the CSI which have the following benefits:

Making use of secure, indigenous, and sustainable natural resources.
Helping to keep California's air clean.
Potential to reduce the production of carbon dioxide - a leading contributor to global climate change.
Helping to create jobs for California and American workers.
Establishing the United States as a world leader and exporter of renewable power technologies
Nationwide, reducing dependence on fossil fuels.

CHAPTER 7: REFERENCES

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Frantzis, L., S. Graham, B. Griggs, and R. Shelton, *Improved PV Business Models for Zero Energy New Homes: Stimulating Innovation in the Californian Marketplace*, Prepared by Navigant Consulting, Inc. for the California Energy Commission, 2005.

CHAPTER 8. GLOSSARY

BAU	Business-as-Usual
CSI	California Solar Initiative
EPBB	Expected Performance Based Buy-down
ERP	Emerging Renewables Program
GW	Giga Watt
MACRS	Modified Accelerated Cost Recovery System
MW	Mega Watt
NBM	New Business Model
NCI	Navigant Consulting Inc.
PBI	Performance Based Incentive
PIER	Public Interest Energy Research
PV	Photovoltaics
REC	Renewable Energy Certificate
SGIP	Self Generation Incentive Program

APPENDIX A: DATA

APA-1

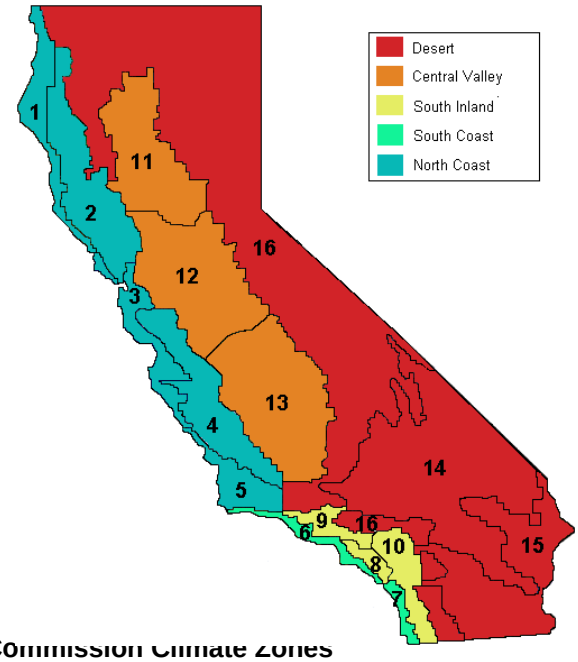

Figure A.1: Energy Commission Climate Zones

Table A.1: Energy Commission Climate Zone Designation for Each California County

County	Climate Zone
Alameda	12
Alpine	16
Amador	12
Butte	11
Calaveras	12
Colusa	11
Contra Costa	3
Del Norte	1
El Dorado	16
Fresno	13
Glenn	11
Humboldt	1
Imperial	15
Inyo	16
Kern	13
County	Climate Zone
Kings	13

Lake	2
Lassen	16
Los Angeles	9
Madera	13
Marin	3
Mariposa	16
Mendocino	1
Merced	12
Modoc	16
Mono	16
Monterey	3
Napa	2
Nevada	11
Orange	8
Placer	11
Plumas	16
Riverside	10
Sacramento	12
San Benito	4
San Bernardino	10
San Diego	7
San Francisco	3
San Joaquin	12
San Luis Obispo	5
San Mateo	3
Santa Barbara	6
Santa Clara	4
Santa Cruz	3
Shasta	11
Sierra	16
Siskiyou	16
Solano	3
Sonoma	2
Stanislaus	12
Sutter	11
Tehama	11
Trinity	2
Tulare	16

County	Climate Zone
Tuolumne	16
Ventura	6
Yolo	12
Yuba	11

Table A.2: Key Financial and System Assumptions

Key System and Financial Assumptions		
Factor	Commercial	Residential
System Life (Years)	30	30
O&M Cost ($/kW/year)	$12 declining at 3.5% per year	$10 declining at 4% per year
REC Value ($/MWh)	$15 with no escalation	0
Federal Tax Credit	30% ITC through 2008, 10% after	$2,000 credit for 2006-2008
System Size (kW)	250 kW	5 kW
Module Tilt (°)	5	15
Depreciation	5 Year MACRS	-
System Power Density (MWp/million sq. ft)	10 MW in 2006, increasing to14 MW by 2016	10 MW in 2006, increasing to 14 MW by 2016

