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Environmental and Economic Benefits of Building Solar in California: Quality Careers — Cleaner Lives

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DONALD VIAL CENTER ON EMPLOYMENT IN THE GREEN ECONOMY
Institute for Research on Labor and Employment
University of California, Berkeley

November 10, 2014

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Peter Philips (B.A. Pomona College, M.A., Ph.D. Stanford University) is a Professor of Economics and former Chair of the Economics Department at the University of Utah. Philips is a leading economic expert on the U.S. construction labor market. He has published widely on the topic and has testified as an expert in the U.S. Court of Federal Claims, served as an expert for the U.S. Justice Department in litigation concerning the Davis-Bacon Act (the federal prevailing wage law), and presented testimony to state legislative committees in Ohio, Indiana, Kansas, Oklahoma, New Mexico, Utah, Kentucky, Connecticut, and California regarding the regulations of construction labor markets. His academic work on the construction labor market over the last 20 years can be found at http://faculty.utah.edu/u0035312-PETER_W_PHILIPS,_Labor_Economist/bibliography/index.hml

He is currently a Visiting Scholar at the UC Berkeley Institute for Research on Labor and Employment.

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Introduction

On November 1, 2014, the U.N. Intergovernmental Panel on Climate Change[i] warned:

> Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems.[ii]

In summarizing this study, the *Washington Post* reported:

> The planet faces a future of extreme weather, rising sea levels and melting polar ice from soaring levels of carbon dioxide and other gases, the U.N. panel said. Only an unprecedented global effort to slash emissions within a relatively short time period will prevent temperatures from crossing a threshold that scientists say could trigger far more dangerous disruptions, the panel warned.[iii]

And the *New York Times* reported:

> Failure to reduce emissions, the group of scientists and other experts found, could threaten society with food shortages, refugee crises, the flooding of major cities and entire island nations, mass extinction of plants and animals, and a climate so drastically altered it might become dangerous for people to work or play outside during the hottest times of the year.... The gathering risks of climate change are so profound that they could stall or even reverse generations of progress against poverty and hunger if greenhouse emissions continue at a runaway pace, according to a major new United Nations report.[iv]

Yet the world is moving only slowly to meet this increasingly clear and present danger.

However, in California over the last five years, dramatic action has taken place addressing greenhouse gas emissions through an ongoing transition from fossil fuel generated electricity to renewable energy electricity generation. While currently in California natural gas accounts for 44% of the total system's electrical power and coal accounts for 8%, renewable energy sources account for 19%, up from 11% in 2008. The fastest growing segment of California's renewable energy portfolio over the last five years has been solar energy. In-state, utility-scale solar generated electricity has quadrupled since 2010.

In this report, *Environmental and Economic Benefits of Building Solar in California*, we provide a case study where federal, state, and construction industry policies and practices are cutting through the Gordian Knott of economic, political, and policy paralysis in the face of impending, irreversible, and destructive climate change. Describing California's leadership in the expansion of renewable energy electricity generation, we first discuss the current boom in utility-scale solar farms in California and the emissions averted by California's renewable energy generated electricity.

The study also examines the employment effects of having built 4,250 MW of utility-scale solar powered electricity generating facilities in California over the last five years. We calculate the new construction, maintenance, and operations jobs created by California's boom in utility-scale solar plants plus the upstream and downstream jobs stimulated by this construction. We estimate the income and health and pension benefits of these new construction and plant operations jobs.

Because the vast majority of construction jobs in California's recent utility-scale solar boom have been organized under collective bargaining, these contracts have required payments into apprenticeship training programs for each hour worked building these solar power plants. Reflecting this, we calculate the new monies that have gone into the training of the next generation of construction workers who will be called upon to build a more climate-friendly infrastructure over the coming decades.

This new human capital not only raises the productive capacity of California's construction labor force but also transforms the lives of newly trained workers. We estimate how this training affects the lifetime earnings of these new workers, and we provide personal case studies of four new apprentices as they consider their past and look into their future.

Finally, we look at the federal, state, and industry policies that have made this solar boom possible. We conclude that there is a synergy between good jobs and green energy projects. Smart government policies and high-road construction practices are a foundation for addressing climate change, and, in turn, good jobs and clean energy projects reinforce the policies and practices that stimulated these jobs and practices in the first place.

Global warming is a clear, present, and serious threat but it is not intractable. California's recent solar boom is an example of how politics and economics can work together to untie the knot of inaction in the face of the gathering risks of climate change.

The Environment

In the first half of 2014 in the United States, 42% of the new utility-scale electricity generation capacity put in place was from solar and wind power plants. Solar alone accounted for 26% of the new power plant generation. According to industry sources, when rooftop solar is added to the mix, solar accounted for about half of all new electricity generation put in place in the U.S. during this time period. Government data on power plants show that, comparing the first half of 2013 to the first half of 2014, new additions to natural gas and coal fired power plants fell while both wind and solar new utility-scale generation capacity almost doubled.

This boom in renewable energy electricity generation has been given a substantial boost from federal policy and legislative action. The Obama Administration's American Recovery and Reinvestment Act (ARRA) of 2009 earmarked more funds for clean energy than had been done at any time in our nation's history. Loan guarantees helping first movers introducing new technologies in the face of technological and business cycle uncertainties allowed for solar energy to take off in the depths of the Great Recession. Similarly, the Federal Business Energy Investment Tax Credit, which provides a 30% credit to residential, commercial, and utility-scale solar systems, was renewed in 2008 for eight additional years. While these policies and, in the case of ARRA, legislative action have stimulated renewable energy electricity generation across the nation, they have been especially successful in boosting solar electricity generation in California, a state with rich solar resources in close proximity to population centers where the electricity demand primarily resides.

Just as federal action has driven a national expansion of the renewable energy sector, California has pioneered policies that have been critical in making it the renewable energy capital of the United States. The Global Warming Solutions Act (AB 32), passed in 2006, requires a steep reduction in greenhouse gas emissions, and in 2011 Governor Brown signed Senate Bill X1-2, which expanded California's Renewables Portfolio Standard (RPS) to a 33% target by 2020. The state's aggressive climate change policies, abundant photovoltaic (PV) solar resources, large population centers, and need to conserve water used to cool thermal power plants have coalesced to make California the country's leading user of PV-generated electricity. Among the top ten states, California accounts for fully half of all installed PV electricity generation capacity. California is on track to install in 2014 almost ten times more new PV generating capacity than any other state.

Within California, renewable energy technologies have recently come to dominate the growth in overall electrical generation capacity and usage. Subsequent to the passage of ARRA and California's SBX1-2, California's use of electricity from renewable energy sources almost doubled its share of overall California electricity generation, moving from around 11% in 2008 to 19% in 2013.

The National Renewable Energy Laboratory (NREL) estimates that a 16.5% penetration of wind power combined with a 16.5% penetration of solar power, for a total of 33% Western Grid reliance on these two renewable energy sources, would reduce carbon emissions from electricity generation by about one-third. Currently 19% of California's power grid is fed by biomass, geothermal, wind, solar, and small hydroelectric renewable energy sources. While the emissions impact of each of these renewable resources varies, California is moving toward a level of renewable energy reliance and emission reduction similar to the scenario envisioned by the NREL study.

The Solar Energy Industry Association estimates that solar-powered electricity generating facilities in California (both rooftop and utility-scale), with roughly 5,000 MW of collective capacity, have per year reduced carbon dioxide (CO2) emissions by about 4.4 million tons, nitrogen oxides (NOx) emissions by about 6.3 million tons, and sulfur dioxide (SO2) emissions by about 700,000 tons. At this time, recently installed utility-scale solar farms in California account for approximately 75% of the state's solar power-generated electricity. Thus, utility-scale solar power in California has effectuated an overall reduction of about 4.8 million tons of nitrogen oxides, 3.3 million tons in carbon dioxide, and 525 thousand tons of sulfur dioxide.

Job Creation

Over the last five years, 10,200 well-paying construction jobs were created in California during the expansion of California's solar-based, utility-scale electrical generating facilities. These jobs pay, on average, $78,000 per year and offer solid health and pension benefits. In addition, 136 permanent operations and maintenance jobs have been created and will last for the lifetime of these facilities. These operations and maintenance jobs pay an average of $69,000 per year, usually with solid benefits. In addition to the jobs created on the construction projects, about 1,600 jobs have been created to handle increased business up and down the supply chain and to perform other new business activities associated with these projects. These newly-created construction, maintenance, and business-related jobs have boosted consumer spending, which in turn has induced the creation of over 3,700 additional California jobs aimed at meeting increased consumer demand. In total, more than 15,000 new jobs have been created by the solar farm construction boom in California over the last five years.[1]

Career Development and Human Capital Formation

Utility-scale solar construction in California over the last five years built 4,250 MW of renewable energy generating capacity in California. Because most of the construction was organized under collectively bargained contracts or project labor agreements, contractors have agreed to contribute training money for apprenticeship training based on each hour of work for every blue-collar worker on the site. This has provided $17.5 million in new money to help finance the training of construction apprentices and pre-apprentices. This infusion into California construction apprenticeship and pre-apprenticeship training includes $8.3 million into electrician training, $3.1 million into the training of construction craft laborers, $2.6 million into training ironworkers, $1.7 million to train carpenters and piledrivers, and $1.9 million dollars to train operating engineers.

This new human capital formation will generate a stream of higher income over decades, reflecting the greater skill set and higher productivity of these trained California construction workers. For instance, over the lifetime of electrical apprentices, as they become journeyworkers, their income in today's dollars will be higher by about $1 million compared to what their income would have been absent this training. In addition, these workers not only earn while they learn but they also participate in family-supportive health insurance programs, promoting family formation and stable child-rearing, and they begin building savings for their retirement. By the time these electrical apprentices retire as journeyworkers at age 65, they will have amassed a retirement nest egg of about $525,000 in defined contribution and defined benefit programs sponsored by their contractors and unions. This is substantially more than what the median single or married worker at age 65 today has for retirement.

[1] Here jobs are understood to be job-years, or 2,080 hours of work, though in many cases a construction worker will not be on a job for a full year. Construction apprentices are often rotated off jobs to get experience in other types of construction and therefore one job-year may be spread across two or more construction workers. In contrast, the 136 operations and maintenance jobs are 25 job-years, each lasting the expected lifetime of a newly-built solar electrical generation plant.

The California solar boom has not only prepared California for a future of energy independence, it is preparing a new generation of California blue-collar workers for a future of skilled and productive work and a life of financial security.

Policy Leads the Way

Policy and legislative action at both the federal and state levels has stimulated the boom in California's renewable energy electricity generation over the last five years, enabling California to become the national model in demonstrating how to generate new economic opportunity through aggressive climate change action. Key federal policies include the American Recovery and Reinvestment Act (ARRA) of 2009 and the Federal Business Energy Investment Tax Credit (ITC). California's policies include the Global Warming Solutions Act (AB 32), Senate Bill X1-2, and AB 327, which passed in 2013 and established the 33% Renewables Portfolio Standard (RPS) goal set forth in SB X1-2 as a floor to be achieved and not a ceiling to reach for. The California Environmental Quality Act has also played an important role in promoting California's renewable energy growth. Collectively, these policies helped marshal the needed investment capital, helped create the market certainty needed to turn financial capital into specific investment plans, and helped provide the business, worker, and public incentives that brought these players together.

The synergy between building green, utility-scale power plants and quality construction career development has also benefited from federal and state policies. Utility-scale solar projects that receive federal subsidies fall under the Davis-Bacon Act, which requires that prevailing wages and benefits be paid. Furthermore, California is not a right-to-work state and as a result prevailing wages in construction tend to be the collectively bargained rate that includes good wages with decent benefits and contributions to apprenticeship training.

On some federally-subsidized solar projects in western right-to-work states, nonunion rates prevail. In these cases, workers are often obtained from temporary labor agencies; they earn low wages with limited benefits and they have little access to training or career advancement. In California, by contrast, strong unions and strong prevailing wage laws combine to create green construction projects that also build the skills of the local construction labor force and improve the career opportunities of many new entrants into the industry.

For 200 years, government has promoted, subsidized, incentivized, and encouraged canals, railroads, schools, highways, the internet and other infrastructure foundational to economic growth and prosperity. In the 21st Century, energy and the environment are key infrastructure for future economic growth and prosperity. But neither green energy projects that create dead-end jobs nor projects that degrade the environment but provide good jobs are sustainable building blocks for the future. Legislation, regulation, and policy are key to creating a synergy between electricity generation, the environment, and the labor market. Four key policy actions that should be taken in the near-term to continue building on California's leadership in creating high-quality jobs while decarbonizing the energy sector are:

- **Renewing the Federal Business Energy Investment Tax Credit so it remains at 30% after December 2016.**
- **Expanding California's statewide renewable energy mandate beyond 33%.**
- **Protecting AB 32 from implementation delays or weakening.**
- **Supporting policies that promote collective bargaining and the use of joint labor-management apprenticeship programs on energy projects during construction, operations, and maintenance.**

Scope, Methodology, and Limitations of this Study

Scope

This study focuses on the environmental and economic impact of utility-scale solar electricity generation in California since 2010. Between utility-scale thermal and photovoltaic (PV) solar electricity generation, this report focuses more on PV energy. The reasons for this focus on solar power plants emphasizing PV are ones of empirical importance, methodological approach, and research practicality.

Empirically, over the last five years, utility-scale renewable energy construction in California has centered on solar energy, which has primarily been PV solar energy. Of the approximately 4,250 megawatts (MW) of new utility-scale solar electricity generation capacity coming online or currently under construction in California over the last five years, about 3,350 MW were PV electricity and 900 MW were solar thermal generated electricity. From an empirical perspective, therefore, this report focuses on the leading sector in California's march towards cleaner electrical generation.

Nonetheless, wind, geothermal, small hydroelectric, energy-storage, ocean-wave energy, and emerging technologies, along with energy conservation, all have important roles to play in moving California toward a cleaner environment. Further research is needed to measure and analyze the environmental and employment impacts of these important forms of renewable energy generation and conservation.

We focus on utility-scale solar electricity generation even though rooftop (or distributed) solar electricity generation is also an important and growing form of green energy in California. This limitation is partly borne of practicality: due to the size and prevalence of utility-scale solar, it is just easier to get information on its whereabouts, construction methods, and progress.

Methodological reasons also lead us to limit this study to utility-scale solar. We rely on the research of others to calculate the number of construction job-years per MW of electrical capacity put-in-place, as well as the upstream and downstream off-site employment impacts of solar construction. These are key steps in measuring the employment impact from the expansion of solar electricity generation in California. Currently, the literature on construction employment per MW of solar energy installed for California is limited to utility-scale PV electricity generation, partly because this research stems from permitting processes and partly because there is a greater heterogeneity of construction practices on rooftop solar installations.

More research needs to be done on both the technical and economic dimensions of rooftop solar construction in order to provide an analysis similar to the one done here on utility-scale solar electricity generation. Additionally, more employment-related research needs to be done on the other green electricity generating technologies, energy-storage, and conservation that together with solar comprise the set of approaches that will move California towards a cleaner environment.

Examination of renewable energy electricity generation and the jobs it creates is a new and exciting field of research. This report's focus on California's recent utility-scale solar boom is simply a first step in the research needed to understand the importance of this sector and the policies and practices needed to reinforce the synergy between building green and developing good construction careers.

Method

Methodologically, our calculation of the employment impact of utility-scale solar construction and operations goes as follows. First, we identify the electricity generation capacity of new utility-scale solar projects that have been built or are currently under construction in California. Second, from studies done by others, we take the average number of job-years required per MW installed from three recent large PV projects built in central and southern California. We multiply the total MW of utility-scale solar power installed over the last five years in all of California by this estimate of job-years required per photovoltaic utility-scale MW to obtain our estimate of the number of job-years created by this recent solar boom.

We also average the multipliers developed in these other studies to calculate the upstream and downstream jobs that new jobs in solar farm construction stimulate, and also average the estimates from these other studies to estimate the income and health and pension benefits paid on solar farm construction sites.

Limitations

This approach has several limitations. First, as mentioned above, about 900 MW of recent utility-scale solar electricity generation has been thermal (also called concentrating) solar power. Thermal solar construction requires more workers per MW installed and a different crew mix (e.g., fewer electricians, more welders). Our estimate of job-years created by the recent California solar boom is probably an undercount due to treating all of the megawatts installed as if they were PV solar.

The recent utility-scale solar boom in California has not only created new job-years of work directly building these facilities, but also new job-years were created upstream and downstream of these projects as suppliers fed the ongoing work, and those directly employed in the construction of these projects spent their income on consumer goods and services. As mentioned above, we do not calculate the multipliers from this direct construction work ourselves. Rather we rely upon the research of others who have calculated these upstream and downstream indirect and induced jobs analyzing the aforementioned three large PV solar projects in central and southern California.

