Title

The Link Between Good Jobs and a Low Carbon Future

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The Link Between Good Jobs and a Low Carbon Future:

Evidence from California's Renewables Portfolio Standard, 2002—2015

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Cover photo by Johnny Swanson.

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Introduction

On October 7, 2015, California's Governor Jerry Brown signed SB 350 into law, committing California to increasing its Renewables Portfolio Standard (RPS) to 50% and doubling energy efficiency savings by 2030.[1] On stage at the signing were two state labor leaders: Robbie Hunter, President of the State Building and Construction Trades Council of California, and Marvin Kropke, Business Manager of Local 11, the biggest International Brotherhood of Electrical Workers (IBEW) building trades local in the state. A statement issued by the California Building Trades to mark the occasion read:

> The passage of Senate Bill 350 in the closing moments of the 2015 legislative session last week is fantastic news for Building and Construction Trades workers in California. The legislation, strongly supported by the California Building Trades, increases the percentage of California's energy that must be from renewable sources from 33 to 50 percent over the next 15 years. That creates an immediate demand for the construction of new renewable power plants—solar, wind and geothermal—along with transmission lines to tap into other sources that this bill now mandates must be built under prevailing wage. California's Building Trades workers will now go to work by the thousands building those plants.[2]

While there is no shortage of analyses on job creation in the renewable energy industry, there is a lack of research that measures the quality of these jobs and the ability of workers in the clean energy industry to build careers and support their families. Due to its aggressive climate policies and the size of its economy, California, by far, supports the most clean energy jobs of any state in the nation. What has proven more significant than the sheer numbers of jobs, however, is the quality of those jobs. California's renewable energy has been built primarily by the building trades unions, so the jobs have been good quality jobs—jobs that support skilled workers and compensate them with family-supporting wages and benefits. In return, the State Building Trades have been a powerful political ally for increasingly aggressive policies to address climate change.

Between 2002 and 2015, 11,234 megawatts (MW)[3] of new RPS-compliant generation capacity[4] have been built in the state. This paper describes the impacts of this construction, driven by California's RPS, on statewide blue-collar construction workers. We outline how the RPS has produced a significant number of good quality jobs with family-supporting wages, health and retirement benefits, and career training opportunities across the state of California. The major beneficiaries of the growth in renewable energy generation were workers in very high unemployment, low-income counties, such as Imperial and Kern Counties. The concentration of renewable energy construction in these areas further amplifies the benefits of renewable energy jobs.

Contrasting the "high-road" strategies developed in California to train, support, and retain workers in the construction industry with outcomes from elsewhere, we illustrate how the RPS provides benefits beyond carbon reduction. In supporting the development of a skilled and productive construction labor force within the state, the RPS has been good not only for workers but also for the California construction industry.

This paper continues a discussion started in our previous analysis[5] of the solar industry in California regarding how the unique regulatory environment of the state solidifies "high-road" workforce practices. SB 1078 established the initial RPS in California in 2002. Senate Bills 107 and X1-2 increased the target. Those bills facilitated the growth in renewable energy jobs documented here, to which SB 350 will continue to contribute. A combination of state policies helps to ensure that these new jobs provide quality careers. Most utility-scale renewable energy installation in California have been governed by collectively-bargained project labor agreements (PLAs), which require prevailing wage rates, benefits (e.g., pension and healthcare contributions), and employer contributions for training.

In this report, we report employment estimates in "job-years," equal to 2,080 hours of work. Over the period from 2002 to 2015, we estimate that California's RPS created 25,500 blue-collar job-years (about

53 million hours of blue-collar construction work) and 7,200 white-collar construction job-years (about 15 million hours of white-collar construction work), almost 90% of which have been created since 2012. Full-time construction workers work about 80% of the 2,080 hours per year (about 1,664 hours), due to seasonality and downtime between construction projects. In addition, one job-year may be spread across multiple construction workers, so we are not capturing the actual head count of workers on renewable projects.

As a direct consequence of this job creation, we estimate that $46.6 million has been invested in apprenticeship training. This important contribution to workforce education and training of California residents is made jointly by workers and their employers, rather than taxpayers. The apprenticeship system is a self-funded sustainable workforce training model that ensures an ongoing supply of well-trained construction workers with the relevant skills to take on new and challenging work in the state including work associated with the transition to a low-carbon economy (e.g., renewable energy, transmission infrastructure, battery storage, energy efficiency retrofits, electric vehicle charging stations, green buildings, etc.). This private contribution to apprenticeship training translates roughly into a $35,000 investment in classroom training for each of the approximately 1,200 apprentices who graduated over that period due to growth in renewable generation. This investment in classroom training is in addition to the paid on-the-job (worksite) training that apprenticeship also provides.

The jobs generated between 2002 and 2015 also contributed almost $340 million into blue-collar construction workers' pension funds and almost $400 million towards health insurance coverage for these workers and their families, both of which are managed jointly by the unions and their employers in Taft-Hartley trust funds. The contributions per worker average $10,650 in pension contributions and $12,500 in health coverage for each worker.

These tangible gains for construction workers continue to play an important role in building and sustaining California's distinctive political coalition of building trades unions, environmentalists, community activists, and others supporting California's RPS policies.

Understanding New Job Creation under the California RPS

Over the period from 2002 to 2015, 11,234 MW of renewable energy electrical generation capacity was built in California. Panel 1 of Exhibit 1 shows that half of this new capacity was photovoltaic (PV) solar facilities, while 38% was wind farms, and 8% was solar thermal, also called concentrated solar power (CSP). In contrast, Panel 2 of Exhibit 1 shows that in terms of jobs created, PV solar accounted for 67% of all construction jobs and solar thermal accounted for 18%, while new wind-powered facilities created 9% of the construction jobs on these sites.

We use the Jobs and Economic Development Impact (JEDI) models developed by the National Renewable Energy Laboratory for our job estimates. JEDI uses standard economic impact assessment methods and applies them to renewable and conventional energy production to estimate the total number of construction jobs, including both blue- and white-collar jobs,[6] that are created per megawatt installed for each renewable technology.[7] To estimate the number of jobs created by the RPS from 2002 to 2015, we entered into the appropriate JEDI model the parameters from each renewable energy project built in California over this period.[8]

The estimation of white-collar and blue-collar jobs is derived from the 2012 US Census Bureau Economic Census data for the power and communications construction industry, which shows that 78% of all the employees of these construction contractors were blue-collar craft workers and 22% were white-collar workers.[9] Exhibit 2 shows the estimated MW of completed renewable energy projects over 2002–2015, with the corresponding estimated blue-collar and white-collar employment in job-years. (Wind involves much less onsite construction labor per megawatt relative to the other renewable energy technologies.)