Table A.3: Assumed Utility Rates ($2006) in $/kWh using a 3%/year real escalation rate

	Commercial			Residential		
County	2006	2010	2016	2006	2010	2016
Alameda	0.184	0.207	0.247	0.185	0.208	0.249
Alpine	0.192	0.216	0.258	0.178	0.200	0.239
Amador	0.184	0.207	0.247	0.164	0.185	0.221
Butte	0.184	0.207	0.247	0.171	0.192	0.230
Calaveras	0.184	0.207	0.247	0.164	0.185	0.221
Colusa	0.184	0.207	0.247	0.171	0.192	0.230
Contra Costa	0.192	0.216	0.258	0.166	0.187	0.223
Del Norte	0.054	0.061	0.073	0.078	0.088	0.105

	Commercial			Residential		
County	2006	2010	2016	2006	2010	2016
El Dorado	0.192	0.216	0.258	0.159	0.179	0.214
Fresno	0.184	0.207	0.247	0.170	0.191	0.228
Glenn	0.184	0.207	0.247	0.171	0.192	0.230
Humboldt	0.192	0.216	0.258	0.181	0.204	0.243
Imperial	0.066	0.074	0.089	0.073	0.082	0.098
Inyo	0.141	0.159	0.189	0.128	0.144	0.172
Kern	0.184	0.207	0.247	0.165	0.186	0.222
Kings	0.184	0.207	0.247	0.165	0.186	0.222
Lake	0.192	0.216	0.258	0.175	0.196	0.235
Lassen	0.079	0.089	0.107	0.073	0.082	0.098
Los Angeles	0.161	0.181	0.216	0.150	0.169	0.202
Madera	0.184	0.207	0.247	0.170	0.191	0.228
Marin	0.192	0.216	0.258	0.195	0.219	0.262
Mariposa	0.192	0.216	0.258	0.163	0.183	0.219
Mendocino	0.192	0.216	0.258	0.153	0.172	0.206
Merced	0.098	0.110	0.131	0.123	0.139	0.166
Modoc	0.054	0.061	0.073	0.079	0.089	0.106
Mono	0.141	0.159	0.189	0.193	0.217	0.259
Monterey	0.192	0.216	0.258	0.216	0.243	0.290
Napa	0.192	0.216	0.258	0.197	0.221	0.264
Nevada	0.184	0.207	0.247	0.187	0.210	0.251
Orange	0.168	0.190	0.226	0.202	0.227	0.272
Placer	0.184	0.207	0.247	0.187	0.210	0.251
Plumas	0.192	0.216	0.258	0.180	0.203	0.242
Riverside	0.183	0.206	0.246	0.143	0.161	0.193
Sacramento	0.079	0.089	0.107	0.097	0.109	0.130
San Benito	0.192	0.216	0.258	0.177	0.199	0.238
San Bernardino	0.183	0.206	0.246	0.226	0.255	0.304
San Diego	0.204	0.230	0.274	0.133	0.150	0.179
San Francisco	0.192	0.216	0.258	0.216	0.243	0.290
San Joaquin	0.184	0.207	0.247	0.147	0.165	0.198
San Luis Obispo	0.192	0.216	0.258	0.217	0.244	0.292
San Mateo	0.192	0.216	0.258	0.195	0.219	0.262
Santa Barbara	0.185	0.209	0.249	0.230	0.259	0.309
Santa Clara	0.192	0.216	0.258	0.177	0.199	0.238
Santa Cruz	0.192	0.216	0.258	0.202	0.227	0.271
Shasta	0.192	0.216	0.258	0.129	0.146	0.174
Sierra	0.192	0.216	0.258	0.178	0.200	0.239