Our reliance on the work of others has a benefit and a drawback. The benefit is that we are able to average the multipliers of more optimistic and more conservative analyses done by others thus obtaining a middle-ground estimate of the ripple effects in the overall labor market from these new construction jobs. The limitation is that all of these other studies were focused on county employment multipliers. Our focus is on the entire state. Because California is a larger economy compared to any one of its counties, California's overall economy is better positioned to meet the indirect and induced demands created by the solar construction boom. In pooling estimates of county employment multipliers to get an average of more optimistic and more conservative views, we have inevitably used conservative employment multipliers for California as a whole. Both our measures of direct employment in the construction of utility-scale solar plants and the multiplied indirect and induced employment from this work are probably undercounts.

Our measure of new jobs created by the utility-scale solar boom is a measure of new job-years but not a measure of *net* new job-years. Net new jobs are the number of jobs that were created by the solar boom minus the number of jobs that would have been created had there not been a solar boom. The computation of net new jobs is quite complex, and involves the construction of a counterfactual hypothesis describing what would have happened absent the growth of utility-scale solar farms in California. Would other forms of zero-emission, renewable energy generating capacity in California have substituted for the hypothetically absent solar farms? Would renewable energy have been imported from out of state? Would gas-fired plants have substituted for solar despite current renewable portfolio standards? Would regulatory requirements have been altered? Given the difficult character of these questions, this study limits its analysis to a calculation of the *new* jobs created by the recent utility-scale solar boom in California and leaves the question of *net new* jobs for another day.

The construction jobs created by the California utility-scale solar boom have been good jobs paying decent wages, providing good benefits, and creating career ladders for upward mobility within blue-collar construction work. However, solar farm construction does not necessarily provide good jobs. In neighboring Arizona, much of the PV solar construction work is nonunion with low-paid, unskilled workers being provided by temporary labor companies. These workers face limited upward mobility and little access to apprenticeship training. While this report touches on the policies and practices that bend construction work toward high-skilled careers or alternatively low-wage casual labor, this is a large topic which is for the most part beyond the scope of this report. Further research is required to better understand the policies and practices that create synergy between construction career development and green energy construction.

California Leads the Way in Building Solar

Section Summary

In the first half of 2014 in the United States, 42% of the new utility-scale electricity generation capacity put in place was from solar and wind power plants. Solar alone accounted for 26% of the new power plant generation. According to industry sources, when rooftop solar is added to the mix, solar accounted for about half of all new electricity generation put in place in the U.S. during this time period. Government data on power plants show that, comparing the first half of 2013 to the first half of 2014, new additions to natural gas and coal fired power plants fell while both wind and solar new utility-scale generation capacity almost doubled. This boom in renewable energy electricity generation has been given a substantial boost from federal policy. The Obama Administration's American Recovery and Reinvestment Act of 2009 earmarked more funds for clean energy than had been done at any time in our nation's history. Similarly, the Federal Business Energy Investment Tax Credit, which provides a 30% credit to residential, commercial, and utility-scale solar systems, was renewed in 2008 for an additional eight years to 2016.

While these policies and, in the case of ARRA, legislative action have stimulated renewable energy electricity generation across the nation, they have been especially successful in boosting solar electricity generation in California, a state with rich solar resources in close proximity to population centers where the electricity demand primarily resides. Just as federal action has driven a national expansion of the renewable energy sector, California has pioneered policies that have been critical in making it the renewable energy capital of the United States. The Global Warming Solutions Act (AB 32), passed in 2006, requires a steep reduction in greenhouse gas emissions, and in 2011 Governor Brown signed Senate Bill X1-2, which expanded California's Renewable Portfolio Standard (RPS) to a 33% target by 2020. The state's aggressive climate change policies, abundant photovoltaic (PV) solar resources, large population centers, and need to conserve water used to cool thermal power plants have coalesced to make California the country's leading user of PV-generated electricity. Among the top ten states, California accounts for fully half of all installed PV electricity generation capacity. California is on track to install in 2014 almost ten times more new PV generating capacity than any other state.

Within California, renewable energy technologies have recently come to dominate the growth in overall electrical generation capacity and usage. Subsequent to the passage of ARRA and California's SBX1-2, California's use of electricity from renewable energy sources almost doubled its share of overall California electricity generation, moving from around 11% in 2008 to 19% in 2013.

The National Renewable Energy Laboratory (NREL) estimates that a 16.5% penetration of wind power combined with a 16.5% penetration of solar power, for a total of 33% Western Grid reliance on these two renewable energy sources, would reduce carbon emissions from electricity generation by about one-third. Currently 19% of California's power grid is fed by biomass, geothermal, wind, solar, and small hydroelectric renewable energy sources. While the emissions impact of each of these renewable resources varies, California is moving toward a level of renewable energy reliance and emission reduction similar to the scenario envisioned by the NREL study.

The Solar Energy Industry Association estimates that solar-powered electricity generating facilities in California (both rooftop and utility-scale), with roughly 5,000 MW of collective capacity, have per year reduced carbon dioxide (CO2) emissions by about 4.4 million tons, nitrogen oxides (NOx) emissions by about 6.3 million tons, and sulfur dioxide (SO2) emissions by about 700,000 tons. At this time, recently installed utility-scale solar farms in California account for approximately 75% of the state's solar power-generated electricity. Thus, utility-scale solar power in California has effectuated an overall reduction of about 4.8 million tons of nitrogen oxides, 3.3 million tons in carbon dioxide, and 525 thousand tons of sulfur dioxide.

This section describes the growth and environmental impact of renewable energy electricity generation focusing on utility-scale solar energy in California.

California Leads in the Expansion of Electrical Generation with Renewable Energy

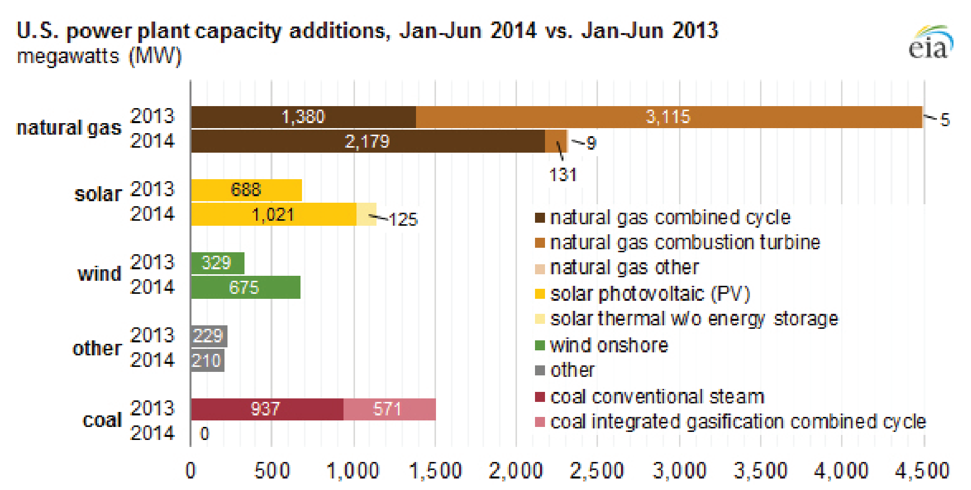
Solar and Wind Energy Are Increasingly Important Sources of Electricity Nationally

When rooftop (or distributed) and utility scale electricity generation are combined, according to the Solar Energy Industry Association (SEIA), currently the fastest growing segment of electricity generation in the United States is electricity generated from renewable resources—solar, wind, geothermal, small hydroelectric and biomass. SEIA figures show that in the first half of 2014, over half of the new U.S. electrical generating capacity came from photovoltaic and thermal solar power plants and facilities. Another 14% came from wind-generated electricity. Together, SEIA figures indicate that utility-scale and distributed solar and wind accounted for two-thirds of all new electrical generating capacity while natural gas accounted for almost one-third. Coal is not currently an important part of the expansion of electrical generating capacity in the United States.[v]

When considering utility-scale power plants only and excluding rooftop electricity generation, wind and solar plants accounted for 42% of new utility capacity in the first half of 2014, and their share is growing. Comparing the first half of 2013 to the first half of 2014, natural gas remains the largest single source of new utility-scale electricity generation. But as U.S. Energy Information Administration data in **Exhibit 1** show, new natural gas utility-scale generating capacity in 2014 was about half of what it had been in 2013. In contrast, new utility-scale solar capacity in the first half of 2014 almost doubled compared to 2013, and new wind generation capacity did double. There was no new addition to coal electricity generation in 2014. Of the 4,350 MW of

Exhibit 1

New Utility-Scale U.S. Electrical Generating Capacity Put in Place, First Half of 2013 and First Half of 2014 Compared [vi]



new utility-scale electricity generation put in place in the first half of 2014, natural gas accounted for 2,319 MW (53%) while utility-scale solar and wind together accounted for 1,821 MW (42%). In short, utility-scale solar and wind shares of new utility-scale capacity rose compared to 2013 while both natural gas and coal shares of new power plant capacity fell compared to 2013.

Federal Policies Supporting Renewable Energy Track with Dramatic National Expansion of this Sector

The central role of policy in stimulating the recent expansion of renewable energy will be discussed in further detail later in this report. However, it is worth noting here that the growth in renewable energy was given a substantial boost from the Obama Administration's American Recovery and Reinvestment Act of 2009, which provided more funding for clean energy than had been the case at any time in our nation's history, as well as the 2008 renewal for eight years of the solar Investment Tax Credit, which provides a 30% credit to residential, commercial, and utility-scale solar systems. The timing of these two policies is consistent with expanded renewable energy growth not just in California over the past five years, the focus of our study, but also in many states across the nation.

Statewide Climate Action Policies Have Positioned California to Lead in Solar Growth

Just as federal policy was instrumental in driving a national expansion of the renewable energy sector, particularly in providing access to capital, state policies pioneered by California have been critical in making it the renewable energy capital of the United States. The Global Warming Solutions Act (AB 32) was passed in 2006, and in 2011 Governor Brown signed Senate Bill X1-2 expanding California's Renewable Portfolio Standard to a 33% target by 2020. The focus of these policies is to combat climate change by reducing statewide greenhouse gas emissions. However, they have also given California an edge in insuring national investment in renewable energy projects flow to California first. This policy connection will be discussed in further detail later in this report.

California Is Rich in Photovoltaic and Thermal Solar Resources

Two types of Solar Power: Photovoltaic and Thermal

There are two basic forms of solar-generated electrical power: photovoltaic and thermal (also known as concentrating) solar power.

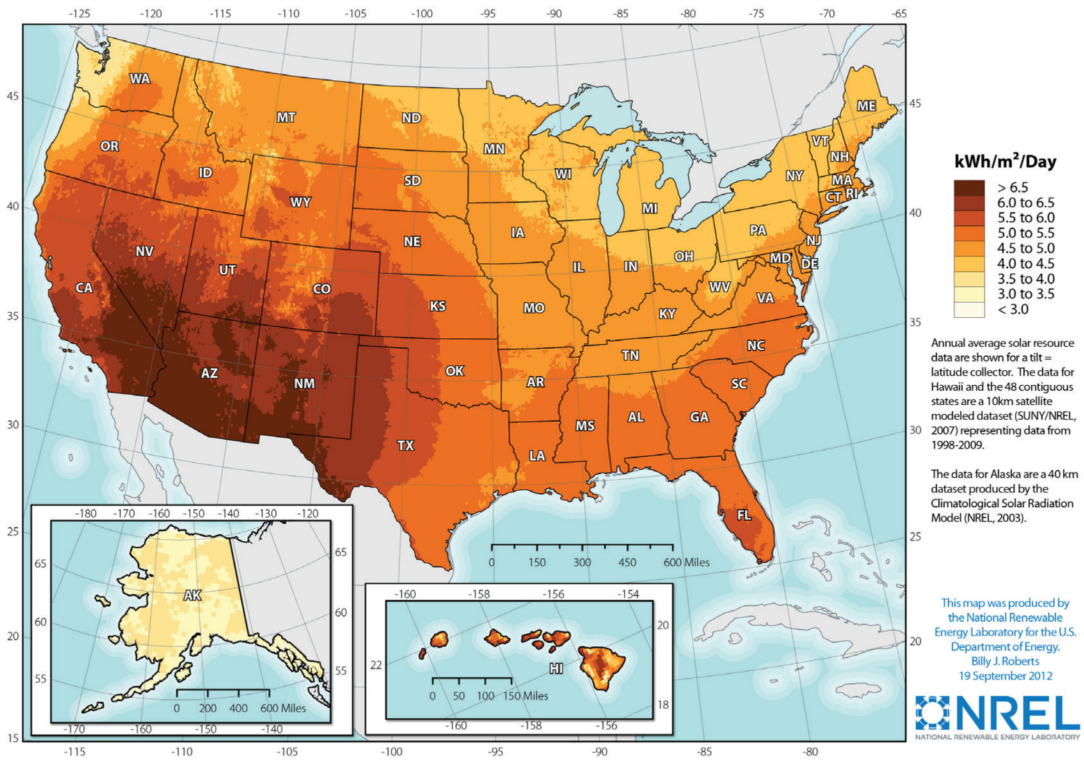
Photovoltaic:

> Photovoltaic (PV) devices generate electricity directly from sunlight via an electronic process that occurs naturally in certain types of material, called semiconductors. Electrons in these materials are freed by solar energy and can be induced to travel through an electrical circuit, powering electrical devices or sending electricity to the grid.[vii]

Exhibit 2 shows that California, like much of the southwest United States, is richly endowed with photovoltaic solar resources. California is further blessed by the proximity of solar resources to population centers where the electricity demand primarily resides. Furthermore, photovoltaic solar resources, unlike most electrical generating technologies, do not require significant amounts of water. Because the sun often is where water is not, photovoltaic solar resources are doubly valuable as a clean *and* dry form of energy creation.

Exhibit 2

U.S. Photovoltaic (PV) Resources[viii]



California Leads the Nation in Photovoltaic (PV) Electricity Generating Capacity

Not surprisingly, the combination of abundant PV solar resources, aggressive climate change policies, large population centers, and the need to conserve water have coalesced to make California the leading user of PV generated electricity. **Exhibit 3** shows that California accounts for fully half of the PV electrical generating capacity among the top ten states, with the next closest state (Arizona) following with a 15% share.

California Also Leads in *Newly* Installed PV Solar Electrical Generation

California also leads in the growth of new PV electrical generating capacity. **Exhibit 4** shows that in 2014 alone, California is predicted to install 3,213 MW of new rooftop and utility-scale photovoltaic electrical generating capacity, approximately 10 times more than any other state. Indeed, the map in **Exhibit 4** does not draw California to scale because doing so would have dwarfed the contributions to PV electrical generation in all the other states. About two-thirds of this new California PV capacity in 2014 is utility-scale, while residential accounts for about 20% and non-residential accounts for about 10% of the new PV capacity.

Comparing PV solar resources shown in **Exhibit 2** with overall generating capacity in **Exhibit 3** and new generating capacity in **Exhibit 4**, it is apparent that solar resources alone do not account for the location of PV generated electricity. Population proximity to PV solar resources is also important, as is public policy supporting the transition to renewable, clean energy generation.