Exhibit 1

Distribution of MW built and direct construction jobs created by type of renewable energy technology, California, 2002–2015

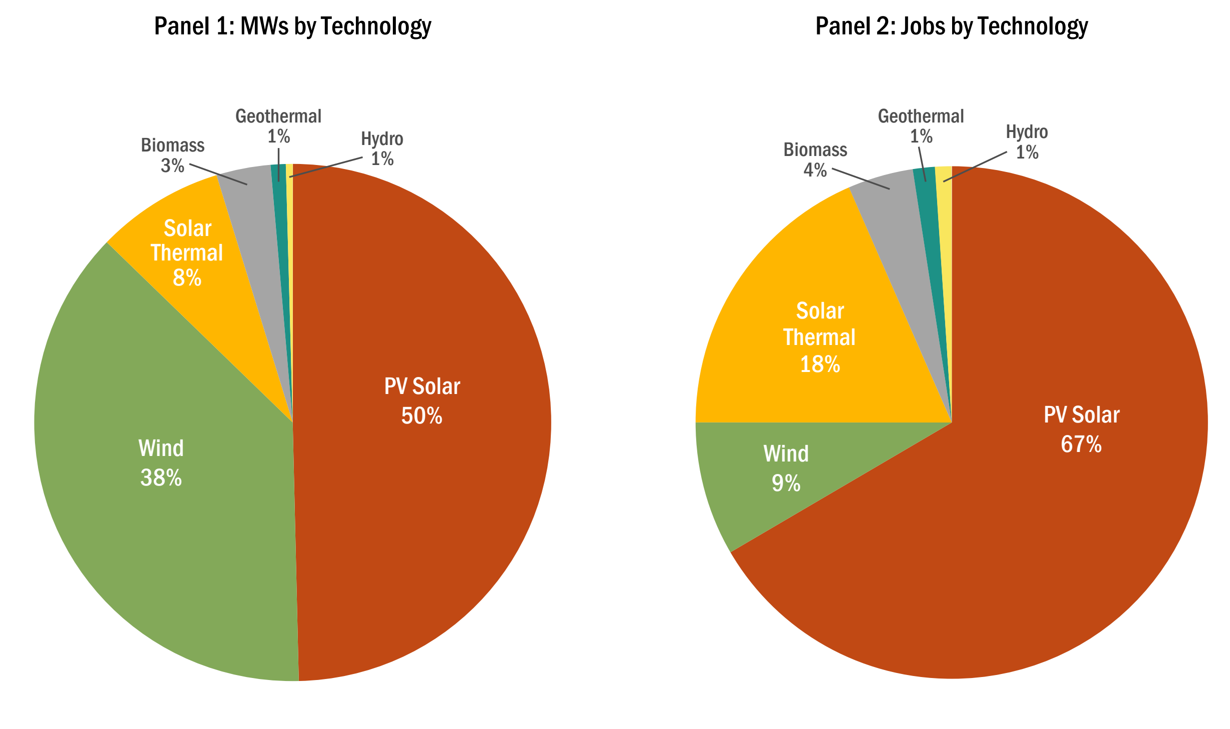


Exhibit 2

Renewable energy MW installed and construction jobs created, California, 2002–2015[10]

Type of Renewable Energy	New In-State MW Capacity Built	Total Construction Job-Years	Blue-Collar Construction Job-Years	White-Collar Job-Years per MW	Blue-Collar Job-Years per MW
Photovoltaic (PV)	5,575	21,724	16,945	0.9	3.0
Large Commercial (0.25–1MW)	15	88	69	1.3	4.5
Community Scale (1–5 MW)	618	2,405	1,876	0.9	3.0
Utility (>5MW)	4,942	19,231	15,000	0.9	3.0
Concentrated Solar Power	897	6,014	4,691	1.5	5.2
Land-Based Wind Power	4,226	2,754	2,148	0.1	0.5
Geothermal	105	457	357	1.0	3.4
Small Hydro	48	341	266	1.6	5.5
Biomass (+Biogas)	381	1,346	1,050	0.8	2.8
Battery Storage	2	NA	NA	NA	NA
Total Renewable*	**11,234**	**32,636**	**25,456**	**0.6**	**2.3**

*May not sum or multiply due to rounding

In addition to the onsite project work, there is almost always substantial additional work required to move the power to the grid. This involves constructing a switchyard, substation, and transmission lines to connect to the grid. The amount of this type of work required varies based on how closely the new project is sited to existing substations and power lines. Consequently, it cannot easily be calculated from technology and MWs installed. There are also construction-related jobs created by the building of these facilities. These include work designing the project as well as legal, marketing, finance, and other related activities not done by construction contractors or onsite by the owner or developer. These construction-related activities are not included in our job estimates, nor are supply chain jobs or other indirect employment created by these projects. We also do not include any jobs induced or stimulated in the broader economy by the wage and business income associated with this construction work. Other employment impacts left out of this study include the ongoing operations and maintenance jobs associated with these facilities. This report is limited to the quantity and quality of the onsite blue-collar construction work associated with building renewable infrastructure in California.

With the exception of some commercial PV projects with relatively low megawatt capacity between 0.25 and 1 MW, almost all of the large-scale renewable energy construction work in California during the period 2002 to 2015 was built by union contractors or nonunion contractors paying union rates under project labor agreements. Almost all construction workers on these renewable energy projects have been covered by health insurance and provided pension benefits. In addition, almost all construction workers working on these projects have made contributions into apprenticeship training programs to train the next generation of construction workers.

The Geography of Job Growth under the California RPS

With the exception of biomass, renewable energy generation must take place where the sun shines, the wind blows, the water flows, or the earth rumbles. In addition, utility-scale energy production needs land, and lots of it. As a result, this activity typically is found outside of urban areas. Exhibit 3 provides a map of the county distribution of construction jobs (blue- and white-collar combined) on renewable energy projects (see list in Appendix A). As this map shows, larger counties with mountain passes and desert lands have received the greatest share of these jobs.

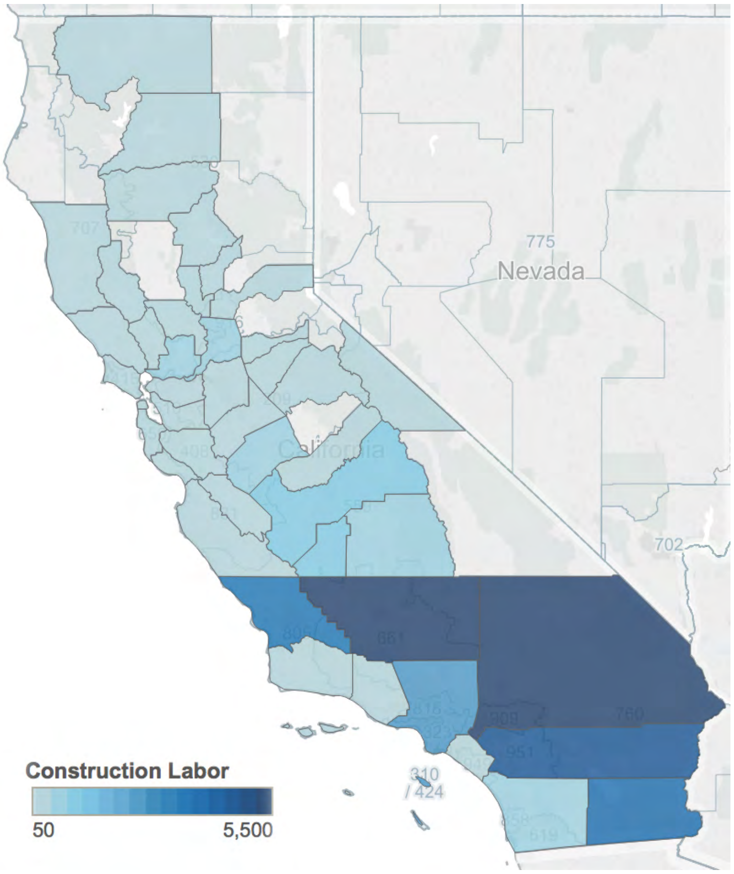
Given that the projects we examined in this study were often situated in isolated areas, construction workers frequently had to travel some distance for this work with some workers even coming from outside the county. However, because the majority of the work was union—and even nonunion contractors on these projects were restricted by hiring hall rules—in most cases, local workers had preferential access to the jobs.