	Commercial			Residential		
County	2006	2010	2016	2006	2010	2016
Siskiyou	0.054	0.061	0.073	0.079	0.089	0.106
Solano	0.192	0.216	0.258	0.156	0.175	0.209
Sonoma	0.192	0.216	0.258	0.197	0.221	0.264
Stanislaus	0.079	0.089	0.107	0.073	0.082	0.098
Sutter	0.184	0.207	0.247	0.171	0.192	0.230
Tehama	0.184	0.207	0.247	0.164	0.184	0.220
Trinity	0.079	0.089	0.107	0.097	0.109	0.130
Tulare	0.141	0.159	0.189	0.150	0.169	0.201
Tuolumne	0.192	0.216	0.258	0.159	0.179	0.214
Ventura	0.184	0.208	0.248	0.227	0.256	0.306
Yolo	0.184	0.207	0.247	0.147	0.165	0.198
Yuba	0.184	0.207	0.247	0.187	0.210	0.251

APPENDIX B: RESULTS

APB-1

Table B.1: Technical Potential by County (MWp)

	Residential			Commercial			Total (MWp)		
County	2006	2010	2016	2006	2010	2016	2006	2010	2016
Alameda	1137	1360	1717	735	879	1109	1872	2239	2826
Alpine	4	5	7	54	60	67	57	64	74
Amador	41	54	76	10	12	15	51	65	91
Butte	192	247	347	61	75	100	253	322	448
Calaveras	68	90	133	10	12	16	78	103	149
Colusa	17	21	27	10	11	14	26	32	41
Contra Costa	617	756	989	360	438	565	977	1193	1555
Del Norte	13	16	22	9	11	13	22	27	34
El Dorado	203	266	388	48	62	88	251	329	475
Fresno	687	881	1237	275	346	470	962	1227	1707
Glenn	21	26	35	7	8	9	28	34	44
Humboldt	78	96	125	45	53	64	123	148	189
Imperial	128	171	253	49	64	93	177	234	346
Inyo	14	17	21	7	9	11	21	25	31
Kern	604	793	1153	251	312	420	854	1106	1573
Kings	102	134	194	41	53	74	143	187	268
Lake	39	50	68	11	13	16	50	63	85
Lassen	24	30	42	19	22	27	43	53	69
Los Angeles	5724	6789	8468	4604	5540	7060	10328	12330	15528
Madera	114	152	226	33	42	57	147	194	283
Marin	152	180	222	94	111	138	246	291	360
Mariposa	18	22	29	5	5	7	22	27	36
Mendocino	53	65	86	26	31	38	79	96	123
Merced	207	278	419	65	80	106	272	358	525
Modoc	8	9	11	4	4	5	12	14	16
Mono	20	25	34	8	10	15	28	35	49
Monterey	222	277	373	147	177	226	369	454	599
Napa	79	100	137	62	78	107	141	178	244
Nevada	113	145	201	22	28	38	135	172	239
Orange	1879	2301	3009	1509	1850	2426	3388	4151	5435
Placer	389	553	902	126	176	280	516	729	1182
Plumas	33	43	61	7	8	11	40	51	72
Riverside	1609	2268	3665	601	823	1272	2209	3090	4937
Sacramento	1218	1571	2221	573	729	1010	1791	2300	3232
San Benito	36	45	60	11	13	16	47	58	76
San Bernardino	1390	1796	2548	860	1144	1694	2250	2940	4242
San Diego	1970	2460	3312	1282	1617	2210	3253	4077	5522
San Francisco	381	453	567	535	635	792	916	1088	1359
	Residential			Commercial			Total (MWp)		
County	2006	2010	2016	2006	2010	2016	2006	2010	2016
San Joaquin	581	781	1177	230	296	419	811	1078	1596
San Luis Obispo	219	284	404	85	110	154	304	393	558

San Mateo	367	431	531	385	465	595	752	896	1126
Santa Barbara	263	324	426	166	206	276	429	530	702
Santa Clara	1053	1278	1651	935	1129	1447	1987	2407	3098
Santa Cruz	143	175	228	83	101	130	226	275	357
Shasta	164	209	289	54	65	85	218	274	374
Sierra	5	6	8	2	2	3	7	8	10
Siskiyou	47	58	77	16	19	24	63	77	101
Solano	259	331	463	153	190	254	411	521	717
Sonoma	300	375	508	184	230	308	484	605	816
Stanislaus	424	555	802	152	195	274	575	750	1077
Sutter	84	111	163	26	33	47	110	144	210
Tehama	48	62	86	15	18	23	63	80	109
Trinity	9	11	15	3	3	4	12	15	19
Tulare	303	390	550	114	144	196	417	534	746
Tuolumne	66	83	114	17	20	26	83	104	140
Ventura	494	624	855	330	416	566	824	1039	1421
Yolo	160	211	309	91	118	168	251	329	478
Yuba	67	91	138	19	23	30	86	114	168
Total	24658	30932	42181	15634	19323	25708	40293	50255	67889