Exhibit 3

Distribution of Total PV Electrical Generating Capacity Among Top 10 States, December 2013[ix]

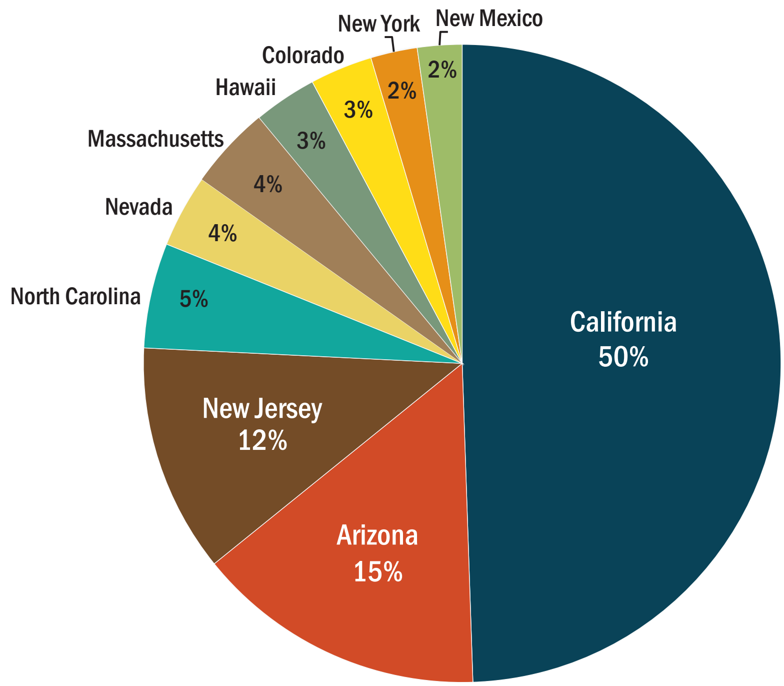
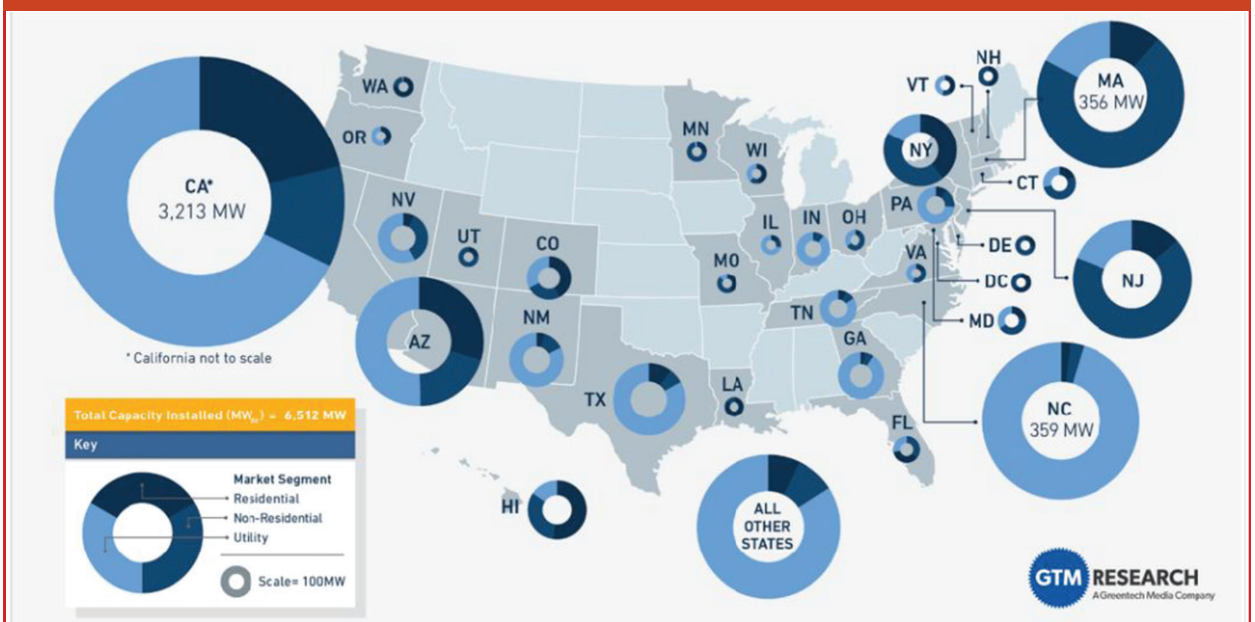


Exhibit 4

Forecasted New Photovoltaic (PV) Solar Energy Generating Capacity to be Put in Place by State and by Residential, Non-Residential, and Utility-Scale Generation During 2014[x]



California Leads in Thermal Solar Power Capacity and New Installation

While PV solar relies on chemical reactions, thermal solar power relies upon the heat of the sun to generate electricity.

Concentrating Solar Power:

> Thermal solar power plants, often called concentrating solar power (CSP) plants, use mirrors or lenses to concentrate sunlight, creating temperatures high enough to drive traditional steam turbines or engines that in turn create electricity. The most cost-effective CSP plants are hundreds of megawatts (MW) in size, making them attractive as wholesale energy suppliers to utilities.[xi]

A key feature of concentrating solar power is that the heat generated by the sun can be stored to generate electricity when the sun is not shining or not shining brightly. This feature creates an important advantage for thermal power compared to most other renewable energy sources including PV solar. When the wind does not blow, water does not flow, or the sun does not shine, renewable energy generation flags.

Currently fossil fuel electricity generation along with large hydroelectricity are the offsets used to handle the irregularity of solar and wind energy generation. Thus, a primary advantage of concentrating solar power and another type of thermal energy, geothermal power, is that both rely upon heat which can be stored, lengthening the diurnal renewable generation of electricity. Emerging technologies in electricity generation, power storage, and conservation may reduce the need for fossil fuel backup to zero-emission-electricity generation in the future. Solar thermal and geothermal power generation are first steps in a future that promises additional new, cleaner energy generation, as well as storage and conservation technologies to handle the variability in solar electricity generation.

Exhibit 5

U.S. Concentrating (or Thermal) Solar Power Resources[xii]

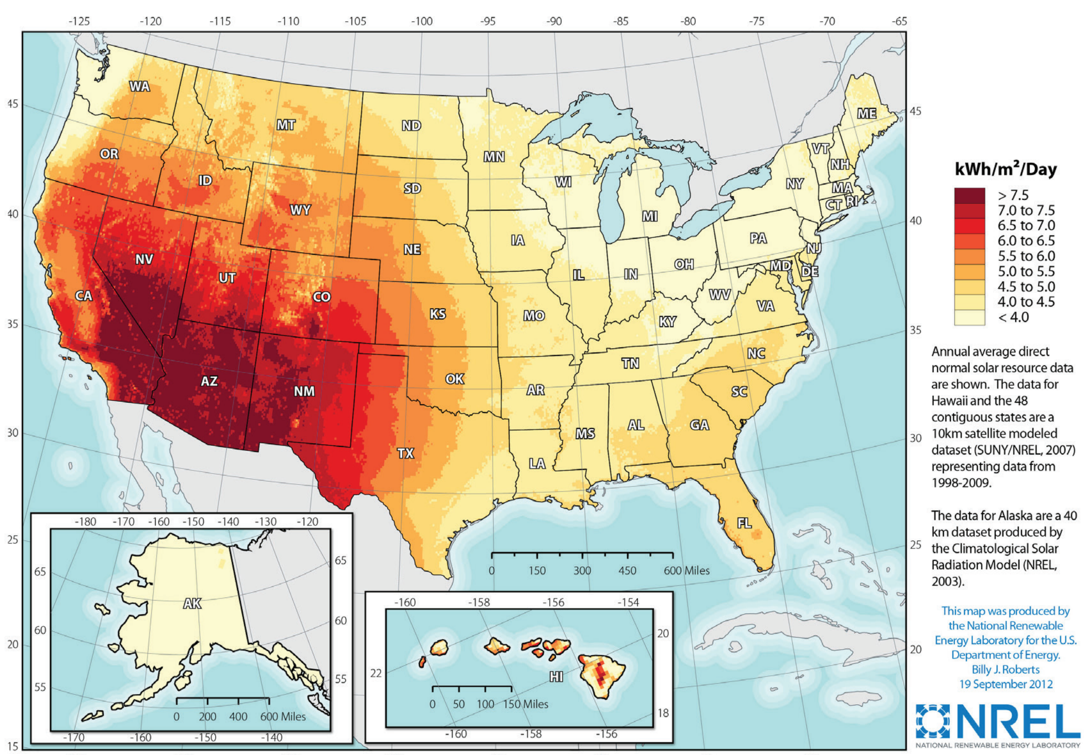


Exhibit 6

List of U.S. Solar Concentrating (Solar Thermal) Plants in Operation or Under Construction in 2014[xiii]

MW	Project	Location	Technology
	IN OPERATION		
392	Ivanpah Solar Power Facility	San Bernardino Co., CA	solar power tower
354	Solar Energy Generating Systems (SEGS)	Mojave Desert, CA	parabolic trough
280	Solana Generating Station	Gila Bend, AZ	parabolic trough
250	Genesis Solar Energy Project	Blythe, CA	parabolic trough
75	Martin Next Generation Solar Energy Center	Indiantown, FL	ISCC with parabolic trough
64	Nevada Solar One	Boulder City, NV	parabolic trough
5	Kimberlina Solar Thermal Energy Plant	Bakersfield, CA	fresnel reflector
5	Sierra SunTower	Lancaster, CA	solar power tower
2	Keahole Solar Power	Hawaii	parabolic trough
1	Saguaro Solar Power Station	Red Rock, AZ	parabolic trough
	UNDER CONSTRUCTION		
280	Mojave Solar Project	Barstow, CA	parabolic trough
110	Crescent Dunes Solar Energy Project	Nye County, NV	solar power tower
17	Stillwater	Nevada	parabolic trough
5	Sundt Power Plant	Arizona	fresnel reflector
1.5	Tooele Army Depot	Tooele, UT	dish
1,841.5	**Total Generating Capacity**		
1,286	**California Generating Capacity**		
70%	**California's Share of Total Generating Capacity**		

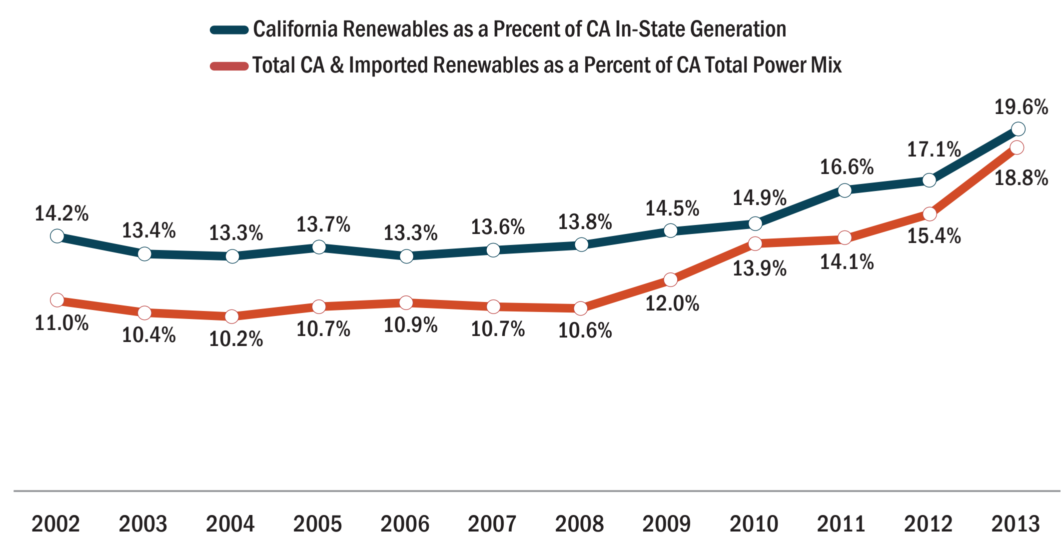
California is rich in valuable thermal solar resources as well as PV solar resources. **Exhibit 5** shows that the California desert and much of the Central Valley and other parts of Southern and Central California are blessed with abundant concentrating solar power resources. Not surprisingly, California leads the nation in thermal solar utility-scale electricity generation as well as leading in new concentrating solar electrical generation capacity coming on line. **Exhibit 6** shows that California accounts for 70% of the thermal solar generating capacity in-place and coming-on-line.

Renewable Energy Has Recently Come to Dominate the Growth in California Electricity Generation Capacity

California is not only the leader among states in adopting renewable energy generation technologies: within California, renewable energy has recently come to dominate the growth in electrical generation capacity and electricity usage. **Exhibit 7** shows that in the first decade of this century, renewable energy electricity generation grew apace with other forms of electricity generation within the state. This was also true of electricity imported from outside California. But about five years ago, with the passage of the 2009 American Recovery and Reinvestment Act and SBX1-2, the importance of renewable energy relative to other sources started to grow dramatically. In-state generation of electricity from renewable energy sources jumped from around 14% in 2008 to about 20% in 2013. The role of renewables in overall energy usage also grew from about 11% in 2008 to about 19% in 2013.

Exhibit 7

Growth of Renewable Energy as a Share of All California Electricity System Generation, 2002 to 2013[xiv]



Solar Energy, both PV and Thermal, Dominate the Growth in California Renewable Energy Electricity Generation

Solar renewable energy, both photovoltaic and concentrating solar power, is a growing share of all renewable energy used in California. **Exhibit 8** shows that solar power took off around 2010 and now generates more than four times the electricity that solar power generated in the first decade of this century. Imported solar power also shot up around 2011 and currently accounts for roughly 20% of the solar power on the California electricity system.

Exhibit 8

California Usage of Solar Electricity Generated in California and Imported, 2002 to 2013[xv]

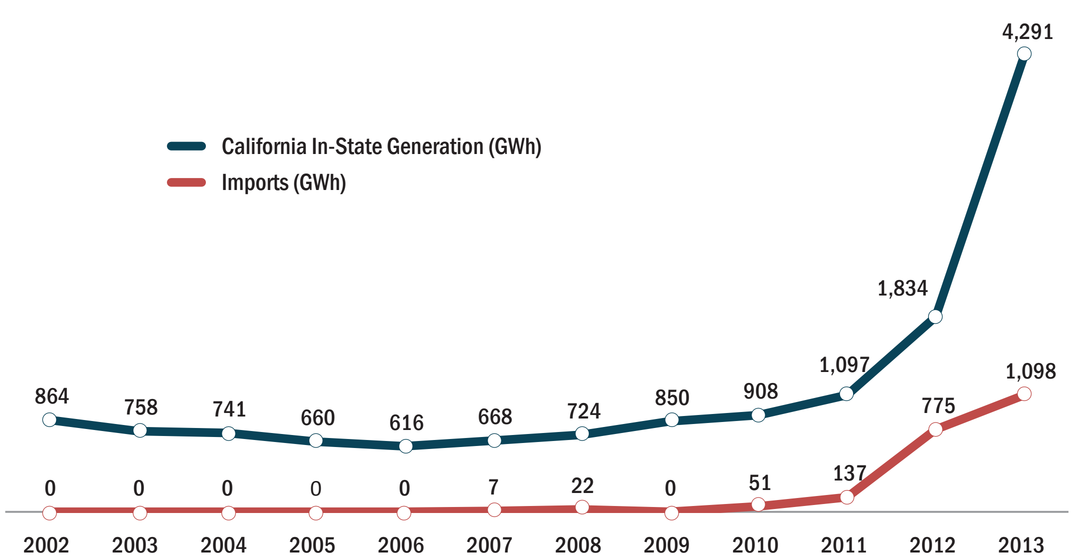


Exhibit 9

Annual Rate of Growth in California Renewable Energy Generation Capacity by Renewable Energy Type, 2009 to 2013[xvi, 2]

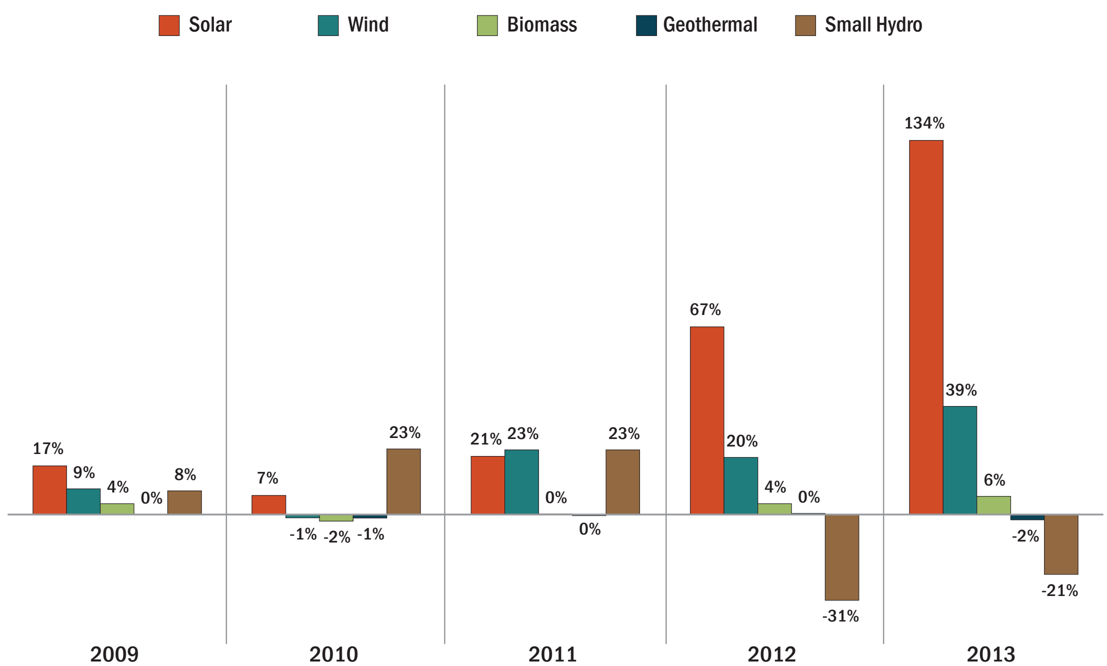


Exhibit 9 shows the annual rate of growth in renewable energy by source for California from 2009 to 2013. In three of the last five years, solar power grew faster than biomass, geothermal, small hydro, and wind power. Overall, the rate of solar power growth is accelerating.