The major beneficiaries of the growth in renewable energy generation were workers in and around Kern, San Bernardino, Riverside, Imperial, San Luis Obispo, and Los Angeles Counties. With the exception of San Luis Obispo and Los Angeles Counties, all of the counties seeing the greatest job gains from renewable energy construction have unemployment rates above the state average of 5.2%. Imperial and Kern Counties have particularly high unemployment (20.1 and 10.6 percent, respectively).[11] The median income in these counties is also below the state average.[12] The coincidence of renewable energy construction in areas with high concentrated poverty further amplifies the benefits of the high quality of the associated jobs described in this report.

The Inland Empire (San Bernardino, Riverside, and Imperial Counties) accounted for 43% of all jobs, followed by parts of the San Joaquin Valley (Kern, Tulare, and Kings Counties) with 22%, and the Central Coast (San Luis Obispo County) with 10%. These regional differences are the result of the total capacity of renewable energy generation facilities constructed and the mix of renewable technologies installed in these counties. Some

Exhibit 3

County distribution of all renewable energy construction jobs, California, 2002–2015



technologies, such as PV solar, require more onsite construction workers than others, such as wind, for the same amount of megawatt capacity installed.

A greater level of granularity is possible when breaking down counties into political districts. Exhibit 4 provides the percent distribution of jobs by California Senate and Assembly Districts. While all Senate Districts had at least some renewable energy generating facilities built in their districts from 2002 to 2015 (see list in Appendix B), 8 Senate Districts accounted for almost 90% of all jobs created. Almost all Assembly Districts had renewable energy generating facilities built in their districts (see list in Appendix C) with 9 Assembly Districts accounting for 83% of all jobs created.

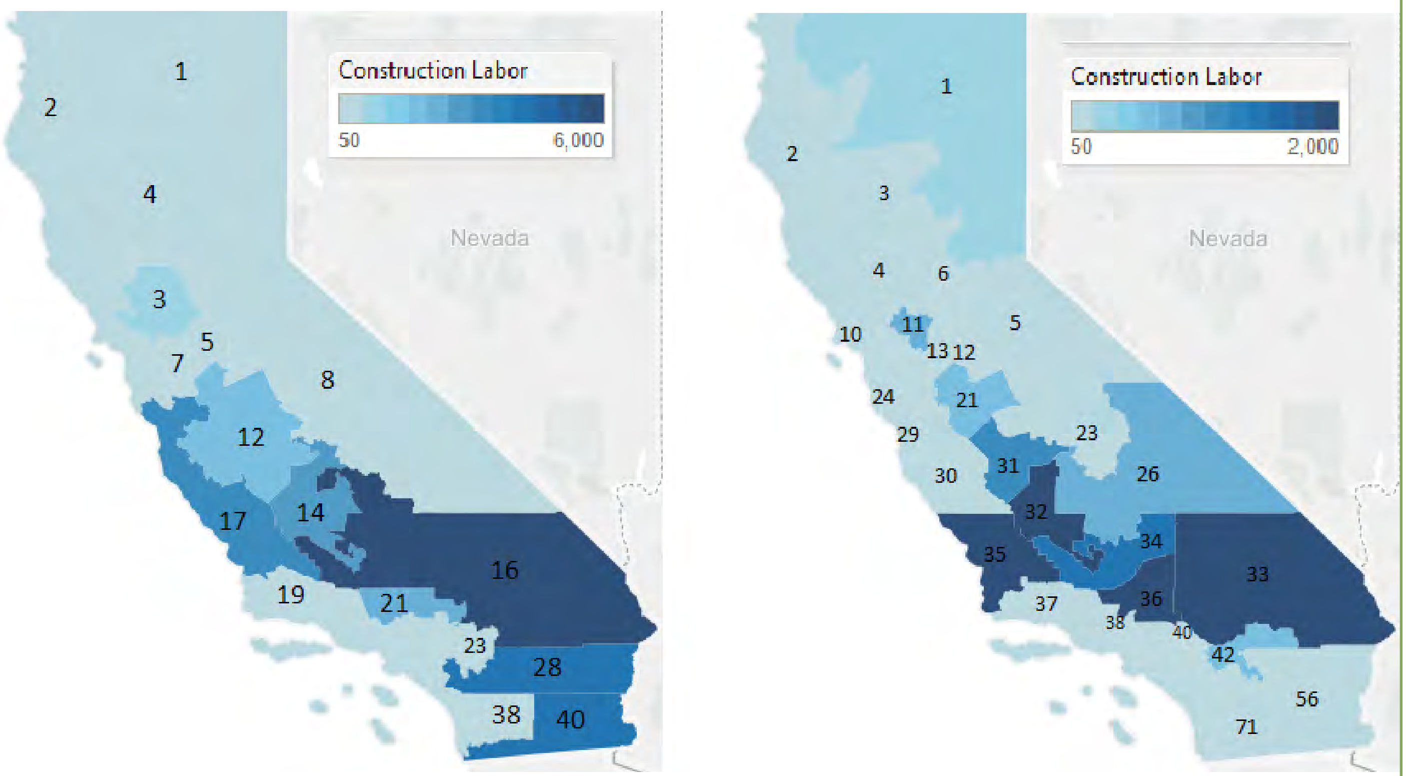
Considering both counties and political jurisdictions, it is clear that some parts of California have received far more benefit in the form of direct construction jobs from building renewable energy facilities than other parts of the state. However, given that the benefiting counties and political jurisdictions typically have significant rural areas, the supply chain jobs feeding these construction sites often spill over into adjoining and even more distant areas as construction materials are delivered to the construction site. The broader induced effects of consumer spending stemming from this work will typically also extend beyond these rural areas. These indirect and induced effects are beyond the scope of this study, but they are nonetheless real additional job impacts of renewable energy construction that have been captured throughout the State of California.

Exhibit 4

Distribution of renewable energy construction jobs created by Senate and Assembly Districts, California, 2002–2015

Panel 1:
Renewable Energy Construction Jobs by Senate District

Panel 2:
Renewable Energy Construction Jobs by Assembly District



The Quality of Blue-Collar Construction Jobs Created by the Construction of Renewable Energy Generation Facilities

Exhibit 5 shows hourly wages and benefits by craft for renewable energy projects in California. Averages at the bottom of the table are weighted by each technology's mix of crafts and each technology's importance in overall renewable construction from 2002 to 2015. Based on this weighted average, an amount equal to 3% of the hourly wage is contributed to apprenticeship training, 23% to pensions, and 23% to health insurance, for each hour worked. Therefore, in total, benefits are equal in value to 49% of the take-home wage: for every dollar of take-home wages, an additional 49 cents are spent on benefits. This remuneration emphasizing benefits has the effect of both training new construction workers and also retaining skilled construction workers already in the field.