Table B.2: Retrofit Economic Potential by County, Without State Incentives (MWp)

	Residential			Commercial		
County	2006	2010	2016	2006	2010	2016
Alameda	0	0	10	1	4	14
Alpine	0	0	0	0	0	1
Amador	0	0	0	0	0	0
Butte	0	0	2	0	0	1
Calaveras	0	0	1	0	0	0
Colusa	0	0	0	0	0	0
Contra Costa	0	0	5	1	2	8
Del Norte	0	0	0	0	0	0
El Dorado	0	0	1	0	0	1
Fresno	0	0	6	1	2	6
Glenn	0	0	0	0	0	0
Humboldt	0	0	0	0	0	1
	Residential			Commercial		
County	2006	2010	2016	2006	2010	2016
Imperial	0	0	0	0	0	1
Inyo	0	0	0	0	0	0
Kern	0	0	6	1	1	6
Kings	0	0	1	0	0	1
Lake	0	0	0	0	0	0

Lassen	0	0	0	0	0	0
Los Angeles	0	1	30	8	22	82
Madera	0	0	1	0	0	1
Marin	0	0	1	0	0	2
Mariposa	0	0	0	0	0	0
Mendocino	0	0	0	0	0	0
Merced	0	0	0	0	0	1
Modoc	0	0	0	0	0	0
Mono	0	0	0	0	0	0
Monterey	0	0	3	0	1	3
Napa	0	0	1	0	0	1
Nevada	0	0	1	0	0	0
Orange	0	0	21	3	8	29
Placer	0	0	5	0	1	4
Plumas	0	0	0	0	0	0
Riverside	0	0	11	1	4	17
Sacramento	0	0	0	1	2	6
San Benito	0	0	0	0	0	0
San Bernardino	0	0	6	3	8	32
San Diego	0	0	5	1	3	10
San Francisco	0	0	3	0	1	5
San Joaquin	0	0	4	0	1	2
San Luis Obispo	0	0	3	1	2	8
San Mateo	0	1	5	0	1	4
Santa Barbara	0	0	9	2	5	19
Santa Clara	0	0	2	0	0	2
Santa Cruz	0	0	0	0	0	1
Shasta	0	0	0	0	0	0
Sierra	0	0	0	0	0	0
Siskiyou	0	0	2	0	1	3
Solano	0	0	6	3	8	32
Sonoma	0	0	3	0	1	4
	Residential			Commercial		
County	2006	2010	2016	2006	2010	2016
Stanislaus	0	0	0	0	0	2
Sutter	0	0	1	0	0	1
Tehama	0	0	0	0	0	0
Trinity	0	0	0	0	0	0
Tulare	0	0	2	0	1	2
Tuolumne	0	0	0	0	0	0
Ventura	0	1	9	1	2	7
Yolo	0	0	1	0	0	2
Yuba	0	0	1	0	0	0

Total	1	8	195	29	82	315

Table B.3: New Construction Economic Potential by County, Without State Incentives (MWp)

	Residential			Commercial		
County	2006	2010	2016	2006	2010	2016
Alameda	0	0	0	0	0	0
Alpine	0	0	0	0	0	0
Amador	0	0	0	0	0	0
Butte	0	0	0	0	0	0
Calaveras	0	0	0	0	0	0
Colusa	0	0	0	0	0	0
Contra Costa	0	0	0	0	0	0
Del Norte	0	0	0	0	0	0
El Dorado	0	0	0	0	0	0
Fresno	0	0	1	0	0	0