Distributed Generation: Another Source of Clean Energy and Economic Growth

While not the focus of this report, distributed generation such as rooftop solar and small-scale dedicated field solar is playing an important role in helping California tackle climate change while creating jobs. Spurred by the California Solar Initiative, the state has a rapidly expanding base of rooftop/distributed solar electrical generating capacity.[xvii] Rooftop systems are not only popular in the residential sector but are seen by industrial users, nonprofits, campuses, and municipal agencies as a smart strategy to reduce electricity bills, meet sustainability goals, and free up capital that can then be reallocated. This distributed generation trend is only expected to continue as technology enables the growth of micro grids and energy storage.

[2] The 33% Renewable Portfolio Standard SBX1-2 passed in early 2011.

Air Pollution and Greenhouse Gas Emissions Have Been Reduced through the Construction of Renewable Energy Capacity

Coal is the dirtiest form of electricity generation. Natural gas is cleaner than coal, but, like all fossil fuel reliant technologies, natural gas electricity generation creates greenhouse gases. Renewable energy electricity generation can also create greenhouse gases, primarily in the building of the materials that go into solar panels, wind turbines, and the other materials that make up a renewable energy electrical generation facility. Nonetheless, as shown in **Exhibit 10**, even when taking into consideration the full lifecycle carbon footprints of various electrical generation technologies, renewable resource electricity generation is fundamentally less pollutive than fossil fuel based technologies.

Some critics of renewable energy argue that a full accounting of the carbon footprint of wind and solar electrical energy must take into consideration the effect of these technologies on the smokestack emissions of fossil fuel electrical generation plants. Fossil fuel powered plants are at their most efficient and emit less pollution per MW of electricity generated when they operate steadily near full capacity. As coal and gas powered plants cycle up and down in order to back up the supply of solar or wind generated electricity, there can be greater wear on those fossil-fuel facilities and a greater generation of emissions. However, the extent of emissions due to cycling are relatively small compared to the savings in emissions from switching to wind and solar power generation. The National Renewable Energy Laboratory (NREL) examined this problem in their study "The Western Wind and Solar Integration, Phase II."[xviii] They found that their "high" wind and solar scenario—a hypothetical case with a 16.5% penetration of wind power combined with a 16.5% penetration of solar power,

Exhibit 10

Greenhouse Gas Emissions over the Lifecycle of Types of Power Plants[xix]

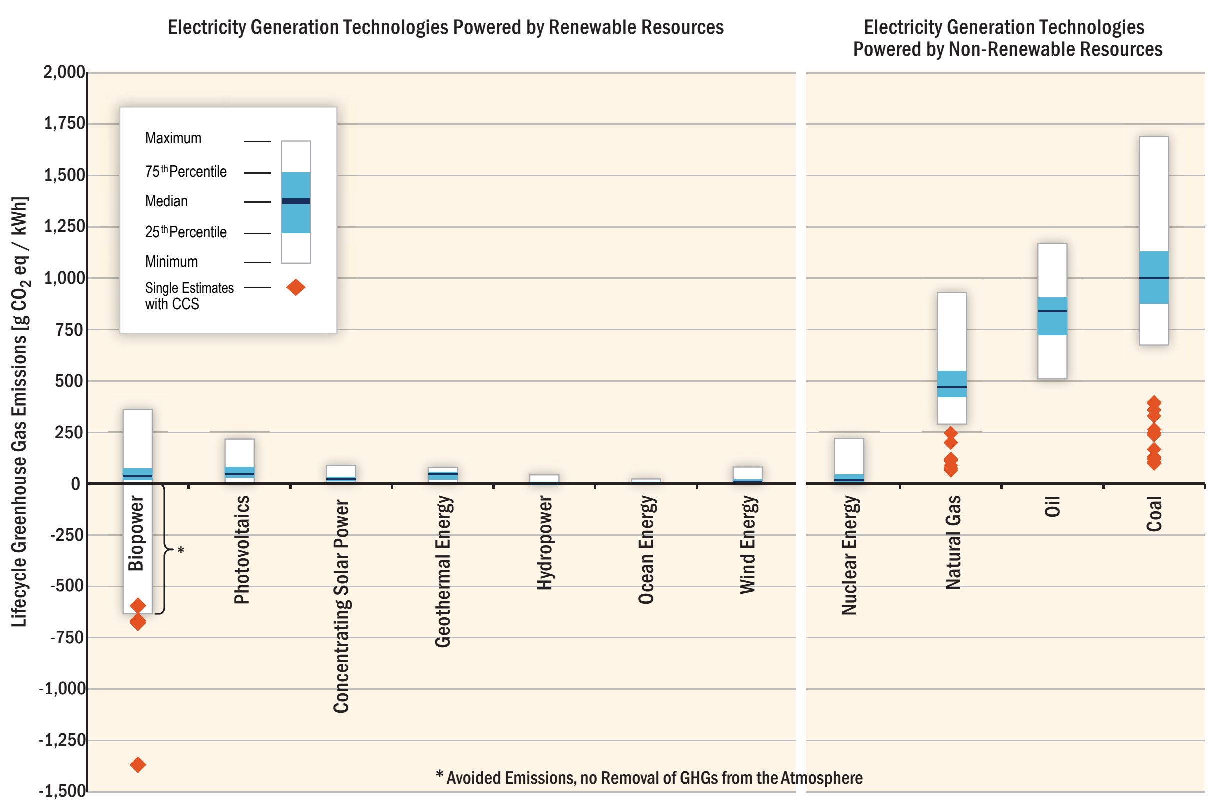


Exhibit 11

Emission Reduced by a 33% Penetration of Wind and Solar Energy onto the Western Grid[xx]

Emission Impacts of Cycling Are Relatively Small Compared to Emission Reductions Due to Renewables

	Emission Reduction Due to Renewables	Cycling Impact
CO_2	260–300 billion lbs 29%–34%	Negligible Impact
NO_X	170–230 million lbs 16%–22%	3–4 million lbs
SO_2	80–140 million lbs 14%–24%	3–4 million lbs

The increase in plant emissions from cycling to accommodate variable renewables are more than offset by the overall reduction in CO_2, NO_X, and SO_2.

for a total of 33% Western Grid reliance on these two renewable energy sources[xxi]—would induce a decline in CO2 of from around 29% to 34% (see **Exhibit 11**). NOx would fall by 16% to 22% and SO2 would fall by 14% to 24%. Increases in these pollutants due to the cycling demands on fossil fuel plants stemming from the timing of renewable energy electricity generation in this scenario were negligible. NREL concluded:

> The increase in plant emissions from cycling to accommodate variable renewables are more than offset by the overall reduction in CO2, NOx, and SO2. In the high wind and solar scenario [which entailed a hypothetical increase on the Western electrical grid to a 16.5% usage of wind power and a 16.5% usage of solar power], net carbon emissions were reduced by one third.[xxii]

“The Western Wind and Solar Integration, Phase II” study considered only the effects of solar and wind—the currently fastest growing segments of renewable energy in California. In considering all forms of renewable energy, as one can see from **Exhibit 7**, California is already at 19.6% renewables as a percent of in-state electricity generation, with about half from wind and solar resources. The remaining half currently comes from biomass, geothermal, and small hydro.[xxiii] Furthermore, as energy storage and other renewable integration solutions expand, the need for fossil fuels as a backup for clean energy generation will decline and emissions will decrease even further.

The Environmental Protection Agency’s Avoided Emissions and Generation Tool (AVERT) can be used to calculate the annually saved emissions from energy efficiency (EE) and renewable energy (RE) policies and programs. The Solar Energy Industries Association used AVERT to calculate the effect of the currently installed utility-scale and rooftop solar generation on carbon emissions from electricity generation in United States regions (see **Exhibit 12**). California and Utah are in the same AVERT region due to the role of the Intermountain Power Plant, a 1,900 MW coal-fired power plant owned by the Intermountain Power Agency and operated by the Los Angeles Department of Water and Power.[xxiv] The 5,171 MW capacity of solar-powered electrical generating facilities in these two states, including both rooftop and utility-scale facilities, have reduced carbon dioxide (CO2) emissions by 4,433,300 tons, nitrogen oxides (NOx) emissions by 6,340,000 tons, and sulfur dioxide (SO2) emissions by 705,700 tons, all per year.

In this study we will examine the employment effects of building 4,250 MW of utility-scale solar powered electricity generating facilities in California. This utility-scale solar capacity represents about 75% of the total solar electrical generating capacity for California presented in **Exhibit 12**. Our primary focus will be the jobs created in building and running these facilities and the upstream and downstream jobs stimulated by this new construction in California. But we should not forget that these facilities have also reduced air pollution in California. The approximate effect has been a reduction of 4.8 million tons of nitrogen oxides, 3.3 million tons in carbon dioxide and 525 thousand tons of sulfur dioxide.[xxv]

Exhibit 12

Estimated Tons of Carbon Emissions Averted through the Solar Generation of Electricity by Region, 2014[xxvi]

AVERT Region	States within AVERT Region	Cumulative Capacity (MW)	CO2 Emissions Reduced (Tons)	SO2 Emissions Reduced (Pounds)	NOx Emissions Reduced (Pounds)
California	CA, UT	5171.70	4,433,300	705,700	6,340,000
Great Lakes/ Mid-Atlantic	DE, IL, IN, KY, MD, MI, NJ, OH, PA, VA, WI, WV	1241.90	1,325,700	6,069,800	2,406,700
Lower Midwest	AR, KS, LA, MO, NM, OK, TX	141.48	180,800	418,300	394,800
Northeast	CT, MA, ME, NH, NJ, NY, RI, VT	1408.35	1,113,600	1,972,900	1,574,000
Northwest	ID, MT, NV, OR, UT, WA, WY	312.70	329,800	389,800	785,200
Rocky Mountains	CO, SD, WY	331.50	464,000	647,900	899,300
Southeast	AL, AR, FL, GA, KY, LA, MO, MS, NC, OK, SC, TN, TX, VA, WV	927.03	959,800	2,975,400	1,486,000
Southwest	AZ, CA, NM, NV, TX	1850.40	2,070,300	977,800	2,987,300
Texas	TX, OK	201.20	203,600	408,800	236,800
Upper Midwest	IA, IL, MI, MN, MO, MT, ND, NE, SD, WI	72.43	94,500	286,000	170,800

Responsible Project Siting is Essential to Maximize Environmental Benefits of Utility-Scale Renewable Energy Electrical Generation

To maximize the environmental benefits of utility-scale electrical generation projects, reducing emissions is a top consideration, and here renewables lead the way. Equally as important to maximizing environmental benefits of these projects, though, is ensuring that electrical generation facilities are sited to minimize impacts on sensitive lands, water, and species. This is particularly critical for projects harnessing renewable resources in remote areas. Locating projects on previously disturbed private land with low habitat value for sensitive plant and animal species and in proximity to existing transmission or distribution lines is the gold standard of environmentally-responsible project siting. Projects must be carefully evaluated on a case-by-case basis to ensure irreplaceable habitat is not being permanently sacrificed in the race to combat climate change. The California Energy Commission for solar thermal facilities and local county governments for private-land PV projects can play a central role as lead agencies in analyzing and mitigating environmental impacts in accordance with the California Environmental Quality Act. The Bureau of Land Management is the lead agency under the National Environmental Protection Act for projects on public land. Both the environment and economics must be analyzed and regulated holistically. Neither green projects that create dead-end jobs nor great jobs that degrade the environment are sustainable answers. These regulators and regulations are one way-station on the road to an energy synergy between the environment and the labor market

Jobs Created in the Solar Boom

Section Summary

Over the last five years, 10,200 well-paying construction jobs were created in California during the expansion of California's solar-based, utility-scale electrical generating facilities. These jobs pay, on average, $78,000 per year and offer solid health and pension benefits. In addition, 136 permanent operations and maintenance jobs have been created and will last for the lifetime of these facilities. These operations and maintenance jobs pay an average of $69,000 per year, usually with solid benefits. In addition to the jobs created on the construction projects, about 1,600 jobs have been created to handle increased business up and down the supply chain and to perform other new business activities associated with these projects. These newly-created construction, maintenance, and business-related jobs have boosted consumer spending, which in turn has induced the creation of over 3,700 additional California jobs aimed at meeting increased consumer demand. In total, more than 15,000 new jobs have been created by the solar farm construction boom in California over the last five years.[3]

Approximately 4,250 MW of PV and Thermal Solar Power were Built in the Last Five Years

Exhibit 13 shows the list of utility-scale solar power projects built or under construction in California since 2010 as of the summer of 2014. Two completed projects (Ivanpah Solar Power Facility and Genesis Solar Energy Center) and one under construction (Abengoa Mojave Solar Power Plant) are solar thermal projects accounting for almost 900 MW while the remaining are photovoltaic solar projects accounting for about 3,350 MW of nameplate generating capacity. We will estimate the employment impact of this construction using PV projects

[3] Here jobs are understood to be job-years, or 2,080 hours of work, though in many cases a construction worker will not be on a job for a full year. Construction apprentices are often rotated off jobs to get experience in other types of construction and therefore one job-year may be spread across two or more construction workers. In contrast, the 136 operations and maintenance jobs are 25 job-years, each lasting the expected lifetime of a newly-built solar electrical generation plant.

Exhibit 13

List of Solar Projects Completed or Under Construction, 2010–2014[xxvii, 4]

Project	Type	County	MW
COMPLETED			
Alpine (First Solar)	PV	Los Angeles	92
Antelope Valley (First Solar)	PV	Los Angeles	230
Borrego Solar NRG	PV	San Diego	26
California Valley Solar Ranch (Fluor)	PV	San Luis Obispo	250
Campo Verde (First Solar)	PV	Imperial	139
Catalina Solar (enXco)	PV	Kern	110
Centinela (Fluor)	PV	Imperial	275
Corcoran Irrigation District (EDF-enXco)	PV	Kings	20
First Solar Blythe	PV	Riverside	21
Genesis Solar Energy Center	CSP (thermal)	Riverside	250
Ivanpah (Bechtel)	CSP (thermal)	San Bernardino	392
McHenry (SunPower)	PV	Stanislaus	25
Mt. Signal Solar (Cupertino Electric)	PV	Imperial	200
Recurrent Kansas South	PV	Kings	35
Recurrent Rio Grande	PV	Kern	5
Recurrent Rosamond 1 and 2	PV	Kern	40
SDSU Sol Orchard Brawley	PV	Imperial	5
SMUD McKenzie, Kammerer, Bruceville, Dillard	PV	Sacramento	69
Sol Orchard (Isolux)	PV	Imperial	20
SunEdison Adobe	PV	Kern	20
SunEdison Orion	PV	Kern	20
TA-High Desert	PV	Los Angeles	20
Tenaska CSolar South (First Solar)	PV	Imperial	200
White River (SPS)	PV	Tulare	20
TOTAL COMPLETED			**2,484**
UNDER CONSTRUCTION			
Abengoa Mojave (Abengoa)	CSP (thermal)	San Bernardino	250
Acacia Solar (White Construction)	PV	Los Angeles	20
Agincourt and Marathon (Lincoln)	PV	San Bernardino	30
Desert Sunlight (First Solar)	PV	Riverside	550
Pioneer Green (Phoenix)	PV	Kern	125
Recurrent Old River 1 and 2	PV	Kern	25
Solar Gen 2 (First Solar)	PV	Imperial	150
SunEdison Regulus	PV	Kern	75
Topaz (First Solar)	PV	San Luis Obispo	550
TOTAL IN PROGRESS			**1,775**
TOTAL COMPLETED AND IN PROGRESS			**4,259**

[4] Reported MW at new utility-scale solar facilities can vary in part because PV projects can come on-line in stages. Thus, the 4,259 MW in this table should be viewed as a current best estimate of the generating capacity of these facilities.

as our model because PV work has accounted for and will likely continue to account for the majority of the utility-scale solar projects in California for the near future.[5]

Previous Studies of Specific Projects

Previous research has yielded four economic impact reports covering three large photovoltaic solar projects in California with a total photovoltaic nameplate capacity of 1,350 MW:

1. As part of the Environmental Impact Report (EIR) for the California Valley Solar Ranch (CVSR) project (nameplate capacity of 250 MW), Stephen F. Hamilton, Chair of the Economics Department at California Polytechnic State University at San Luis Obispo, along with Darin Smith and Tepa Banda of Economic & Planning Systems, Inc., released in December, 2010, a study of the local employment and fiscal impact of the CVSR.[xxiii]

2. Stephen Hamilton again, along with Mark Berkman of the Brattle Group, released a similar report for the nearby Topaz Solar Farm (nameplate capacity of 550 MW) in March, 2011.[xxix]

3. In January, 2011, the Aspen Group, also as part of the CVSR EIR, released a study that combined the impacts of CVSR and Topaz (aggregate nameplate capacity of 800 MW) because these two projects would occur in the same county at approximately the same time. The Aspen Group provided two impact assessments, one assuming a lower set of wages for construction workers and a second assuming a higher set of wages.[xxx]

4. Finally, Wesley Ahlgren of the Coachella Valley Economic Partnership and Mark Berkman of the Brattle Group released an economic impact study of the Desert Sunlight Solar Farm (nameplate capacity of 550) to be built in eastern Riverside County.[xxxi]

The four reports thus covered three large photovoltaic solar farms, in two counties, and ranging in nameplate capacity from 250 MW to 550 MW, for a total MW of 1,350. The two central California projects (CVSR and Topaz) were combined in one study for an analysis of the construction of 800 MW. In that case a high-wage and a low-wage scenario for construction workers were developed. The utility-scale generating capacity from the three projects researched in these four studies accounts for roughly one-third of all the PV solar generating capacity put in place or under construction in California over the last five years.