Exhibit 5

Average benefits as a percent of the average wage weighted by relative craft employment for construction workers on renewable energy projects, California, 2002–2015[13]

Craft	Training	Pension	Health	Total Benefits	Wage
Boilermaker	$0.75	$16.20	$8.57	$25.52	$41.66
Bricklayer	$0.82	$7.37	$7.90	$16.09	$40.56
Carpenter	$0.57	$4.41	$6.60	$11.58	$40.40
Cement Mason	$0.60	$8.09	$7.52	$16.21	$32.30
Electrical Utility Lineman	$0.26	$8.18	$5.50	$13.94	$52.85
Electrician-Wireman	$0.93	$8.52	$8.97	$18.42	$38.20
Insulators	$0.64	$11.51	$8.14	$20.29	$37.99
Ironworker	$0.72	$12.97	$9.42	$23.11	$33.50
Laborers	$0.64	$6.50	$6.86	$14.00	$31.39
Millwright	$0.57	$4.41	$6.60	$11.58	$40.90
Operating Engineer	$0.80	$9.65	$11.20	$21.65	$31.39
Painter, Industrial	$0.79	$3.04	$8.05	$11.88	$30.72
Pipefitter	$2.55	$11.05	$7.11	$20.71	$42.93
Roofer	$0.30	$1.62	$6.00	$7.92	$28.73
Sheet Metal	$0.73	$14.54	$7.92	$23.19	$35.55
Teamster	$1.52	$5.00	$16.02	$22.54	$28.24
Average weighted by share of work	**$0.91**	**$8.59**	**$8.63**	**$18.13**	**$36.84**
Benefits as a percent of average wage	**3%**	**23%**	**23%**	**49%**	

Using the weighted average contributions from the five counties with the most renewable energy construction activity—Kern, San Bernardino, Riverside, Imperial, and San Luis Obispo Counties—Exhibit 6 shows the estimated apprenticeship contributions from renewable energy construction activity between 2002 and 2015 (in 2015 dollars).

In total, over these 14 years, $46.6 million was invested in skilled construction trades training in state-certified apprenticeship programs from the building of solar, wind, and other renewable energy generation facilities in California. This excludes the training contributions to registered apprenticeship programs from substation and electrical line construction or large commercial solar construction. In addition, the hours of work for apprentices constitute further on-the-job investment in supervised learning and experience. Below, we will discuss the impact of these investments on the improved future lifetime earnings of construction workers associated with this training investment.

Using the weighted average pension contribution multiplied by the past hours of work (about 53 million hours), Exhibit 7 shows the total pension contributions by renewable technology. Almost $340 million was contributed to pension funds between 2002 and 2015 (in 2015 dollars). This amounts to about $14,000 per job-year or a $10,500 pension contribution per worker assuming that the typical construction worker works 80% of the year.

Notably, these pension contributions occurred through the Great Recession which, in the overall California construction economy, reduced construction employment by 40% from June 2006 to September 2010. In January 2016, California construction employment was still 20% below what it had been in June 2006.[14]

Exhibit 6

Employer apprenticeship contributions for construction workers on renewable energy projects, by technology, California, 2002–2015

Renewable Energy	Apprenticeship Contributions (2015 dollars)
Photovoltaic (PV)	$31,081,000
Large Commercial (0.25–1 MW)*	$0
Community (1–5 MW)	$3,441,000
Utility (>5 MW)	$27,514,000
Concentrated Solar Power	$8,604,000
Land Based Wind Power	$3,940,000
Geothermal	$654,000
Small Hydro	$486,000
Biomass (+Biogas)	$1,926,000
Total Renewable	**$46,566,000**

* Due to the lack of reliable data on how many large commercial projects were built union, we have made the conservative assumption that no benefits were paid on these projects. However, based on plant names, about 25% of the large-commercial and community solar projects were built in the Municipal, University, School, and Hospital (MUSH) sector. Such projects tend to use state or federal funds, which triggers the prevailing wage and benefits contributions described. Therefore, this figure is likely an underestimate.

Exhibit 7

Employer pension contributions for construction workers on renewable energy projects, by technology, California, 2002–2015

Renewable Energy	Pension Contributions (2015 dollars)
Photovoltaic (PV)	$226,178,000
Large Commercial (0.25–1 MW)	$0
Community (1–5 MW)	$25,040,000
Utility (>5 MW)	$200,223,000
Concentrated Solar Power	$62,614,000
Land Based Wind Power	$28,673,000
Geothermal	$4,758,000
Small Hydro	$3,540,000
Biomass (+Biogas)	$14,014,000
Total Renewable*	**$338,861,000**

*May not sum due to rounding

Exhibit 8

Employer health insurance contributions for construction workers on renewable energy projects, by technology, California, 2002–2015

Renewable Energy	Health Insurance Contributions (2015 dollars)
Photovoltaic (PV)	$266,238,000
Large Commercial (0.25–1 MW)	$0
Community (1–5 MW)	$29,474,000
Utility (>5 MW)	$235,685,000
Concentrated Solar Power	$73,705,000
Land Based Wind Power	$33,752,000
Geothermal	$5,601,000
Small Hydro	$4,167,000
Biomass (+Biogas)	$16,496,000
Total Renewable*	**$398,880,000**

*May not sum due to rounding

Renewable energy construction has played an important role in maintaining the retirement security of current California construction workers in a time when saving for retirement has become increasingly challenging. The National Institute on Retirement Security (NIRS) estimates that:

> Two-thirds of working households age 55-64 with at least one earner have retirement savings less than one times their annual income, which is far below what they will need to maintain their standard of living in retirement.

NIRS notes that those on defined benefit pension plans, such as the ones in construction noted here, are in a position to make up for personal savings shortfalls with the savings their contractors have contributed on their behalf.[15]

Using the weighted average health contribution multiplied by the past hours of work (about 53 million hours), Exhibit 8 shows the employer health insurance contributions by renewable energy development that occurred between 2002 and 2015 (in 2015 dollars). The almost $400 million in health coverage amounts to about $15,700 per job-year or approximately $12,500 per worker—again assuming the typical construction worker is working 80% of the year.

As stated earlier, because renewable energy construction projects in California have primarily been union projects, contractors on these projects systematically contributed funds to health insurance programs and defined benefit pension programs. These benefit packages are portable, meaning that union members retain the same healthcare coverage and pension plan even as they switch between employers on different construction projects.

As we will see below, pension and healthcare benefits accrue to both the worker and the industry. These benefits not only offer long-term security to workers, but also encourage the retention and the accumulation of experience in construction as union members have a vested interest in maintaining their non-wage benefits. When contractors believe they have a good chance of keeping a worker within construction, they are more willing to invest in that worker. Thus, the payment of benefits encourages the development and retention of accumulated skills and experience that would otherwise be lost during steep downturns such as the Great Recession. By investing in renewables under union conditions, the state is also investing in its construction workforce that pays dividends elsewhere.

Apprenticeship Training and Earnings

Many industries in the US have apprenticeship training systems, but construction is by far the largest.[16] Here we estimate the number of apprentices whose training was financed by the construction of renewable energy electrical generation facilities during the years 2002 to 2015. California's renewable energy construction projects vary in the employment of apprentices based on the technology and craft. On utility-scale photovoltaic construction projects, as many as one-third of the workers are apprentices. On other projects that demand a higher ratio of journeyworkers to apprentices, the ratio tends to be around one apprentice for every four journeyworkers.