Glenn	0	0	0	0	0	0
Humboldt	0	0	0	0	0	0
Imperial	0	0	0	0	0	0
Inyo	0	0	0	0	0	0
Kern	0	0	1	0	0	0
Kings	0	0	0	0	0	0
Lake	0	0	0	0	0	0
Lassen	0	0	0	0	0	0
Los Angeles	0	0	1	0	0	2
Madera	0	0	0	0	0	0
Marin	0	0	0	0	0	0
Mariposa	0	0	0	0	0	0
Mendocino	0	0	0	0	0	0
Merced	0	0	0	0	0	0
Modoc	0	0	0	0	0	0
Mono	0	0	0	0	0	0
Monterey	0	0	0	0	0	0
Napa	0	0	0	0	0	0
Nevada	0	0	0	0	0	0
Orange	0	0	1	0	0	1
Placer	0	0	1	0	0	0
Plumas	0	0	0	0	0	0
Riverside	0	0	2	0	0	1
Sacramento	0	0	0	0	0	0
San Benito	0	0	0	0	0	0
San Bernardino	0	0	4	0	0	2
	Residential			Commercial		
County	2006	2010	2016	2006	2010	2016
San Diego	0	0	0	0	0	2
San Francisco	0	0	0	0	0	0
San Joaquin	0	0	0	0	0	0
San Luis Obispo	0	0	1	0	0	0
San Mateo	0	0	0	0	0	0
Santa Barbara	0	0	0	0	0	0
Santa Clara	0	0	0	0	0	0
Santa Cruz	0	0	0	0	0	0
Shasta	0	0	0	0	0	0
Sierra	0	0	0	0	0	0
Siskiyou	0	0	0	0	0	0
Solano	0	0	0	0	0	0
Sonoma	0	0	0	0	0	0
Stanislaus	0	0	0	0	0	0
Sutter	0	0	0	0	0	0
Tehama	0	0	0	0	0	0

Trinity	0	0	0	0	0	0
Tulare	0	0	0	0	0	0
Tuolumne	0	0	0	0	0	0
Ventura	0	0	1	0	0	0
Yolo	0	0	0	0	0	0
Yuba	0	0	0	0	0	0
Total	0	0	15	0	2	11

Table B.4: Retrofit Economic Potential by County, With State Incentives (MWp)

	Residential			Commercial		
County	2006	2010	2016	2006	2010	2016
Alameda	0	3	17	3	7	17
Alpine	0	0	0	0	0	2
Amador	0	0	0	0	0	0
Butte	0	0	3	0	1	2
Calaveras	0	0	1	0	0	0
Colusa	0	0	0	0	0	0
Contra Costa	0	1	8	1	3	13
Del Norte	0	0	0	0	0	0
El Dorado	0	0	2	0	0	1
Fresno	0	1	10	1	3	8
Glenn	0	0	0	0	0	0
Humboldt	0	0	1	0	0	1
Imperial	0	0	0	0	0	1
Inyo	0	0	0	0	0	0
Kern	0	1	9	1	2	10
Kings	0	0	1	0	0	1
Lake	0	0	1	0	0	0
Lassen	0	0	0	0	0	0
Los Angeles	0	3	51	16	39	105
Madera	0	0	2	0	0	1
Marin	0	0	2	0	1	2
Mariposa	0	0	0	0	0	0
Mendocino	0	0	0	0	0	1
Merced	0	0	1	0	0	1
Modoc	0	0	0	0	0	0
Mono	0	0	0	0	0	0
Monterey	0	1	5	1	1	4
Napa	0	0	2	0	1	2
Nevada	0	0	2	0	0	1
Orange	1	7	37	5	13	37
Placer	0	1	8	0	1	4
Plumas	0	0	1	0	0	0
Riverside	0	0	20	2	6	20
Sacramento	0	0	0	1	3	8
San Benito	0	0	1	0	0	0
San Bernardino	1	8	59	3	9	53
	Residential			Commercial		
County	2006	2010	2016	2006	2010	2016
San Diego	0	0	16	7	13	87
San Francisco	0	2	8	2	5	13

San Joaquin	0	0	6	1	2	7
San Luis Obispo	0	1	6	0	1	6
San Mateo	0	1	6	1	4	10
Santa Barbara	0	1	10	1	2	9
Santa Clara	0	2	14	3	9	23
Santa Cruz	0	0	3	0	1	2
Shasta	0	0	0	0	0	1
Sierra	0	0	0	0	0	0
Siskiyou	0	0	0	0	0	0
Solano	0	0	3	1	1	4
Sonoma	0	1	6	1	2	5
Stanislaus	0	0	0	0	1	2
Sutter	0	0	1	0	0	1
Tehama	0	0	1	0	0	0
Trinity	0	0	0	0	0	0
Tulare	0	0	3	0	1	3
Tuolumne	0	0	1	0	0	0
Ventura	0	2	12	1	3	9
Yolo	0	0	2	0	1	3
Yuba	0	0	1	0	0	0
Total	4	42	343	58	140	482