These four studies and five scenarios are available for us to use. Rather than developing our own assumptions regarding the number of direct jobs, wages, and benefits created by this type of construction, we will use the average set of facts developed in these other reports to guide us. These parameters, their averages, and our consequent results are shown in **Exhibit 14**.

The authors drew information from the developers, SunPower and First Solar, upon which they based their a) local input purchase, b) employment, and c) wage assumptions. In the two-scenario case, the Aspen Group provided two sets of wage assumptions, one based on the builder's information and another based on state wage surveys.

In terms of perspective, three reports were done in association with the developer while the Aspen Group's report was done on behalf of the County for the EIR. The three developer-sponsored studies might be more optimistic regarding the beneficial impacts of these projects, and the Aspen study, with its two scenarios, might

[5] Technical note: utility-scale PV solar farms can range widely in MW without fundamentally altering the labor required per MW. Therefore, the range of sizes from small (around 20 MW) to huge (over 500 MW) does not present a major obstacle in calculating the jobs created by this type of work. Solar thermal utility-scale electrical generation tends to focus on large-scale facilities (250 MWs or more) to exploit economies of scale in traditional heat-generated electricity.

Exhibit 14

Analysts' Assumptions for Various Photovoltaic Solar Projects in San Luis Obispo and Riverside Counties and Assumptions for California as a Whole[xxxii]

A	B	C	D	E	F	G	H
Project	**CA Valley Solar Ranch**	**Topaz Solar Farm**	**CA Valley & Topaz Combined**	**CA Valley & Topaz Combined**	**Desert Sunlight**	**Average**	**All CA Solar Projects Last 5 yrs**
Scenario			**Low Wage**	**High Wage**			
Analysts	**Hamilton, Smith & Banda**	**Hamilton & Berkman**	**Aspen Environmental Group**	**Aspen Environmental Group**	**Berkman, Tran & Ahlgren**		
County	**San Luis Obispo**	**San Luis Obispo**	**San Luis Obispo**	**San Luis Obispo**	**Riverside**		
Nameplate Size (MW)	**250**	**550**	**800**	**800**	**550**	**590**	**4,250**
Company	**SunPower**	**First Solar**	**SunPower + First Solar**	**SunPower + First Solar**	**First Solar**		
Construction	**32 months**	**36 months**	**36 months**	**36 months**	**26 months**	**33.2 months**	**60 months**
Operation	**25 years**	**25 years**	**25 years**	**25 years**	**25 years**	**25 years**	**25 Years**
CONSTRUCTION							
Construction FTE Job Years	681	1,200	1,842	1,842	1,353	1,384	10,200
FTE Construction Jobs per MW	2.7	2.2	2.3	2.3	2.5	2.4	2.4
Total Wages (Millions)	$46	$115	$97	$176		$108.6	$796
Total Benefits (Millions)	$25	$52	$44	$80		$50.3	$376
Total Compensation (Millions)	$72	$167	$142	$256	$197	$166.5	$1,172
Annual Wage	$68,135	$95,500	$52,769	$95,603		$78,002	$78,002
Annual Benefits	$37,004	$43,250	$24,104	$43,160		$36,880	$36,880
Total Annual Compensation	$105,140	$138,750	$76,873	$138,762	$145,602	$114,881	$114,881
OPERATIONS							
Permanent Operations FTE Jobs	12	15	26	26	15	19	136
MW per Operations FTE Jobs	21	37	31	31	37	31.1	31.1
Operations FTE Job Years	300	375	650	650	375	470.0	3,412
Total Wages (Millions)	$20	$24	$36	$36	$27		$236
Total Benefits (Millions)	$11		$16	$16			$113
Total Compensation (Millions)	$31		$52	$52	$27		$350
Annual Wage	$66,667	$63,200	$72,192	$72,192	$72,000	$69,250	$69,250
Annual Benefits	$36,333		$31,654	$31,654		$33,214	$33,214
Total Annual Compensation	$103,000		$103,846	$103,846		$102,464	$102,464

Notes for column H, Exhibit 14:

- total FTE construction job-years = 10,200 = 4,250 MW x 2.4 job-years per MW; a job-year is 2,080 hours of work which may involve one or multiple workers and may involve both straight and overtime hours
- construction total wages and benefits = average wages and benefits for other projects in Exhibit 14 x 10,200 (FTE jobs for California as a whole)
- average annual permanent operation jobs = 136 = 4250 MW/31.1 where 31.1 = average MW per operation job on other projects
- operation job-years = 3,412 = 136 x 25 years
- operation average annual wage income = average for other projects in Exhibit 14
- operation average annual benefits = average for other projects in Exhibit 14
- total annual compensation including payroll taxes = annual wages + benefits
- total wages = annual average wage x FTE job-years
- total benefits = annual average wage x total FTE job-years

be somewhat more skeptical. We therefore have a rough balance of three potentially more optimistic and two potentially more conservative estimates of the employment impact of building utility-scale PV solar farms.

Exhibit 14 shows the relevant assumptions used in these studies to assess the economic and fiscal impacts of building these three photovoltaic projects in the near future. In column B, for the 250-MW California Valley Solar Ranch in San Luis Obispo County, based on information provided by SunPower, Hamilton, Smith, and Banda assumed 681 full-time equivalent (FTE) construction, supervisory, on-site engineering, and other personnel would be employed over the life of the project.[6] On average, these workers would earn $68,135 per year in wages and an additional $37,004 in benefits. Total wages from these new jobs would amount to $72 million in new wages (681 x $68,135) and total benefits would add up to an additional $25.2 million (681 x $37,004).

Hamilton, Smith, and Banda do not explicitly consider overtime wages that may be earned on this project. We will ignore the possibility of overtime in our estimates of economic impact as well.[7]

In addition to these 681 construction job-years in column B for CVSR, Hamilton, Smith, and Banda assumed that there would be 12 permanent FTE jobs in operating and maintaining the 250-MW facility after it was constructed. They assumed a 25-year worklife for the facility, thus creating 300 FTE operations and maintenance job-years over the life of the facility (12 jobs x 25 years). On this project, Hamilton, Smith, and Banda assumed operations and maintenance workers would receive, on average, $66,667 in wages (in today's dollars) and $36,333 in benefits (including payroll taxes) for an annual total compensation of $103,000. Over 25 years, these new jobs would inject into the economy $20 million in wages (300 FTE job-years x $66,667) and $11 million in benefits (300 FTE job-years x $36,333) for a total of $31 million in new dollars from new jobs.[xxxiii]

Hamilton, Smith, and Banda do not consider how many of the construction workers on this project would be new apprentices or pre-apprentices. Nor do they consider the economic impact over their career of pre-apprentices or apprentices becoming journeyworkers, gaining new skills and earning more than they otherwise would have if the opportunities of investment in training had not been created by this facility.

Thus, while we will see that in aspects such as jobs created per MW installed the Hamilton, Smith, and Banda study is perhaps the most optimistic among the reports under review, on the key issue of human capital formation these optimists understate one of the most significant benefits of the CVSR project. If apprenticeship training is offered, the benefit of substantial human capital investment in a local apprentice on a project such as this is both immediate and lifelong. And it is a benefit that accrues not only to the apprentice-turned-journeyworker but to the community that enjoys the long term economic development advantages of more human capital in their labor market and more spending over a lifetime in their consumer market.[xxxiv, 8]

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[6] A full-time equivalent (FTE) worker is 2,080 hours of work, though this work may be done by one, two, or more individuals splitting the 2,080 hours. In impact studies, jobs are counted in terms of "job years": one FTE worker = 2,080 hours of work = one job-year. Using the term and concept "FTE jobs" is standard in employment impact studies and all the reports under review do so.

[7] Overtime is not uncommon in industrial construction, particularly when a contractor is seeking to accelerate towards the project's final completion, or the contractor at various points in the construction process tries to avoid bottlenecks along the critical construction path by using overtime to complete strategic tasks. Furthermore, contractors intending to accelerate construction from the outset may include scheduled overtime in their initial planning. While overtime is common in industrial construction, it is often ignored in analyses like the ones under review here.

[8] Solar farm construction involves pre-apprentices, apprentices, and journeyworkers within each craft. Pre-apprentices are new to construction and receive safety and basic-skills training. Through their job performance and work ethic, many, but not all, transition from pre-apprentice to apprentice. Apprenticeship programs entail substantial off-the-job classroom training and supervised on-the-job training lasting typically four or five years. Upon graduation, apprentices turn out as journeyworkers qualified to do the work of their craft across a multitude of different kinds of construction projects. Because no one utility-scale solar farm construction project lasts as long as four or five years, and because the range of skills an apprentice needs to learn span a wider scope than the skills required on solar farm work, apprentices will be rotated off solar work into other work in their craft. This potentially opens up spots for pre-apprentices on the solar work to move into an apprenticeship position. The purpose of apprenticeship training is to build human capital within the industry, to provide the rounded skills so that as journeyworkers each individual can tackle most or all of the jobs in the craft, and to provide each worker with more steady work despite the volatility of construction by qualifying the worker for any job that comes up within the craft.

In column C of **Exhibit 14**, for the Topaz project in San Luis Obispo County, Hamilton and Berkman use information from First Solar to assume that an annual average of 400 construction workers over 36 months are required to build this 550-MW solar facility. This amounts to 1,200 FTE job-years over 36 months with average annual wages of $95,000 and benefits of $43,250. These jobs would inject $167 million in wages into the local economy, which the authors define as San Luis Obispo County plus adjacent Kern County.

Looking at operations and maintenance jobs, Hamilton and Berkman assume 15 FTE-jobs per year over 25 years, with an annual average wage of $63,200. The authors do not provide an assumption regarding operations workers' benefits. Similarly, in column F for the Desert Sunlight project in Riverside County, Berkman, along with co-authors Tran and Ahlgren, again does not provide a benefit estimate for operations personnel.

While in terms of total compensation for construction workers the two Berkman reports are the more optimistic of the four reports under review, this assumption of zero benefits and no payroll taxes for operations and maintenance workers downplays the positive benefits of these new facilities.

The combined CVSR and Topaz study with the high-wage and low-wage scenarios was based on information from two separate developers, SunPower and First Solar. These two developers provided substantially different construction worker annual average FTE total compensation including payroll taxes. SunPower indicated a total compensation of $105,140 while First Solar planned for $138,750. It appears that First Solar was planning to schedule substantial overtime: with a disproportionately low number of additional workers, the 550-MW Topaz project was scheduled to be built in about the same amount of time as the 250-MW CVSR project. The CVSR project assumes 32 months to put in place 250 MW while the Topaz project assumes 36 months to put in more than twice the nameplate capacity (550 MW vs. 250 MW) with only 1.5 times as many workers (400 vs. 264). Therefore, it's fair to assume that the total compensation discrepancy between these two projects is likely due to differences in scheduled overtime on the bigger Topaz project.

The Aspen Environmental Group was asked to provide an additional, separate assessment of the economic and fiscal impact of the CVSR project. Part of the reason Aspen chose to combine CVSR with Topaz was to get a sense of what the full impact of 800 MW of photovoltaic solar construction, scheduled for about the same time in about the same location, would be on the local economy.[xxxv] Reflecting a more conservative approach, Aspen defined "local" as San Luis Obispo County, and did not include Kern or any other adjoining counties.

Aspen presents a low-wage scenario (column D) with wages based on government wage survey data and a high-wage scenario (column E) based on First Solar data. Aspen's low-wage scenario is inapt for two reasons.

First, the government survey of construction wages they relied upon yielded average wages lower than those paid on industrial construction. This is because it included both industrial and residential construction workers in the same average wage. Industrial construction requires greater skills than traditional residential construction, and therefore averaging the two sets of wages puts apples and oranges together yielding an estimated wage significantly lower than those typical of industrial construction projects. Second, in the case of the CVSR project, a project labor agreement was signed based on wages reflecting industrial construction wage rates and not the lower average wage rates of government surveys. Aspen's presentation of this low-wage scenario reflects its skeptical or conservative stance relative to the more optimistic reports under review.

In any case, Aspen assumes 1,842 FTE job-years in both their high-wage and low-wage scenarios for the CVSR and Topaz projects taken together. This is very close to the assumptions of the other analysts in considering each job separately (681 + 1200 = 1881 FTE job-years). The Aspen low-wage scenario is only applied to construction workers. They have just one scenario for maintenance and operations personnel, and their estimate of total compensation is very much in line with those of the other reports at about $103,000 per year including benefits and payroll taxes.

Berkman, Tran, and Ahlgren (column F) analyze the impact of the 550-MW Desert Sunlight project in eastern Riverside County. They assume 1,353 FTE job-years to put this facility into place over 26 months.[xxxvi] The San Luis Obispo Topaz and Riverside Desert Sunlight projects are both 550-MW jobs. They are roughly comparable in expected construction FTE job-years (1,200 over 36 months for Topaz vs. 1,311 over 26 months for Desert Sunlight). The higher Desert Sunlight construction FTE manpower requirements may be due to the planned accelerated schedule (26 vs. 36 months). Differences in planned overtime probably explain the differences in estimates of construction worker total compensation across all three projects: Desert Sunlight, with the fastest schedule, has the highest total compensation ($145,602); Topaz, with a slower schedule but fewer workers per MW, has a total compensation in the middle ($138,750); and the smaller CVSR project, with a slower schedule and more planned workers per MW, has the lowest total compensation ($105,140).

Developers and contractors on large industrial projects sometimes have strong economic interests in accelerating construction to get to market faster, even if it means a considerable increase in construction labor costs either through scheduled overtime or overmanning the job. Much of the variation in total compensation for construction workers found in **Exhibit 14** may well reflect variations in developer/contractor strategies regarding the use of overtime in building the project.

Overall California Employment Boost from Utility-Scale Solar Power Construction

Our assumptions are shown in column G of **Exhibit 14**. We have taken a middle road between more optimistic and more conservative approaches by taking the average across all reports for the relevant assumptions regarding wages, benefits, and FTE workers per MG put in place. The only novel information in our scenario is the total amount of MW put in place (4,250) based on all the utility-scale solar projects built in the last five years or currently under construction in California.[9]

Calculating the Direct, Indirect, and Induced Jobs Created by California Solar Farm Construction Over the Last Five Years

To provide a standard estimate of the upstream and downstream jobs created off the solar farm construction sites, we use the average estimate of what are called "indirect" and "induced" jobs from the previous recent studies reviewed in this report. **Exhibit 15** summarizes the total job-years of direct construction employment, indirect supply-chain employment, and induced consumer-chain employment found by the other studies for the CVSR, Topaz, and Desert Sunlight photovoltaic solar farms.

Line 1 in **Exhibit 15** shows the direct construction worker job-years and other construction-site personnel required for the building of these various projects (it is the same as the row "Construction FTE Job Years" in **Exhibit 14**). The predicted total within-county indirect supply chain job-years and induced consumer chain job-years are shown in lines 2 and 3 of **Exhibit 15**. Total direct, indirect, and induced job-years from construction (but not subsequent solar farm operations or maintenance) are shown in line 4.

To compare across previous reports, lines 5 through 8 divide job-years for each type of job creation (i.e., direct, indirect, induced) by the nameplate capacity of the project or combined projects. As stated, our job-year calculation is based on averaging the jobs-multipliers of these former reports, and this is shown in column F.

[9] Three projects in our sample accounting for 900 MW out of our total are solar thermal rather than photovoltaic solar projects. Solar thermal projects require more workers per megawatt to build. Nonetheless, we have conservatively assumed a worker-per-MG for these two projects equivalent to PV projects, which understates the full employment impact of building this solar generating capacity.