Exhibit 9 calculates, for renewable energy construction projects in California between 2002 and 2015, the number of job-years that went to apprentices and the number of apprentices in training, plus the number who graduated. For these calculations we use the blue-collar employment by technology data from Exhibit 2 and make the following assumptions:

a) On utility-scale PV projects, the apprentice-to-journeyworker ratio is 1 to 2;

b) On large commercial PV installations, there are no apprentices;

c) On other renewable energy projects, the apprentice-to-journeyworker ratio is 1 to 4;

d) The overall graduation rate is 70%.

For renewable projects other than solar PV, there were almost 1,700 apprentice job-years and for PV projects there were about 5,570 apprentice job-years. Based on apprentice-to-journeyworker ratios, and years of apprenticeship training, we estimate that 486 apprentices were trained on non-PV projects and 1,238 on PV projects, for a total of 1,724 apprentices trained on-the-job as a result of the RPS. Based on an assumed 70% graduation rate, 1,207 eventually graduated to journeyworker status.[17] Due to the prevalence of utility-scale PV projects among all of the renewable projects built in the 2002–2015 period, approximately 75% of the graduating apprentices were electricians (around 800 out of 1,200).

This data, matched with data on the number of graduates of electrical apprenticeship programs, also allows us to estimate the relative importance of renewable projects in the context of overall apprenticeship training. From 2010 to 2014, 83% of all the PV work completed between 2002 and 2015 was put-in-place. During this time period, 4,821 electricians graduated from registered union and nonunion apprenticeship programs in California. Therefore, in general terms, the training of more than 16% (800 of the 4,800) of the graduating electrical apprentices in California over the period from 2010 to 2014 was financed by PV projects driven by the state's RPS.

Exhibit 9

Estimated graduated apprentices from renewable energy construction projects in California, 2002–2015

Projects	Job-Years	Percent Apprentices	Apprentice Job-Years	Years to Complete Apprenticeship	Number of Apprentices in Training	Number Who Graduate (70%)
Solar PV- Community and Utility	16,876	33%	5,570	4.5	1,240	866
Solar PV -Commercial	69	0%	0	0	0	
All Other Renewable Energy	8,510	20%	1,700	3.5	486	340
Total	**25,455**				**1,724**	**1,207**

Just as 800 of all newly trained electricians had their on-the-job apprenticeship training financed by renewable energy construction, renewable energy projects financed the training of another 400 graduating apprentices from other trades. These trades included mainly laborers, operating engineers, carpenters, ironworkers, pipefitters, and boilermakers.

We estimate that $46.6 million from building renewable energy electrical generation facilities in California went into apprenticeship classroom training during the years 2002 to 2015 through contributions to the training trust fund. This covered the training of about 1,700 apprentices, of whom about 1,200 graduated to journeyworker status. If one assumes that all the 500 apprentices who did not graduate dropped out after the first year (most dropouts come early), then these individuals account for about $3.5 million of the $46.6 million spent on apprenticeship training (about $7,000 per apprentice per year). The majority of this funding went to apprentices who graduated from the multi-year training. Through the renewable energy construction work between 2002 and 2015 (90% of which took place since 2011), employers invested more than $35,000 on the apprenticeship classroom training for each of about 1,200 individuals who then graduated to journeyworker status ($43 million divided by 1,200 graduating apprentices).

This investment does not include wages and benefits paid to the apprentices for their on-the-job construction work. Nor does it include the on-the-job instruction that apprentices receive from experienced journeyworkers as part of the requirements of apprenticeship. Taking both classroom and on-the-job training together, apprentices who stay until graduation benefit the most from apprenticeship training. Nonetheless, because apprentices learn from the moment they begin their apprenticeship program, even those who fail to graduate may benefit from the training they received before dropping out. Still, there is a significant payoff to graduating compared to dropping out of an apprenticeship program or receiving no training at all.

In a 2012 report, Mathematica described how both graduates and apprentices who do not complete their programs gain in lifetime earnings from their participation in registered apprenticeships:

> Registered Apprenticeship (RA) is designed to improve the productivity of apprentices through on-the-job training and related technical instruction. We assessed RA effectiveness by comparing the earnings of RA participants to those of nonparticipants, adjusting for differences in pre-enrollment earnings and demographic characteristics. We found that RA participation was associated with substantially higher annual earnings in every state studied....

Over a career, the estimated earnings of RA participants are an average of $98,718 more than similar nonparticipants. For RA participants who completed their program, the estimated career earnings are an average of $240,037 more than similar nonparticipants.... Including benefits, RA completers would receive an average of $301,533 more in compensation than nonparticipants over their careers.[18]

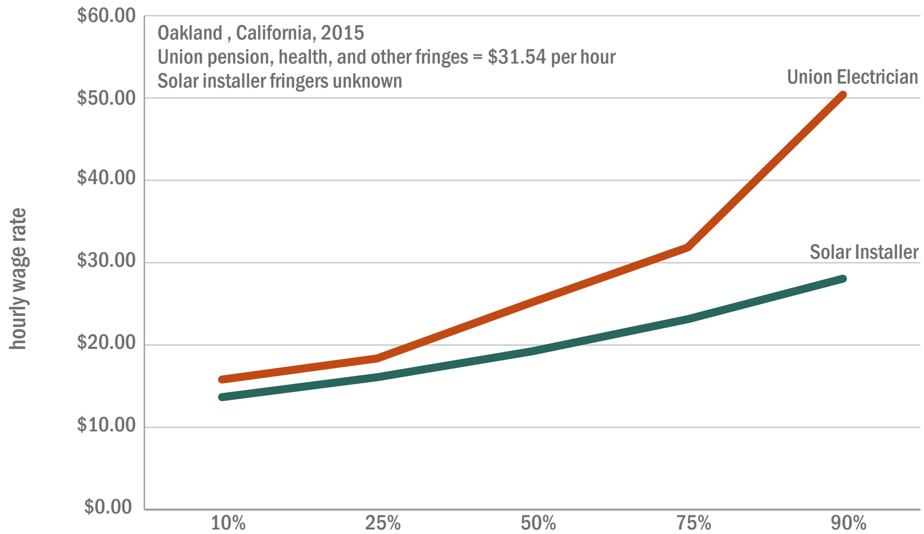
In rough terms, investing $35,000 up front, plus on-the-job instruction, yields about $300,000 in the present value of increased earnings over the lifetime career of the apprentice who graduates. That is roughly a ten-fold return on investment and primarily reflects the productivity advantages graduating apprentices gain both from their apprenticeship training and also from the career path—the enhanced post-apprenticeship job opportunities—to which their apprenticeship gives them access.

An example of the effects of registered apprenticeship training on earnings can be seen in comparing the earnings profiles of solar installers to electricians. Solar installers currently dominate rooftop PV construction. Exhibit 10 shows the earnings career paths of solar installers in California's Bay Area compared to electrician pre-apprentices moving into apprentice status and then graduating to becoming journeyworker electricians.