Table B.5: New Construction Economic Potential by County, With State Incentives (MWp)

	Residential			Commercial		
County	2006	2010	2016	2006	2010	2016
Alameda	0	0	1	0	0	0
Alpine	0	0	0	0	0	0
Amador	0	0	0	0	0	0

Butte	0	0	0	0	0	0
Calaveras	0	0	0	0	0	0
Colusa	0	0	0	0	0	0
Contra Costa	0	0	1	0	0	0
Del Norte	0	0	0	0	0	0
El Dorado	0	0	0	0	0	0
Fresno	0	0	1	0	0	0
Glenn	0	0	0	0	0	0
Humboldt	0	0	0	0	0	0
Imperial	0	0	0	0	0	0
Inyo	0	0	0	0	0	0
Kern	0	0	2	0	0	0
Kings	0	0	0	0	0	0
Lake	0	0	0	0	0	0
Lassen	0	0	0	0	0	0
Los Angeles	0	0	2	0	1	3
Madera	0	0	0	0	0	0
Marin	0	0	0	0	0	0
Mariposa	0	0	0	0	0	0
Mendocino	0	0	0	0	0	0
Merced	0	0	0	0	0	0
Modoc	0	0	0	0	0	0
Mono	0	0	0	0	0	0
Monterey	0	0	0	0	0	0
Napa	0	0	0	0	0	0
Nevada	0	0	0	0	0	0
Orange	0	0	3	0	0	1
Placer	0	0	2	0	0	1
Plumas	0	0	0	0	0	0
Riverside	0	0	5	0	0	2
Sacramento	0	0	0	0	0	0
San Benito	0	0	0	0	0	0
San Bernardino	0	0	10	0	1	3
	Residential			Commercial		
County	2006	2010	2016	2006	2010	2016
San Diego	0	0	1	0	0	3
San Francisco	0	0	0	0	0	0
San Joaquin	0	0	1	0	0	0
San Luis Obispo	0	0	1	0	0	0
San Mateo	0	0	0	0	0	0
Santa Barbara	0	0	1	0	0	0
Santa Clara	0	0	1	0	0	1
Santa Cruz	0	0	0	0	0	0
Shasta	0	0	0	0	0	0

Sierra	0	0	0	0	0	0
Siskiyou	0	0	0	0	0	0
Solano	0	0	0	0	0	0
Sonoma	0	0	1	0	0	0
Stanislaus	0	0	0	0	0	0
Sutter	0	0	0	0	0	0
Tehama	0	0	0	0	0	0
Trinity	0	0	0	0	0	0
Tulare	0	0	0	0	0	0
Tuolumne	0	0	0	0	0	0
Ventura	0	0	2	0	0	1
Yolo	0	0	0	0	0	0
Yuba	0	0	0	0	0	0
Total	0	2	39	0	4	20

Table B.6: Retrofit Economic Potential by County, With State Subsidies and New Business Models (MWp)

	Residential			Commercial		
County	2006	2010	2016	2006	2010	2016
Alameda	0	5	24	3	8	44
Alpine	0	0	0	0	1	4
Amador	0	0	1	0	0	1
Butte	0	1	4	0	1	4
Calaveras	0	0	1	0	0	1
Colusa	0	0	0	0	0	1
Contra Costa	0	2	12	1	4	31
Del Norte	0	0	0	0	0	0
El Dorado	0	1	4	0	1	5
Fresno	0	3	16	1	3	26
Glenn	0	0	0	0	0	0
Humboldt	0	0	1	0	0	1
Imperial	0	0	0	0	0	1
Inyo	0	0	0	0	0	0
Kern	0	2	14	1	3	23
Kings	0	0	2	0	0	4
Lake	0	0	1	0	0	1
Lassen	0	0	0	0	0	0
Los Angeles	0	16	85	16	45	168
Madera	0	0	3	0	0	3
Marin	0	1	3	0	1	6
Mariposa	0	0	0	0	0	0
Mendocino	0	0	1	0	0	1
Merced	0	0	2	0	0	1
Modoc	0	0	0	0	0	0
Mono	0	0	1	0	0	0
Monterey	0	2	14	1	2	11
Napa	0	0	2	0	1	5
Nevada	0	1	3	0	0	1
Orange	1	11	71	5	15	77
Placer	0	2	12	0	2	11
Plumas	0	0	1	0	0	1
Riverside	0	4	33	2	7	60
Sacramento	0	0	5	1	3	9
San Benito	0	0	1	0	0	1
San Bernardino	1	14	181	3	11	99
	Residential			Commercial		
County	2006	2010	2016	2006	2010	2016
San Diego	0	3	23	7	15	137