Exhibit 15

A Comparison of the Total Job-Years of Direct Employment, Indirect Supply Chain Employment, and Induced Consumer Chain Employment Effects of Photovoltaic Construction in this and other Recent Reports[xxxvii]

A	B	C	D	E	F	G	H
Project	**CA Valley Solar Rancn**	**Topaz Solar Farm**	**CA Valley & Topaz Combined**	**CA Valley & Topaz Combined**	**Desert Sunlight**	**Average**	**All CA Solar Projects Last 5 yrs**
Scenario			**Low Wage**	**High Wage**			
County	**San Luis Obispo**	**San Luis Obispo**	**San Luis Obispo**	**San Luis Obispo**	**Riverside**		
Nameplate Size (MW)	**250**	**550**	**800**	**800**	**550**		
TOTAL WORKERS							
Direct	681	1,200	1,842	1,842	1,353		**10,200**
Indirect	230	225	190	180	121		**1,609**
Induced	480	746	330	340	324		**3,762**
Total	1,391	2,171	2,362	2,362	1,798		**15,572**
WORKERS PER MW OF NAMEPLATE CAPACITY							
Direct	2.7	2.2	2.3	2.3	2.5	**2.4**	
Indirect	0.9	0.4	0.2	0.2	0.2	**0.4**	
Induced	1.9	1.4	0.4	0.4	0.6	**0.9**	
Total	5.6	3.9	3.0	3.0	3.3	**3.7**	

In addition to the direct 10,200 FTE jobs in solar farm construction that were created in California over the last five years (shown in both **Exhibits 14** and **15**), **Exhibit 15** shows that approximately 1,600 FTE jobs were created indirectly in the California construction supply chain and related business activity. Furthermore, more than 3,700 jobs were induced by consumer spending[10] from the wages paid to construction workers on these projects and subsequent ripple effects from this new consumer spending. Thus, overall, 15,572 FTE jobs-years have been created over the past five years from the work on solar farm construction in California. In addition, 136 FTE operations jobs lasting roughly 25 years each have been created. In general round terms, more than 15,000 jobs have been created by the recent California solar boom.

[10] This is actually an underestimate because the previous studies were primarily focused on the supply chains and consumer activity within the county of the project. When we zoom out to the California economy as a whole, as we do in our analysis, the indirect and induced effects become larger due to longer supply chains and more widespread consumer activity.

Creating High-Quality Construction Careers

Section Summary

Utility-scale solar construction in California over the last five years built 4,250 MW of renewable energy generating capacity in California. Because most of the construction was organized under collectively bargained contracts or project labor agreements, contractors have agreed to contribute training money for apprenticeship training based on each hour of work for every blue-collar worker on the site. This has provided $17.5 million in new money to help finance the training of construction apprentices and pre-apprentices. This infusion into California construction apprenticeship and pre-apprenticeship training includes $8.3 million into electrician training, $3.1 million into the training of construction craft laborers, $2.6 million into training ironworkers, $1.7 million to train carpenters and piledrivers, and $1.9 million dollars to train operating engineers.

This new human capital formation will generate a stream of higher income over decades, reflecting the greater skill set and higher productivity of these trained California construction workers. For instance, over the lifetime of electrical apprentices, as they become journeyworkers, their income in today's dollars will be higher by about $1 million compared to what their income would have been absent this training. In addition, these workers not only earn while they learn but they also participate in family-supportive health insurance programs, promoting family formation and stable child-rearing, and they begin building savings for their retirement. By the time these electrical apprentices retire as journeyworkers at age 65, they will have amassed a retirement nest egg of about $525,000 in defined contribution and defined benefit programs sponsored by their contractors and unions. This is substantially more than what the median single or married worker at age 65 today has for retirement.

The California solar boom has not only prepared California for a future of energy independence, it is preparing a new generation of California blue-collar workers for a future of skilled and productive work and a life of financial security.

Building Clean Energy with Good Jobs

New ways of generating electricity require not only new technologies but also new worker skills. Skilled scientists and technicians are needed to develop and perfect renewable energy technologies, and skilled engineers, project managers, and construction workers are needed to put these new technologies in place in buildings and in the field. In California, new workers on solar projects have not been treated as disposable labor but have in many cases been put on a path to become skilled craft workers through pre-apprenticeship and apprenticeship training. And because of the classroom and on-the-job training that this solar boom is financing, human capital in construction is being built alongside the physical capital of utility-scale and distributive solar power that is rising in the deserts and on the rooftops of California.

The PV panels being installed in the California desert not only catch the sun but also serve as launch pads for skills development beyond the desert. Because these apprenticeship programs prepare workers for the broad range of skills needed in their craft, these new entrants into construction are positioning themselves to work on the entire extent of green technologies as well as skill-demanding work across the full sweep of the construction industry. Apprentices beginning on a PV solar project will later rotate off to work on hospitals, industrial facilities, rooftop solar, or other projects within their craft. Entry work on solar farms helps construction workers get through their early apprenticeship stage, and it also helps finance their further training farther afield.

The California construction industry as a whole is getting an infusion of new, young workers with the career-building, rounded skills that will allow owners, contractors, and public agencies to build into the future the whole array of structures and infrastructure needed to help make California's physical plant, public buildings, highways, schools, and universities world-competitive facilities.

This means that the current solar boom is a gift that will keep on giving in multiple ways. The workers who bootstrap solar work into multiyear training both on and off solar projects are becoming the next generation of skilled California construction workers earning decent paying incomes with family-friendly benefits for the rest of their construction careers. Almost universally, utility-scale solar workers have received family-friendly health benefits that promote family formation and stability.[11] The public-at-large benefits by having construction workers in California become the secure families and responsible citizens that make for good neighbors and a solid middle class.

Construction develops along a knife edge. There is a high-road construction path which trains workers to master all the skills of a craft. But poor policies and exploitive practices can push construction off the high road and mire it in low-wage, low-skilled, low-road construction work. Fortunately, due to policies and regulatory decisions within the state, the high road has general been taken during the California solar boom.

A Solar Boom Becomes a Skilled Training Boom

The boom in utility-scale solar construction in California has set in motion a related boom in apprenticeship and other forms of training for electricians, operating engineers, ironworkers, carpenters, millwrights, piledrivers, and laborers. The gold standard of training in construction is apprenticeship training, and about 30% of all the workers on these solar projects have been apprentices. Also significantly represented on solar construction projects are pre-apprentices, whose exposure to construction and basic safety and skills training is preparing them to enter apprenticeship programs.[xxxviii]

Apprentices learn a full range of skills in their craft enabling them not only to construct solar farms but also to build other green electrical facilities and other industrial and commercial facilities more quickly, efficiently, and in good order. For instance, an electrical apprenticeship program includes the skills needed for traditional construction as well as the skills required to build green energy projects. Electricians use a variety of green technologies including energy efficient lighting, systems, and appliances; motion and occupancy sensors, dimmers, timers, and smart power strips; and PVC free cables. They install wireless switches for remodeling, electrical consumption economizers— devices that reduce energy use of AC units—and programmable thermostats, as well as daylight harvesting systems, which use photosensors to detect light levels in a room. In addition to these energy efficient technologies, electricians are knowledgeable about different types of renewable energy such as solar, wind, and geothermal, and are able to integrate these sources into a comprehensive energy efficiency system. In addition to working on commercial and residential building retrofits, they also work on wind turbine installations, parking lot electrical outlets, electrical vehicles, mass transit and light rail projects, and smart electrical grid transmission systems.[xxxix]

California has a growing need for green skills associated with the building of both centralized (utility-scale) and distributed (rooftop) green electrical generating facilities, including the installation and retrofitting of green technologies on industrial, commercial, public, and residential buildings. The work that has taken place in constructing renewable energy generation facilities is positioning the California construction labor force to go forward with a widening and deepening of both utility-scale and distributed renewable energy generating infrastructure, as well as energy efficiency. This has been done in part because of multiemployer/union commitments to training.

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[11] Typically, workers who are new to a union have to work 90 days or 720 hours before qualifying for collectively bargained health insurance. These hours may be accumulated across multiple jobsites and permit breaks in work as workers move from job to job. In most cases, one utility-scale PV project will provide the 90 days of work needed to enter the health care program. In some jurisdictions, while individual coverage is paid for completely by the contractor, family coverage may require a worker co-payment. For instance in Imperial County, where there is considerable PV utility-scale work, IBEW workers do not have a family co-pay, but in San Diego, where there is limited utility-scale PV work, family health coverage does require a co-payment.

Solar Boom Stimulates Investment in Apprenticeship Training Programs

All collectively bargained agreements in California construction require contractors to pay into registered apprenticeship programs. We can estimate the effects of these contributions on training investment by looking at a large photovoltaic solar farm built in San Luis Obispo Country for which we have labor force data broken down by craft. **Exhibit 16** shows the hourly training contribution by trade for the 2014 collectively bargained agreements in San Luis Obispo County applicable to the building of the California Valley 250 MW Solar Ranch (CVSR) in that county.

The apprenticeship contributions on this project ranged from 47 cents per hour of work for carpenters, millwrights, and piledrivers to 86 cents per hour for electricians. Column c in **Exhibit 16** shows the approximate percent of all the work done on CVSR by each craft, based on the force curve[12] provided by SunPower for the project.[xl] Total project hours were calculated by multiplying 2,080 hours (52 weeks x 40 hours per week) against the 680 FTE blue- and white-collar workers projected by SunPower to build this 250 MW facility. Column D multiplies total hours by each craft's share of these total hours; this result is then multiplied by each craft's hourly apprenticeship contribution. Thus, column D shows an estimate of the apprenticeship training investment resulting from the building of the California Valley Solar Ranch. Column E multiplies these training investment sums by 17 to scale up apprenticeship training investment from a 250 MW facility to the roughly 4,250 MW of solar generating capacity that has been put in place over the last five years or that is under construction currently.[13] Basically, we estimate that the renewable-energy utility-scale generation capacity put in place in California over the last five years has also led to an additional $17.5 million investment in apprenticeship and other training for young workers entering the construction industry.[xli]

Exhibit 16

Investment in Worker Training by Craft from the Construction of California Valley Solar Farm 250 MW Project and Scaled Up to 4,250 MW of Solar Generating Capacity[xlii]

A Occupation	B Training Contribution per Hour	C Share of Total Hours	D Training Investment from a 250 MW Project = Total Hours for a 250 MW Project *Share* Training Contribution	E Total Investment in Training from 4,250 MW of PV Solar Work = 250 MW Investment *17
Carpenters, Millwrights & Piledrivers	$0.47	15%	$99,715	$1,695,158
Operating Engineers	$0.80	10%	$113,152	$1,923,584
Ironworkers	$0.72	15%	$152,755	$2,596,838
Laborers	$0.64	20%	$181,043	$3,077,734
Electricians	$0.86	40%	$486,554	$8,271,411
Total		100%	$1,033,219	**$17,564,726**

[12] A force curve shows the growth and decline of employment by craft over the lifetime of a construction project.

[13] (4,250 MW)/(250 mw)=17

Apprentices on Solar Work in the Imperial Valley

From the 4,250 MW of new solar generating capacity put in place or under construction over the last five years, about $8.3 million was invested in the training of electrical apprentices and pre-apprentices, and about $2.5 went to the training of ironworker apprentices and pre-apprentices. Here we describe these two apprenticeship programs and present four brief stories of current apprentices who got their start on solar farms in the Imperial Valley.

Electrical Apprenticeship

In San Diego and Imperial Counties, every union electrical contractor puts in 89 cents into apprenticeship training for every hour worked by every electrician on every job in those two counties.[xliii] With part of these funds, in August of 2009, at the bottom of the Great Recession, the National Electrical Contractors Association (NECA) and the International Brotherhood of Electrical Workers (IBEW) Local 569 opened an apprenticeship training facility in Imperial County, at a time when the county had lost 60% of its construction jobs.[xliv] This doubling down on the future of Imperial County at the worst of times reflected not only the prospects for solar resource development in the county, and state and federal policies promoting solar power, but also NECA's and the IBEW's long-term commitment to the construction industry and the development of a skilled electrician labor force.

IBEW Training Center, El Centro.
Photo by Micah Mitrosky

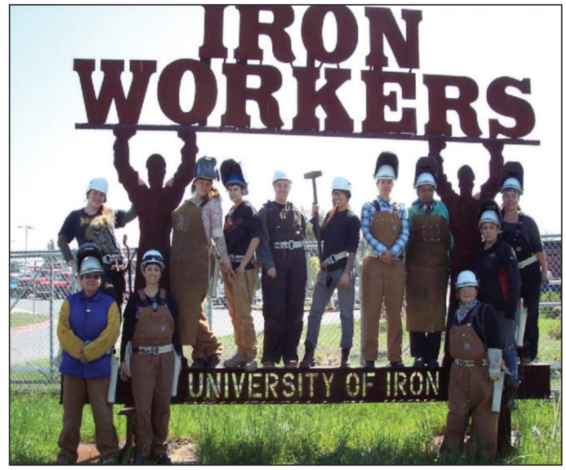
The IBEW-NECA electricians' apprenticeship program lasts five years and involves 1,020 hours of classroom training and 8,000 hours of on-the-job training. IBEW-NECA describe this program as follows:

> During the first three years of apprenticeship, [electrician] apprentices go through [a] compressed and vigorous curriculum two nights a week—one night for lecture and one night for hands-on applications of their skills. Apprentices are required to pass various competency assessments to successfully complete their classes. In the last two years of apprenticeship, apprentices have the choice of selecting a "career path" or specialty field. Each career path is comprised of several continuing education and skill improvement classes. Typical "career path" classes consists of the following: AutoCAD, Advanced Motor Controls, Low Voltage, Electrical Certification Prep, Electronics (Analog and Digital), Fire Alarm Systems, Instructional Leadership, Service Equipment, Test Equipment, Photovoltaics, Job/Project Management, Programmable Logic Controllers.[xlv]

By setting up a training facility in El Centro, NECA-IBEW made it possible for locals to get to and through their rigorous class schedule while working in the Central Valley. In short, the union and their contractors brought training to the valley in the hope and anticipation that work would come back from the depths of the Great Recession.

Ironworker Apprenticeship

Since the end of World War II, the Southern California Ironworkers Union and signatory contractors have also been betting smartly on the Southern California economy. The multiemployer–union SoCal Ironworkers Fund has overseen training for Southern California ironworkers since 1946. In 2013, about 300 union contractors employing about 9,000 journeyworker and 700 apprentice ironworkers put in 72 cents to the fund for every hour worked by every ironworker in Southern California.[xlvi] The fund operates a 29,600-square foot training center in La Palma, servicing most of Southern California, but also operates a smaller training facility in San Diego for San Diego County and Imperial County pre-apprentices and apprentices. In San Diego, first-year apprentices start out at $16.75 per hour, half the journeyworker wage. Over the four years of their apprenticeship, their wages rise to 90 percent of the journeyworker wage of $33.50 per hour. Apprentices also receive health and pension benefits, and in addition $3.92 for every hour they work is put into a vacation fund to help them take time off or handle the periodic unemployment that is inevitable in construction.[xlvii] In 2012, the Fund graduated 222 ironworker apprentices, most of whom started their training during the bottom of the Great Recession three or four years earlier.[xlviii] In ironwork:



Pre-apprenticeship Women's Gladiator Graduating Class 2014, Benecia, CA
Photo: University of Iron
http://www.universityofiron.org/

> Apprentices are required to receive at least 204 hours of classroom and shop instruction during every year of training. The subjects taken in the shop and classroom complement the hands-on training received in the field. The subjects include blueprint reading, care and safe use of tools, mathematics, safety issues, welding and oxy-acetylene flame cutting.[xlix]

Apprentices are required to demonstrate:

- Complete cooperation and willingness to learn
- Regular school attendance
- Dependability on the job
- The ability to work as part of a team
- The development of safe work habits
- Perform a day's work for a day's pay
- Be drug and alcohol free[l]

These solid work habits instilled in the ironworkers apprenticeship program are typical of all registered union apprenticeship programs including the IBEW-NECA program described above. The result of instilling a solid work ethic, conveying broad and deep career skills, and developing safe work habits raises the productivity of California construction labor force, and is transformative for the workers themselves as well.[li]

Impact of a Union Construction Apprenticeship on Workers' Lives

Thus far, Imperial County has had more solar farm construction than any other county in California. The Over a worklife, the value to a young Imperial County worker of obtaining five years of on-the-job supervised electrical training and employer–union paid-for classroom training is enormous. Because of the skills developed through extensive formal apprenticeship training, apprentices who turn out as union electricians earn substantially more than they would absent that training.

The current hourly wage rate in Imperial County for union electricians is $39.25, which at 2,000 yearly work hours amounts to an annual individual income of $78,500. In addition, union journeyworkers currently receive $6.63 per hour in health insurance contributions and $4.35 in pension contributions.[lii] Again at 2,000 work hours per year, this adds up to about $13,000 in health insurance coverage and $8,700 in pension investment. With a median *family* income in Imperial County of $41,255,[liilvii] this *individual* income of $78,500 plus benefits amounts to a substantial annual economic gain compared to a worklife without the upfront human capital investment in apprenticeship classroom training plus five years of supervised on-the-job training.

In rough terms, in Imperial County the annual average difference between the skilled worklife of an electrician and an individual without this human capital investment amounts to about $37,245 per year ($78,500 minus $41,255), *plus* additional pension and health benefits.[14] Assuming that an apprentice becomes a skilled journey-worker electrician at age 25 and works for 40 years until age 65, and using an inflation-adjusted real discount rate of 2%, the net present value in today's dollars of that additional income is just over $1 million for each new electrician's worklife.[15] This does not include the top notch health insurance and pension benefits the apprenticed electrician receives.