In the case of solar installers, there is not a regulated career path. Informally, the earnings of solar installers increase with experience: either they can receive raises from their employers or they move to higher paying employers. The career paths of solar installers and pre-apprentice electricians begin close to each other in terms

Exhibit 10

Comparison of wages and wage trajectories for rooftop solar installers and union electricians in California



	10%	25%	50%	75%	90%
Union Electrician	$15.80	$18.36	$25.20	$31.84	$50.40
Solar Installer	$13.66	$16.08	$19.24	$23.12	$28.05

wage rate as a percentile of top wage

Source: US Bureau of Labor Statistics and Construction Electrician/Construction Wireman Wage and Fringe Benefits, California Bay Area Region[19]

of entry level wages. As pre-apprentices gain experience, their wages rise, but only slightly faster than those of solar installers. Once pre-apprentices enter apprenticeship programs and gain skills, however, their earnings grow much more quickly and significantly compared to the earnings of solar installers. This difference widens substantially once the apprentices graduate to journeyworker status.[20]

The higher earnings of the electrician career path compared to the solar installer path is due to the fact that apprenticeship training for electricians does not focus exclusively on the skills needed for photovoltaic construction jobs. The pre-apprentice/apprentice path steadily broadens the apprentice's training to encompass the entire electrician craft. This is why this "craft training" is more remunerative. A young worker will eventually gain knowledge of a wide range of skills, qualifying him or her for a range of projects. This broad occupational skill set is essential not only for higher hourly wage rates, but also for staying employed in a turbulent construction market. The solar installer learns only the specific tasks associated with solar installation jobs, which limits the workers' job opportunities and potential earnings as well as their ability to remain in construction during a downturn.

When benefits are also considered, the difference in the electrician and solar installer occupations are even more dramatic. Exhibit 10 does not show the differences in benefits between the electrician path and the solar installer path because government data on solar installation earnings do not include benefits. Nonetheless, in general, one would expect that adding the benefit advantages of apprenticeship training would further widen the gap in total compensation between these two types of workers.

Why Good Jobs Are Important to the Clean Energy Construction Industry

Construction demand varies dramatically over the season, across regions, across construction sectors, between contractors, and throughout the business cycle. Left unchecked, volatile construction demand can detach workers from their contractor, employer, or the construction industry itself. These separations occur in a regular yet often unpredictable pattern. Exhibit 11 uses "box-and-whiskers" graphs to compare the distribution of monthly employment separation rates in construction to those in the total US nonfarm labor market from 2002 to 2015. This figure shows that separations between employers and workers happen much more often in construction compared to the overall economy.

The box in the box-and-whiskers graph contains the middle 50% of the distribution of all separations. The horizontal line inside the box is the median or half-way point between the highest and lowest separation rates. The whiskers above and below the box contain most of the remaining half of the distribution. Roughly 25% of the highest separation rates are bracketed between the box and the upper whisker while roughly 25% of the lowest separation rates are bracketed between the box and the lower whisker. Sometimes there are some extreme outliers beyond the whiskers, which are shown as dots. In Exhibit 11, the box-and-whiskers graph displays the distribution of separation rates with half within the box and half outside—25% below the box and 25% above. Almost all of construction's separation rates shown in Exhibit 11 are above the vast majority of the separation rates typical of the overall nonfarm labor market.

Given this turbulence in the construction industry, it is not surprising that the distribution of monthly unemployment rates for construction workers shown in Exhibit 11 also lie above and are more widely spread out

Exhibit 11

Comparison of labor market turbulence in and out of the construction industry[21]

compared to the total nonfarm labor market. This turbulence discourages both training of workers who are soon to be unneeded and the accumulation of construction work-experience as workers find themselves unemployed. Maintaining and increasing the pace of renewable energy development is dependent on the availability of a skilled workforce, but due to high volatility inherent in the construction industry maintaining a skilled workforce requires practices and institutions for recruiting, training, managing, and retaining construction workers that are different than more stable industries. Unions offer a proven pathway to stabilize construction careers in the face of extraordinarily variable demand for construction services.

Good jobs are the by-product of efforts by union contractors, some nonunion contractors, and the Building Trades unions to develop and preserve human capital in the construction industry through contracts, institutions, and regulations, despite unchecked and volatile construction demand. A key pillar to creating good jobs in construction is collective bargaining.

Collectively bargained contracts require signatory contractors to contribute a fixed amount to apprenticeship training for every hour of work in the public or private sector. Prevailing wage laws can assist in creating skills in construction, by either requiring or incentivizing nonunion contractors to contribute training funds for every hour of work their workers perform on public projects.

Legally required unemployment insurance and worker compensation premiums help both union and nonunion contractors preserve experience in construction by providing funds that help workers bridge spells of unemployment or injury.

Voluntary health and pension benefits that are typically required by collectively bargained contracts and sometimes provided by nonunion contractors further create a baseline security for construction workers and allow them to continue working within the construction sector despite regular bouts of unemployment. For example, relative to a nonunion construction worker with no health insurance, the same worker with health insurance is about 30% more likely to remain in the industry through the business cycle. Relative to a nonunion construction worker with no health insurance, the same worker with portable health insurance is 50% more likely to remain through the business cycle.[22] Good jobs are the result of policy, regulation, and contractor efforts to compete based on skill while compensating workers adequately for those skills.

At the other end of the spectrum are workers with limited skills and interrupted or minimal work experience in construction who receive low wages. These "low-road" construction jobs do not just happen, but are by-products of a very different contractor strategy for survival in the turbulent construction industry than the unionized sector. This low-road strategy is quite common both in construction generally and in the renewable energy segment of the construction industry. Bad jobs inevitably result when contractors capitulate to the pressures of turbulence. These contractors can see basic and legally-required practices such as paying payroll taxes as a hindrance to short-term cost minimization strategies. Fraudulent schemes like under-the-table cash payments and misclassifying workers as independent contractors feeds into an overall strategy of treating workers as disposable assets.

A recent study of the Texas construction industry estimated that 41% of all construction workers in the state were subject to one or more of the following illegal employer tactics:

a) They were misclassified as independent contractors rather than appropriately classified as employees eligible for Social Security, workers' compensation, and unemployment;
b) They were victims of payroll fraud;
c) They were paid cash under-the-table.

The study estimated that $7 billion in unreported wages occurred annually in Texas, and that the average under-the-table hourly wage was $11.19.[23]