San Francisco	0	3	22	2	6	37
San Joaquin	0	1	10	1	3	16
San Luis Obispo	0	2	26	0	1	10
San Mateo	0	2	8	1	4	28
Santa Barbara	0	3	31	1	2	16
Santa Clara	0	4	22	3	10	68
Santa Cruz	0	1	4	0	1	6
Shasta	0	0	1	0	0	1
Sierra	0	0	0	0	0	0
Siskiyou	0	0	0	0	0	0
Solano	0	1	5	1	2	12
Sonoma	0	2	8	1	2	15
Stanislaus	0	0	0	0	1	2
Sutter	0	0	2	0	0	2
Tehama	0	0	1	0	0	1
Trinity	0	0	0	0	0	0
Tulare	0	1	6	0	1	3
Tuolumne	0	0	1	0	0	1
Ventura	0	4	52	1	4	27
Yolo	0	0	3	0	1	7
Yuba	0	0	2	0	0	1
Total	4	94	727	58	163	991

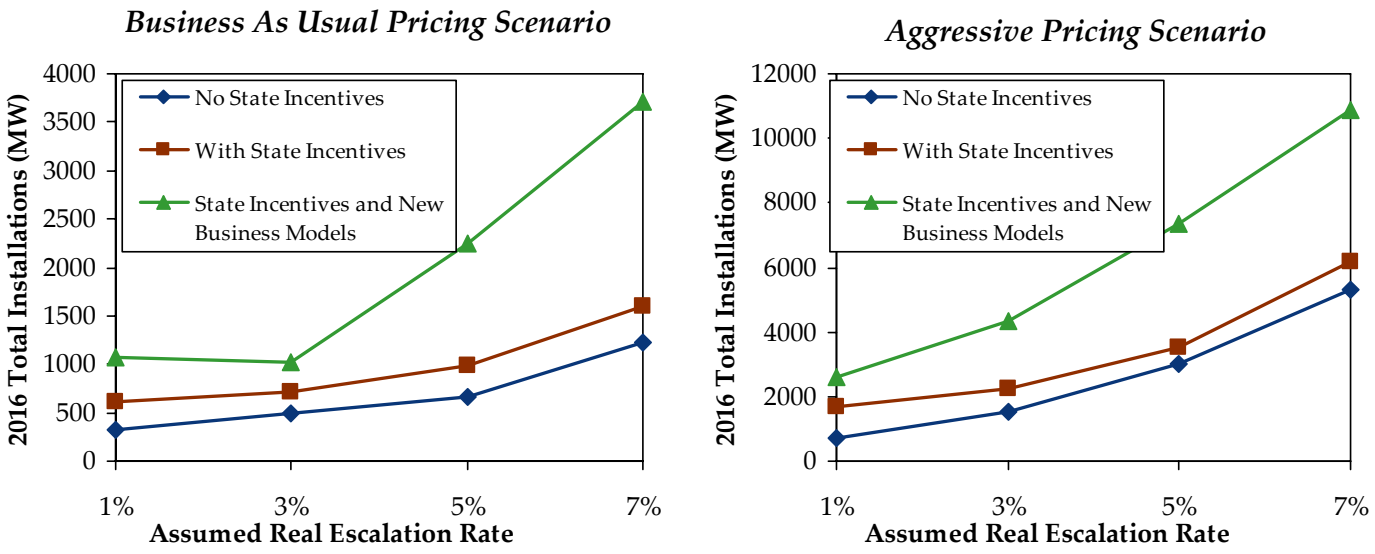

Figure B.1: Sensitivity of Economic Potentials Due to Real Escalation of Electric Rates