With an hourly pension contribution of $4.35, a newly trained electrician working 2,000 hours a year would receive $8,700 in pension contributions. Assuming a 40-year worklife and a conservative 2% return, this annual contribution of $8,700 would yield a pension nest egg of about $525,000. Having a half-million dollars in a retirement nest egg at age 65 is substantial. In 2010, the median net worth of the family of a 65-year old, married head of household was $300,000.[liv, 16]

A similar story can be told for the other trades on solar projects in Imperial County. For instance, after they turn out from their apprentices, ironworkers earn $33.50 per hour with $8.87 going into health insurance and $12.32 going into pension. As the reader will see in the stories below, the skills acquired in construction over four and five years of schooling and on-the-job training confer wages and benefits that are life changing.[lv]

The apprenticeship training and human capital investment dimensions of the renewable energy construction boom that has taken place in California is a gift that keeps on giving to multiple recipients: the workers themselves, the employers that will need their skills, and the business community that will find business opportunities in serving them.

One direct beneficiary of this investment is the energy-efficiency side of the emerging green economy. Despite the Great Recession, enlightened government policy has stimulated the harvesting of California's solar, wind, and geothermal energy-generation resources. This renewable energy electricity generation is developing alongside the development of better ways of baking into newly built structures greater energy efficiency and conservation. Because apprenticeship training financed in power plant construction is broad-based craft training, this human capital investment will also train much of the skilled labor force needed to build more energy efficient structures across the entire spectrum of California construction.

In addition, these newly skilled workers, rather than posing a potential burden on public services as low-wage, unskilled labor, instead become mainstays of the local health delivery system and other local public services due to their health insurance contributions and tax contributions to the local economy. Building solar capacity thus also builds the healthcare delivery system through private health care insurance contributions. It also builds the local tax base to the tune of roughly $1 million more in taxable income per newly trained worker over the 40-year period of their worklives.

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[14] In some ways this is a conservative estimate because we are comparing the *individual* income of a newly trained electrician in Imperial County against the average *family* income in the county. But in other ways, this estimate may not be conservative. We are assuming 2,000 hours of work for this electrician, and while it may be more hours in a construction boom it could be considerably less in a recession. Also, in other California counties, average family income is often higher than in Imperial County.

[15] While 40 years x $37,245 = $1,489,800, the present value of this future stream of income is less because the value of $37,245 40 years from now is less than the value of $37,245 today. Discounting for the time value of money at 2% per year yields a present value of this future stream of income = $1,019,128.

[16] Construction joint labor-management pension contributions typically go partially into defined contribution and partially into defined benefit programs. So workers get some guaranteed retirement income through their defined benefit pension and some retirement income will fluctuate associated with their defined contribution program. The estimated $525,000 in contributions is spread between these two types of programs. The comparison of this "nest egg" with family net worth is only an approximate measure of the relative importance of a full worklife participation in these multiemployer-union pension programs.

Apprentice Success Stories

Evangeline McDonald
Lives in Holtville, CA
Electrician Apprentice

Photo by Micah Mitrosky

Imperial County has been a center of solar farm construction in California, and electricians have been a big part of that work. In 2009, at the bottom of the Great Recession, the International Brotherhood of Electrical Workers Local 569 (IBEW) and the local chapter of the National Association of Electrical Contractors (NECA) opened a new training facility in Imperial County. There were no new IBEW 569 apprentices in Imperial at that time. By 2011, eleven new apprentices enrolled with the IBEW 569-NECA apprenticeship program serving Imperial County. Twenty enrolled in 2012 and 47 more enrolled in 2013. Evangeline McDonald is one of these apprentices, now in her fourth year.

Evangeline grew up on a reservation in New Mexico. After graduating high school, she joined the Navy and became an aviation electrician. Evangeline served in the Navy for five years and also earned a B.A. in psychology. Her husband was in the Navy as well and was stationed at the Naval Air Station in El Centro. When they moved to Imperial County, Evangeline was a stay-at-home mom but she decided to go back to work to help support the family.

Evangeline spoke with the Veterans Assistance service providers at the local Employment Development Department in Imperial County, who referred her to a representative from IBEW 569. Evangeline attended a presentation and was particularly attracted to the health insurance benefits although, she admits, she initially wasn't sure what she was getting into. Green energy wasn't really on her radar screen, and when she thought of the IBEW she pictured power plants and commercial work. That impression changed when she arrived on her first job site, the SunPeak solar project in Niland. Evangeline remembers thinking at that time, "Wow, renewable energy is going to be big. It is the future."

Since then, Evangeline has also worked building the Pattern Energy wind project in Ocotillo, the Desert Center project in Riverside, and LS Power's Centinela solar project in Imperial County.

Because of her new career in the IBEW, Evangeline and her husband were able to buy a home in Holtville a couple of years ago. She thinks Imperial is a great place to stay and will be a great place for her kids to grow up. She is proud of her career and feels her kids can look up to her and think, "Wow, my mom is an electrician."

Evangeline says that taking on a craft career has shown her kids the value of education, particularly math which is a bigger part of her electrical work than kids would think.

Despite her busy schedule, she tries to stay as active as possible in her community of Holtville. Her daughter just entered the Junior Princess Carrot Festival contest and is also in Girl Scouts. Evangeline was recently able to refer a friend's husband to the IBEW. He was accepted and is now working. Evangeline said it feels good to be able to have helped someone change their life.

Evangeline hopes to someday work at a geothermal or other power plant. One of the things she likes best about her new career in the IBEW is the pride she takes in her work. "When I see the finished project, I think, 'Wow, I did that. I was part of that team.' I love what I do."

Alfonso Carmona-Jimenez
Lives in Calexico area
Electrician Apprentice

Photo by Micah Mitrosky

Alfonso Carmona-Jimenez grew up in Mexicali, Mexico, and moved to Las Vegas when he was 19. He worked a variety of jobs: driving a cab, doing deliveries, managing a flower shop, and installing fences for a fence company. It was not until he joined IBEW Local 357 in Las Vegas as a Maintenance Wireman, a sub-journeyman classification, working at one of the casinos, that he found a true career. He eventually became the shop steward there. A few years ago he moved his family to Calexico to be close to his sick mother, and at that time he was referred to IBEW Local 569. He joined the local as a pre-apprentice trainee about three years ago and eventually, because of all of the renewable energy work, was accepted into the IBEW 569-NECA five-year apprenticeship program.

Alfonso really enjoys the apprenticeship program and is learning a lot more about the trade as he works towards becoming an IBEW Journeyman Wireman.

Since becoming an IBEW 569 member, Alfonso has primarily worked on renewable energy projects: the Sunora NRG solar project in Borrego Springs, a water treatment facility in Heber, the 8minutenergy Mount Signal solar project, the Pattern Energy Ocotillo Express wind project, and the Sol Orchard Community Solar project on San Diego State University's Brawley campus. Rotating across jobs and among signatory union contractors has allowed Alfonso to learn the full range of skills required on solar and wind projects.

Alfonso has also been called out on other types of projects and is becoming a skilled and well-rounded electrician. Favorite projects of his include a water treatment plant because of the control work; the wind farm, he says, "blew his mind." It took him about a week to get used to scaling up and down the towers which are hundreds of feet tall.

The things Alfonso likes best about his career in the IBEW are the camaraderie, friendship, and brotherhood, the benefits and security for his family, the challenges of the work, and the quality of life his work affords him. He notes the IBEW has "so many things to offer" and says that once he found the IBEW, "I found my path and my path was working union."

Alfonso has been a very active member of the local, for example, joining other IBEW 569 members on a Saturday volunteering time and skills to help beautify and repair the Ward Swarthout Park in El Centro. Alfonso hopes to work towards becoming a foreman someday and feels the "sky is the limit" in terms of his career opportunities.

According to Alfonso, renewable energy projects in Imperial County have helped sustain his career and support his family over the past few years. The projects are making an impact on people's lives, creating a growing economy in a place where there hasn't really been one. He is happy to see people paying their bills and starting to get ahead. "So many people didn't have work for so long, and can now pay their mortgage two and three months ahead."

Alfonso is excited for what's next in green technology and looks forward to continuing his apprenticeship training. He especially likes the fact that green energy projects are helping the environment and future generations. "That's what it's all about."

Maria Gradilla
Lives in Brawley, CA
Ironworker Apprentice

Maria joined Ironworkers Local 229 in November 2013 as a pre-apprentice. Before joining the Ironworkers, Maria was working in a warehouse doing packaging for pharmaceutical supplies. She had dreamed about working in construction and when the ironworkers union started recruiting local people for the Solar Gen 2 project, a 150-MW First Solar project in Imperial County, she decided to seize the opportunity.

After being accepted into the pre-apprenticeship, she proved herself and her dedication to the trade, and was subsequently accepted into the Ironworker apprenticeship program. She is now on track to becoming a journeyman after she completes her four years of apprenticeship training.

With two children—a 12-year old boy and a 10-year old girl—Maria really values being able to help support her family and especially the good-quality medical insurance she is getting as a union member. She says that, though a lot of people in Imperial County rely on social services, people who are working in minimum wage jobs often do not qualify for state medical aid but do not make enough money to be able to afford quality healthcare.

Maria really enjoyed the work she did on the Solar Gen 2 project, the fact that it is eco-friendly, and especially that she was working close to home and family. After the project was completed she was rotated out to work on a hospital project in San Diego, where she is now getting new exposure to different skills within the ironworker trade. She sees her career as "having no limits" and is especially interested in welding, which requires numerous certifications.

Maria notes that there is a lot of poverty in Imperial Valley and it is a little bit of a "forgotten area." These union jobs with the skills they confer allow people to earn twice what they would earn working in the harvest fields or doing other types of work. In her view, her Ironworker Union apprenticeship has also given both men and women an equal opportunity to make a good living and earn a good wage.

Photo by Johnny Swanson

Laura Lizarraga
Lives in Calexico, CA
Ironworker Apprentice

PHOTO BY JOHNNY SWANSON

Laura joined Ironworkers Local 229 in November 2013. She started out in a pre-apprenticeship classification and has since been accepted into the four-year Ironworker apprentice program.

Before joining the Ironworkers, Laura was working at a gas station, after which she was out of work for two years. She learned about the Ironworkers program from a friend who had heard that the Ironworkers were recruiting local people for a project. Laura was very interested in the opportunity to grow, learn, earn more money, and advance.

During her initial eight weeks of training, Laura attended Saturday school, driving two hours one way to San Diego to train at the Ironworkers Hall. Now, she will be doing one week of classroom training every three months.

Laura's first job site was the Solar Gen 2 project in Imperial County, a 150-MW solar project. After this she was rotated onto a hospital job in San Diego where she was able to continue working and learning. On this project she was exposed to a different facet of the trade. She learned new skills and was also able to log a lot of valuable overtime hours.

One of the things Laura is enjoying most about the apprenticeship is the challenge of the work and advancing her skill set and her career. Laura is hoping to have an opportunity to work on another solar project in Imperial County that has recently broken ground and is just getting underway.

Laura's family in Imperial County has traditionally worked out in the farm fields and she noted, "I never thought in a million years I'd be working in this type of industry." Laura hopes to stay in construction, graduate as an ironworker journeyman, and support her family. She is thrilled to have this opportunity to offer her two-year old daughter a better future than what most families are facing in the Imperial Valley. This is a unique opportunity and she is working hard to make the most of it.

She notes that in the Imperial County there is a lot of poverty and unemployment. Good-paying jobs offering skill enhancement and career advancement are dearly needed. "These jobs create a lot of opportunity for a lot of people."

Policy's Role in Creating Good Jobs and a Cleaner Environment

Section Summary

Policy and legislative action at both the federal and state levels has stimulated the boom in California's renewable energy electricity generation over the last five years, enabling California to become the national model in demonstrating how to generate new economic opportunity through aggressive climate change action. Key federal policies include the American Recovery and Reinvestment Act (ARRA) of 2009 and the Federal Business Energy Investment Tax Credit (ITC). California's policies include the Global Warming Solutions Act (AB 32), Senate Bill X1-2, and AB 327, which passed in 2013 and established the 33% Renewable Portfolio Standard (RPS) goal set forth in SB X1-2 as a floor to be achieved and not a ceiling to reach for. California's Environmental Quality Act has also played an important role in promoting California's renewable energy growth. Collectively, these policies helped marshal the needed investment capital, helped create the market certainty needed to turn financial capital into specific investment plans, and helped provide the business, worker, and public incentives that brought these players together.

The synergy between building green, utility-scale power plants and quality construction career development has also benefited from federal and state policies. Utility-scale solar projects that receive federal subsidies fall under the Davis-Bacon Act, which requires that prevailing wages and benefits be paid. Furthermore, California is not a right-to-work state and as a result prevailing wages in construction tend to be the collectively bargained rate that includes good wages with decent benefits and contributions to apprenticeship training.

On some federally-subsidized solar projects in western right-to-work states, nonunion rates prevail. In these cases, workers are often obtained from temporary labor agencies; they earn low wages with limited benefits and they have little access to training or career advancement. In California, by contrast, strong unions and strong prevailing wage laws combine to create green construction projects that also build the skills of the local construction labor force and improve the career opportunities of many new entrants into the industry.

Federal Policies and Legislation Supporting Renewable Energy Growth

The election of President Barack Obama in 2008 ushered in a new era for renewable energy that was unprecedented in our country's history. Shortly after taking office, President Obama spearheaded and signed the American Recovery and Reinvestment Act (ARRA) of 2009 which contained "more than $31 billion to support a wide range of clean energy projects across the nation" according to the Department of Energy.[lvii] Funds were disbursed through grants, loans, tax assistance, and contracts supporting a wide variety of clean energy activities.[lviii] Besides providing direct financial support, ARRA also sent a clear message from the highest office in the nation that renewable energy was a priority for the new Administration.

Perhaps most importantly, ARRA monies provided business certainty for "first movers" at a doubly uncertain time. New technologies are inherently risky. The first businesses to move into a new industry face risk levels that followers do not. The bottom of the Great Recession made the risks faced by companies moving into utility-scale solar electricity generation exponentially more daunting. Through the ARRA loan guarantees to selected PV and solar thermal projects during the depths of the Great Recession, a take-off in guaranteed solar projects, and subsequently solar projects without loan guarantees, occurred. Had it been left alone, the market would have done little in the face of first-mover uncertainty and severe business cycle risks.

All three California solar thermal projects listed in **Exhibit 13**—Ivanpah, Genesis, and Mojave—received loan guarantees that together amounted to about $3.7 billion. Three of the California PV projects also received loan guarantees—California Valley Solar Ranch, Antelope Valley, and Desert Sunlight—that amounted to about $3.5 billion.[lix] Under current technologies, solar thermal is more risky than PV. As *MIT Technology Review* pointed out in 2011:

> Solar panels are established technology—banks have a pretty good idea how long they'll last and what the return on investment will be [making it easier to get private financing.] Much of the solar thermal technology being deployed now hasn't been tested on a large scale for long periods of time, which can make financing harder.... But solar thermal stands a chance, especially in light of a series of DOE loan guarantees announced in recent weeks.... [lx]

It may be that in the end solar thermal (also called concentrating solar power, or CSP) is an unworkable technology. But should it succeed, the value of utility-scale solar thermal is that it provides greater diversification in the portfolio of green energy generation by its ability to store heat past daylight hours. Solar thermal when combined with heat storage allows for solar energy generation to be dispatchable—that is, provided upon demand. Thus, solar thermal is one way of backing up photovoltaic solar electricity generation.

2014 has been a milestone year for utility-scale solar thermal power. The DOE reports:

> Through sustained, long-term investments by the United States Department of Energy (DOE) and committed industry partners, some of the most innovative CSP plants in the world connected to the United States electricity grid in 2013, and five plants of this kind are expected to be fully operational by the end of 2014. One of them is the largest CSP plant in the world; another represents a first-of-its-kind in energy storage technology at commercial scale in the United States. Collectively, these five CSP plants will nearly quadruple the preexisting capacity in the United States, creating a true CSP renaissance in America.[lxi]

The DOE has supported solar energy not only through loan guarantees for first movers but also through a research and development program called SunShot Initiative, begun in 2011 with the goal of developing solar technologies to become fully market competitive with traditional energy generation by 2020.

> The SunShot Initiative's investments support innovation in solar energy technologies that are aimed at improving efficiency and reducing the cost of materials, as well as making it easier, faster, and cheaper for homeowners, businesses, and state, local, and tribal governments to "go solar."[lxii]

Thus two key DOE supports for the development of solar energy are loans for selected projects to reduce first-mover risks and basic research-and-development to reduce the costs of these new technologies. What these policies actually do is release an untapped energy resource—the abundant photovoltaic and solar thermal energy reserves of a sun-rich America.