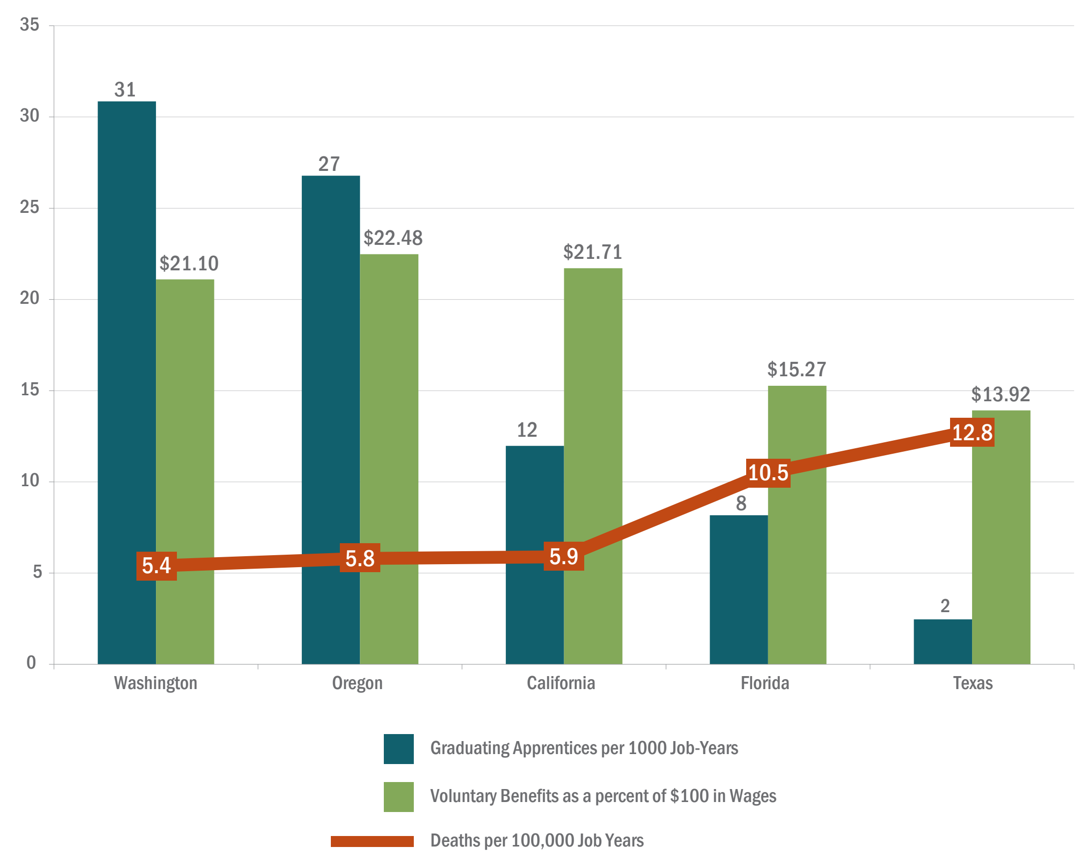
In addition, 22% of the Texas construction workers interviewed for the study reported being denied payment on occasion for their construction work, while 50% reported not being paid overtime wage rates for overtime work. Texas construction workers likewise receive relatively few non-wage benefits with only 40% reporting workers' compensation coverage and even lower numbers for other benefits: medical insurance (22%), vacation (15%), sick leave (12%), and retirement or pension benefits (9%). Over 70% reported receiving no pension, health, or other benefits.[24]

In 2012, Texas construction contractors in unilateral and joint apprenticeship programs had a total of $54 million in training facilities, whereas California had $300 million in training facilities. From 1995 to 2003, Texas had 33,184 registered apprentices in construction (5.4% of construction workforce) while California had 121,558 (19.2% of construction workforce) over the same period.[25] The absence of training puts Texas construction workers at a higher risk of injury and death on the job. For instance, for the years 2012 through 2014, California and Texas construction employed about the same number of workers, on average 634,000 in California and 616,000 in Texas. Yet almost twice as many construction workers in Texas as in California died on the job over these three years: 326 in Texas and 166 in California.[26]

Exhibit 12 illustrates the relationship between provision of voluntary benefits (health insurance, pensions), apprenticeship training, and construction safety in five states with significant development of renewable energy. In

Exhibit 12

Voluntary benefits, apprenticeship training, and construction industry fatality rates, 2012



Source: US Bureau of Labor Statistics, Injuries, Illnesses and Fatalities, State Occupational Injuries, Illnesses and Fatalities, Census of Fatal Occupational Injuries, California, Florida, Oregon, Texas and Washington, 2012[27]

Washington State, Oregon, and California, contractors pay on average $21 in voluntary benefits for every $100 in wages. In Texas and Florida, contractors pay on average $15 in voluntary benefits for every $100 of wages. In Washington, 31 construction apprentices graduate for every 1,000 job-years worked in construction, compared to 27 in Oregon, 12 in California, 8 in Florida, and 2 apprentices in Texas. Similarly, Exhibit 12 shows that in contrast to Washington, where voluntary benefits comprise more than 21% of take-home wages, voluntary benefits fall to less than 14% of take-home wages in Texas. The diagram also shows that as training falls, job fatalities rise. High-road construction jobs are safer construction jobs because they provide training and encourage retention of skilled workers within construction. Contractor strategies that emphasize benefits and training contributions lead to better training, more experience, and safer work lives.

Overall, we find that a high-road workforce strategy means that the long-term costs of training the next generation of skilled construction workers, the cost of providing the family-friendly health insurance benefits needed to retain the current generation of skilled construction workers, and the cost of financing the retirement of the last generation of construction workers are all internalized to the renewable projects themselves. In other segments of construction and other industries, free-rider strategies are endemic, and the long-term costs of construction are excluded from the bid price. But these real costs do not go away. They simply shift into taxpayer-funded vocational schools, uncompensated medical care, Medicaid costs, on-the-job injuries, indigent senior support, and other taxpayer burdens. The model California has pioneered in terms of engaging labor unions in the construction of its renewable energy infrastructure avoids unintentional cost shifting to the state or federal government. Construction compensation that structures in benefits places these costs where they belong, on the construction projects themselves.

Conclusions

In his remarks prepared for the signing on SB 350, Senate President pro Tempore Kevin de León said, "The new standards established in SB 350 aren't just numbers on a timeline—they are real jobs for real people." In this report, we have documented the high quality of these jobs for California construction workers. Moreover, renewable energy has generated middle-class jobs in regions with chronic unemployment and high poverty, with the biggest concentrations in the San Joaquin and Imperial Valleys.

These good construction jobs were secured through collectively bargained project labor agreements on most of the utility-scale renewable energy construction projects in the state. The building of renewable energy electrical generation facilities under union wage, benefit, and training standards contributed about $46.6 million to the training of a skilled construction labor force in California while improving the economic security of construction workers equal to an additional $300,000 in lifetime income and benefits. Renewable energy development put $340 million into worker pension savings and $400 million into health coverage for construction workers. This amounted to more than $10,000 in annual retirement savings per worker and $12,000 in annual health coverage per worker. These defined benefit plans provide economic security for construction workers—a floor that has disappeared for many other workers.[28]

Good wages and benefits are not only good for workers, they are also good for construction productivity because they help retain trained and experienced workers in a turbulent industry. California's RPS not only helps forestall climate change but it also contributes to a more productive and safer California construction labor force and an investment in high-road job creation. California's climate policies are neither job policies nor labor market regulations, and yet they have induced new construction jobs in California and will continue to shape the quality of jobs that are created. Because these jobs are based in California, pay benefits, and invest in apprenticeship training, California's climate policy will help steer California's construction economy away from underground economy practices and free-riding competitive strategies, and towards an industry that promotes the long-run availability of a qualified labor force, all the while fostering a sustainable future where a productive and innovative construction industry will be needed.