In addition to loan guarantees from the ARRA for first movers facing adverse business cycle conditions and DOE-led research and development, the Federal Business Energy Investment Tax Credit (ITC) has helped and continues to help offset the startup costs of this emerging industry at a critical time: when technology is reaching economies of scale and prices are beginning to fall. Originally created in 2005, the ITC applies to residential as well as commercial and utility-scale solar systems; it provides a 30% tax credit.[lxiii] The ITC was renewed in 2008 for an additional eight years. Under current law, after 2016, the 30% credit will fall to 10%.

The ITC is one of the most important federal policies in promoting clean energy generation at both rooftop and utility scales. As a stable, multiyear incentive, the ITC provides the business certainty needed to reduce risk and promote capital investment on utility-scale solar projects.

The ITC has been recognized by solar industry leaders as the "cornerstone"[lxiv] policy enabling a rapid acceleration of renewable energy development. For example, in referencing a recent project announcement in June of this year, a leading solar industry developer noted, "it was one of a number of projects 8minutenergy planned to get online before expiration of the United States' solar Investment Tax Credit (ITC) in December 2016."[lxv]

The federal policies and legislation promoting green energy generation including solar energy follow a long American history of government directly and indirectly supporting the development of the foundational infrastructure that underlies private economic development and community prosperity. From the Erie Canal to the transcontinental railroad to the Hoover Dam to the interstate highway system to the Internet, government has provided some of the underlying research and development, direct capital investment, and private incentives to allow these risky endeavors to proceed and in their development make other market investments and innovations attractive and profitable. Energy and the environment are as much part of the American infrastructure today as canals and roads have been in the past. Federal legislation and policies providing loan guarantees for first movers who invest in new energy technologies, as well as basic research and development in these emerging technologies and investment tax credits boosting takeoff of the green energy industry, have all been pivotal in setting the stage for future American economic development, job and career growth, and a healthy environment.

State Policies Supporting Renewable Energy Growth

In 2006, California passed The Global Warming Solutions Act (AB 32). At the time, this legislation was groundbreaking in its scope, vision, and goal of reducing greenhouse gas emissions in California to 1990 levels by 2020. AB 32 created a legal foundation for the state to enact future policies targeting greenhouse gas reductions in broad sectors of the economy, especially those most responsible for greenhouse gas emissions such as transportation and energy.

Arguably one of the most effective policy drivers influencing the rapid growth of utility-scale renewable energy projects in California is the state's Renewable Portfolio Standard (RPS). In 2011, Governor Jerry Brown signed Senate Bill X1-2, expanding the RPS to require 33% of electricity retail sales to be from renewable resources by 2020.[lxvi] Even today, California's RPS is viewed as one of the most aggressive and effective in the country, and is only expected to expand as the 2013 passage of AB 327 established the 33% goal as a floor and not a ceiling.[lxvii] Since the passage of the 33% RPS, renewable energy growth in California has dramatically accelerated.

Policies and Practices that Tie Green Energy to Career Development

Prevailing Wages and Right-to-Work Regulations

Jobs building utility-scale solar electricity generating facilities are not inevitably good jobs paying decent wages and benefits and providing career training within construction. Under some labor market conditions, many solar farm jobs can be bad jobs paying low wages, with limited benefits or none at all, working for temporary labor agencies with no prospect for training, job rotation, or career development. In California, this low-road approach to utility-scale solar construction is uncommon for several reasons. First, when any federal funds are involved, the project is governed by federal prevailing wage regulations mandating that, for each occupation on the project, the wage in the local area that prevails for that occupation, based on Davis-Bacon surveys, must be paid. All states are covered by the federal Davis-Bacon Act, but in some states, such as Arizona, for some construction crafts, nonunion rates prevail in many counties, meaning that prevailing wage jobs can be paid low wages with limited benefits. In California, union strength has meant that in most cases on prevailing wage solar projects, workers will get paid good wages with good benefits. State right-to-work laws play a role in determining union strength. By undercutting union strength, Arizona's right-to-work law plays a role in determining the low-road practices found on some solar farm construction in that state. In contrast, California's resistance to right-to-work regulations reinforces federal Davis-Bacon wage mandates, thereby helping lead California's solar farm work along a high-road approach to construction.

Project Labor Agreements

Many solar farm projects are not subject to prevailing wage regulations. In the absence of prevailing wages, project labor agreements (PLAs) have often played a role in solar farm construction. PLAs are multi-craft, pre-hire labor agreements negotiated between building and construction trades unions as a group, on one hand, and owners, developers, construction managers, and/or general contractors on the other. PLAs govern labor relations and terms and conditions of employment on an entire construction project. They have been used on both private and public projects in California since at least the 1930s.[lxviii] These include industrial facilities, large commercial projects, large residential projects, public buildings, schools, dams, highways, and other forms of infrastructure.

From the perspective of the owner, project labor agreements are a construction management tool. They can standardize work rules and other conditions on a construction project (e.g., shift schedules, holidays, break times, travel pay, drug testing), thus eliminating the potentially conflicting practices of different contractors and potentially conflicting terms of different craft-specific collective bargaining agreements. PLAs also almost universally provide a no-strike/no-lockout guarantee for the life of the project. Instead of strikes or lockouts, PLAs put in place grievance procedures to settle all disputes. PLA agreements may also provide for local hire, and pre-apprenticeship and apprenticeship opportunities for local or disadvantaged workers. PLAs can lead to union support for bonding, permitting, or financing of projects. Unions agree to these concessions and sweeteners in exchange for a PLA that will cover the specific work at issue.

In California on utility-scale solar construction, PLAs have played a very important role in insuring that some of the money going into building these facilities goes towards apprenticeship training, some goes to paying for health care, and some goes into retirement benefits. This is the tie-in between green construction and construction career development. When solar farms are built without these provisions, the training of the next generation of skilled construction workers does not take place, the retention of this generation of experienced construction workers is undercut by the absence of family-friendly benefits, and the paying for the retirement of the last generation of skilled construction workers gets jettisoned. PLAs and prevailing wage regulations are mechanisms that create a synergy between construction careers and green energy.

Conclusions, Policy Recommendations, and Next Steps

As California demonstrates, complementary policy action at the state and federal levels is a critical factor in driving swift, successful, renewable, clean-energy growth that in turn benefits both the economy and the environment by creating good jobs and new careers while reducing greenhouse gas emissions.

This is exemplified in the comments of one industry source in describing a package of renewable projects in Kern County, California, in 2012 as being:

> .... the direct result of California's renewable energy mandate, as well as the federal production tax credit and the investment tax credit. The PTC [federal Renewable Energy Production Tax Credit] for wind, and more recently the ITC for solar, assist renewable resources in leveling the playing field against fossil fuels, which have decades of government incentives behind them.[lxix]

As this study has demonstrated, the old myth that we must choose between good jobs and a clean environment proves itself to be a false choice. In 21st Century California, sound environmental policy is building middle-class jobs, and economic policy that creates these green skilled career opportunities is good environmental policy.

To keep this positive momentum going, however, will require ongoing state and federal leadership. Four key policy actions that should be taken in the near-term to continue building on California's leadership in creating high-quality jobs while decarbonizing the energy sector are:

- **Renewing the Federal Business Energy Investment Tax Credit so it remains at 30% after December 2016.**
- **Expanding California's statewide renewable energy mandate beyond 33%.**
- **Protecting AB 32 from implementation delays or weakening.**
- **Supporting policies that promote collective bargaining and the use of joint labor-management apprenticeship programs on energy projects during construction, operations, and maintenance.**

Beyond 33%: Diverse Energy Portfolio—A Win-Win for Workers and the Environment

For the many reasons discussed in this report, utility-scale solar thermal and particularly photovoltaic solar energy generation in California have experienced unprecedented growth while playing key roles in creating good, middle-class jobs. This solar energy expansion has helped the state meet the goals of reducing greenhouse gas (GHG) emissions and achieving the 33% targets outlined in California's Renewable Portfolio Standard.

The statewide conversation regarding renewable, emission-free electricity generation, however, has now shifted to "beyond 33%." Issued in September 2013, the Governor's draft Environmental Goals and Policy Report entitled "California @ 50 Million" states that California is "committed to reduce economy-wide GHG emissions 80% below 1990 levels by the middle of this century."[lxx] The report goes on to highlight decarbonizing the state's energy systems through the growth of non-GHG energy sources as a key action to achieving this 2050 target.

Certainly solar power will continue to play a key role as a non-GHG energy source in California's energy future. However, to truly meet the challenges of 2050 will require a diverse mix of non-GHG energy sources such as geothermal and wind that tap a variety of renewable resources and technologies to create a balanced, non-GHG energy portfolio.

The scope of this report has focused on the environmental and economic benefits of the solar boom in California over the past five years. However the "high road" career lessons learned from the California utility-scale solar industry can, and should, be applied to the growth of other non-GHG energy industry sectors including wind, geothermal, and emerging technologies such as ocean waves/tides and others. The current growth in a new generation of apprenticeship-trained craft labor in construction will provide the first wave of new, highly skilled labor to assume the task of building the next generation of green technologies. In turn, if the next generation of green technologies is built with high-road construction practices, the synergy of green construction will continue to be a gift that keeps on giving. This will enable California to sustain skilled, middle-class careers in the construction industry across multiple trade sectors while tackling climate change, a model that is truly economically and environmentally sustainable.

Endnotes

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[xxviii] Stephen F. Hamilton, Darin Smith and Tepa Banda, "Economic Impact to San Luis Obispo County of the California Valley Solar Ranch," Appendix 14B, December, 2010 http://www.sloplanning.org/EIRs/CaliforniaValleySolarRanch/feir/apps/Ap14B_Economic_Impacts.pdf

[xxix] Stephen F. Hamilton, Mark Berkman and Michelle Tran, Economic and Fiscal Impacts of the Topaz Solar Farm, March, 2011, http://topaz.firstsolar.com/downloads/TopazEconomicStudy.pdf

[xxx] Aspen Group, "Socioeconomic and Fiscal Impacts of the California Valley Solar Ranch and Topaz Solar Farm Projects on San Luis Obispo County," Appendix 14A http://www.sloplanning.org/EIRs/CaliforniaValleySolarRanch/feir/apps/Ap14A_Fiscal_Impacts_Study.pdf both from County of San Luis Obispo, Department of Planning and Building, California Valley Solar Ranch Conditional Use Permit, and Twisselman Reclamation Plan and Conditional Use Permit, http://www.sloplanning.org/EIRs/CaliforniaValleySolarRanch/index.htm

[xxxi] Mark Berkman and Wesley Ahlgren, "Economic and Fiscal Impacts of the Desert Sunlight Solar Farm," The Brattle Group, www.brattle.com, personal communication with Wesley Ahlgren, June 13, 2011, wes@cvep.com.

[xxxii] Ibid.

[xxxiii] For underlying data see Hamilton, Smith, and Banda, Part II , tables 1, 3 and 4. Rounding led the authors to sometimes present their assumption as 680 and sometimes 681 FTE construction jobs.

[xxxiv] Hamilton, Smith, and Banda do touch on a related point of the possible synergies between Cal Poly San Luis Obispo and the development of new technologies associated with photovoltaic power. This too would be a long term advantage that could well outlast the life of the construction job, itself.

[xxxv] They also did separate analyses of each project. For simplicity, in Exhibit 14, we present their combined results.

[xxxvi] This include 25 FTE workers spending 20 months (or 42 FTE job-years) constructing tie-in transmission lines.

[xxxvii] Stephen F. Hamilton, Darin Smith, and Tepa Banda, "Executive Summary," Economic Impact to San Luis Obispo County of the California Valley Solar Ranch, December, 2010 Part II, Table 1, p. 4 http://www.sloplanning.org/EIRs/CaliforniaValleySolarRanch/feir/apps/Ap14B_Economic_Impacts.pdf; Aspen Group, "Socioeconomic and Fiscal Impacts of the California Valley Solar Ranch and Topaz Solar Farm Projects on San Luis Obispo County," Appendix 14A p. Ap.14A-12 Tables 4-1 and 4-2 http://www.sloplanning.org/EIRs/CaliforniaValleySolarRanch/feir/apps/Ap14A_Fiscal_Impacts_Study.pdf ; Stephen F. Hamilton, Mark Berkman, and Michelle Tran, Economic and Fiscal Impacts of the Topaz Solar Farm, March, 2011, Table 4.3 p. 11 http://topaz.firstsolar.com/downloads/TopazEconomicStudy.pd ; Mark Berkman and Wesley Ahlgren, "Economic and Fiscal Impacts of the Desert Sunlight Solar Farm," The Brattle Group, Tables 4.1 and 4.2 pp. 9-10, www.brattle.com, personal communication with Wesley Ahlgren, June 13, 2011, wes@cvep.com.

[xxxviii] This estimate of the percent apprentices on solar projects in California comes from interviews with industry practitioners. Currently there are no precise data on the mix of journeyworkers, apprentices, and pre-apprentices on solar work. More research is required on this topic.

[xxxix] CA Employment Development Department, Detailed Guide for Electricians in California, Green Electricians; http://www.labormarketinfo.edd.ca.gov/OccGuides/Detail.aspx?Soccode=472111&Geography=0601000000 (accessed October 7, 2014)

[xl] Table A-3, "Detailed Construction Wages California Valley Solar Ranch Economic Impact Analysis; EPS #20133," footnote 3, Stephen F. Hamilton, Darin Smith, and Tepa Banda, Economic Impact to San Luis Obispo County of the California Valley Solar Ranch, December, 2010. http://www.californiavalleysolarranch.com/pdfs/Economic_Impact_to_SLO__Final1.pdf

[xli] There are two minor qualifications to this conclusion. First, on the two thermal solar plants, Ivanpah and Mojave, the craft mix would be different and the job-years per MW would also differ due to the technical differences between PV and thermal solar technologies. Apprenticeship training contributions would be somewhat different than the estimated $17.5 million due to these differences. Second, two of the projects list in Exhibit 13, the SMUD and TA-High Desert projects, may have had nonunion contractors doing some of the work and not paying into apprenticeship training programs. To the extent that solar work is done nonunion by contractors that do not have apprenticeship programs, the funding of training from solar work would be less.

[xlii] Sources: training contribution rates http://www.dir.ca.gov/dlsr/pwd/index.htm; total and share of hours on project http://www.californiavalleysolarranch.com/pdfs/Economic_Impact_to_SLO__Final1.pdf

[xliii] http://www.dir.ca.gov/OPRL/PWD/index.htm

[xliv] Bureau of Labor Statistics, Quarterly Census of Employment and Wages, http://www.bls.gov/cew/ and "IBEW and NECA to Strengthen Imperial County Green Energy Economy with New Electrical Training Center," http://www.ibew569.org/absolutenm/templates/ibewpressreleasedisplay.aspx?articleid=79&zoneid=3

[xlv] National Electrical Contractors Association-International Brotherhood of Electrical Workers, San Diego and Imperial County, Inside Wireman Apprenticeship Program, http://www.sdett.org/careerinsidewireman.asp

[xlvi] http://www.dir.ca.gov/OPRL/PWD/index.htm

[xlvii] http://www.universityofiron.org/trainingcenters/sandiegoca.html

[xlviii] California Field Ironworkers Apprenticeship Training and Journeyworker Retraining Fund of Southern California, January 25, 2013, http://etp.ca.gov/packet/Ironworkers%20JATC%20130.pdf

[xlix] http://www.ironworkers.org/training/about-training

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[liii] US Census State and County Quickfacts http://quickfacts.census.gov/qfd/states/06000.html

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[lv] http://www.dir.ca.gov/OPRL/PWD/Determinations/Statewide/C-020-X-1.pdf

[lvi] IBEW and NECA to Strengthen Imperial County Green Energy Economy with New Electrical Training Center, August 21, 2009 http://www.ibew569.org/absolutenm/templates/ibewpressreleasedisplay.aspx?articleid=79&zoneid=3

[lvii] http://www.energy.gov/recovery-act

[lviii] http://www.recovery.gov/arra/Transparency/fundingoverview/Pages/fundingbreakdown.aspx

[lix] Energy.gov, Loan Program Office, Projects, http://energy.gov/lpo/projects

[lx] Kevin Bullis, "Solar Thermal Plants Losing out to Photovoltaics," , MIT Technology Review, July 1, 2011, http://www.technologyreview.com/view/424567/solar-thermal-plants-losing-out-to-photovoltaics/

[lxi] DOE, "The Year of Concentrating Solar Power," May 2014, p. 2 http://energy.gov/sites/prod/files/2014/05/f15/2014_csp_report.pdf

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[lxiii] http://www.seia.org/research-resources/case-solar-investment-tax-credit-itc

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[lxv] http://m.pv-magazine.com/news/details/beitrag/8minutenergy-renewables--macquarie-capital-raise-30-million-for-california-solar-project_100015424/

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