Appendices

Appendix A

County location of renewable energy construction jobs in California, 2002–2015

County	All Construction Job-Years	White Collar Job-Years	Blue-Collar Job-Years	% Total CA Job-Years
Alameda	140	31	109	<0.5
Amador	75	17	59	<0.5
Butte	41	9	32	<0.5
Calaveras	7	2	5	<0.5
Contra Costa	185	41	144	0.6
Fresno	1,115	245	869	3.4
Imperial	3,929	864	3,065	12.0
Kern	5,538	1,218	4,320	17.0
Kings	963	212	751	3.0
Lake	20	4	16	<0.5
Los Angeles	2,462	542	1,920	7.5
Madera	143	31	112	<0.5
Marin	6	1	5	<0.5
Mendocino	4	1	3	<0.5
Merced	586	129	457	1.8
Mono	6	1	5	<0.5
Monterey	65	14	51	<0.5
Napa	8	2	6	<0.5
Orange	158	35	123	0.5
Placer	21	5	17	<0.5
Riverside	4,516	993	3,522	13.8
Sacramento	508	112	396	1.6
San Benito	12	3	9	<0.5
San Bernardino	5,506	1,211	4,295	16.9
San Diego	706	155	551	2.2
San Francisco	69	15	54	<0.5
San Joaquin	225	50	176	0.7
San Luis Obispo	3,415	751	2,664	10.5
San Mateo	43	9	34	<0.5
Santa Barbara	16	3	12	<0.5
Santa Clara	158	35	123	0.5
Santa Cruz	34	7	26	<0.5
Shasta	165	36	129	0.5
Siskiyou	48	11	38	<0.5
Solano	727	160	567	2.2
Sonoma	58	13	45	<0.5
Stanislaus	109	24	85	<0.5
Sutter	13	3	10	<0.5
Tehama	41	9	32	<0.5
Tulare	681	150	532	2.1
Tuolumne	6	1	5	<0.5
Ventura	44	10	34	<0.5
Yolo	37	8	29	<0.5
Yuba	28	6	22	<0.5
Total	**32,636**	**7,180**	**25,456**	

*May not sum due to rounding

Appendix B

MW and Jobs by California Senate District, 2002–2015

Senate District	MW Installed	Total Job-Years	White-Collar Job-Years	Blue-Collar Job-Years
1	163	265	58	207
2	18	75	17	59
3	1,042	1,027	226	801
4	27	123	27	96
5	101	336	74	262
6	9	37	8	29
7	159	246	54	192
8	90	335	74	261
9	12	55	12	43
10	15	58	13	46
11	17	69	15	54
12	470	1,833	403	1,430
13	28	106	23	83
14	722	2,834	623	2,210
15	5	52	11	41
16	4,010	9,138	2,010	7,127
17	887	3,474	764	2,709
18	8	34	7	26
19	9	44	10	34
20	46	186	41	145
21	620	2,421	533	1,889
22	9	38	8	29
23	83	338	74	263
24	6	22	5	17
25	1	7	1	5
26	12	94	21	73
27	32	109	24	85
28	1,117	4,339	954	3,384
29	35	100	22	78
31	17	69	15	53
32	9	36	8	28
35	8	35	8	27
36	11	45	10	35
37	20	64	14	50
38	59	237	52	185
39	62	325	71	253
40	1,294	4,033	887	3,146
Total	**11,234**	**32,636**	**7,180**	**25,456**

Appendix C

MW and Jobs by California Assembly District, 2002–2015

Assembly District	MW Installed	Total Job-Years	White-Collar Job-Years	Blue-Collar Job-Years	Assembly District	MW Installed	Total Job-Years	White-Collar Job-Years	Blue-Collar Job-Years
1	150	213	47	166	38	32	14	3	11
2	8	29	6	22	40	51	23	5	18
3	27	704	155	549	41	0	34	7	26
4	26	159	35	124	42	351	64	14	50
5	66	176	39	138	43	1	4	1	3
6	8	143	31	111	44	4	237	52	185
7	8	21	5	16	45	6	7	2	6
8	22	102	22	80	46	8	18	4	14
9	100	39	9	31	47	15	123	27	96
10	6	34	8	27	49	1	4	1	3
11	958	30	7	23	50	2	35	8	27
12	40	31	7	24	51	5	100	22	78
13	61	14	3	11	52	31	7,883	1,734	6,149
14	124	586	129	457	53	1	65	14	51
15	4	39	9	31	54	9	5	1	4
16	34	106	23	83	55	35	29	6	23
17	9	49	11	38	56	2,073	25	6	20
18	8	798	176	623	57	16	43	10	34
19	8	9	2	7	58	1	8	2	6
20	4	38	8	30	60	6	5	1	4
21	151	45	10	35	61	11	49	11	39
23	10	123	27	96	62	1	21	5	16
24	28	69	15	54	64	1	64	14	50
25	13	1,075	237	839	66	1	33	7	26
26	221	2,142	471	1,670	67	4	24	5	19
27	2	4,895	1,077	3,818	68	20	232	51	181
28	1	1,356	298	1,058	70	6	4	1	3
29	9	3,431	755	2,676	71	96	63	14	49
30	15	4,952	1,089	3,863	73	1	41	9	32
31	277	29	6	23	75	14	286	63	223
32	544	107	24	84	76	10	43	9	33
33	786	95	21	74	77	54	34	8	27
34	1,805	202	44	158	78	10	86	19	67
35	877	1	0	1	79	8	12	3	10
36	1,933	681	150	531	80	3	388	85	303
37	5	5	1	4	**Total**	**11,234**	**32,636**	**7,180**	**25,456**

Endnotes

[1] Chris Megerian and Javier Panzar, "Gov. Brown signs climate change bill to spur renewable energy, efficiency standards," October 7, 2015, http://www.latimes.com/politics/la-pol-sac-jerry-brown-climate-change-renewable-energy-20151007-story.html (accessed April 10 2016).

[2] State Building and Construction Trades Council of California, "Passage of SB 350 to Bring Massive New Construction Job Creation for Renewable Energy," September 16, 2015, http://www.sbctc.org/doc.asp?id=4606 (accessed April 10, 2016).

[3] This figure is higher than our previously published figure of 7077 MW between 2002 and 2014 due to the inclusion of the year 2015 and utilization of a more comprehensive data set that included solar projects sized 250 kW to 5 MW rather than only projects over 5MW. Our source for MW of energy capacity put-in-place is the California Energy Commission (CEC), http://www.energy.ca.gov/almanac/power_plant_data/Power_Plants.xlsx (accessed April 15, 2016). We cross-checked this with the US Energy Information Administration (EIA), http://www.eia.gov/electricity/data/eia860/ (accessed April 21, 2016) (see Endnote 6 for more detail).

[4] This does not include installed small commercial or residential solar of approximately 3497 MW over the same time frame. (California Solar Statistics, Currently Interconnected Data Set, as of March 31, 2016), https://www.californiasolarstatistics.ca.gov/media/public_files/nem_sets/NEM_CurrentlyInterconnectedDataset_2016-03-31.zip.

[5] Peter Philips, Environmental and Economic Benefits of Building Solar in California: Quality Careers — Cleaner Lives, Donald Vial Center on Employment in the Green Economy, Institute for Research on Labor and Employment, November 2014, p.10, http://laborcenter.berkeley.edu/pdf/2014/building-solar-ca14.pdf (accessed June 7, 2016); Betony Jones and Carol Zabin, Are Solar Energy Jobs Good Jobs? Donald Vial Center on Employment in the Green Economy, Institute for Research on Labor and Employment, July 2015, http://laborcenter.berkeley.edu/are-solar-energy-jobs-good-jobs/ (accessed June 7, 2016).

[6] There are additional construction jobs associated with the ongoing operation and maintenance of these facilities. We have excluded these jobs from this analysis.

[7] The JEDI model allows for user alteration of some inputs. We altered the assumed blue-collar hourly wage rate for PV construction from around $19 to $36.55 to better reflect California construction on these sites. This wage rate was calculated using the 2015 prevailing wage rate for the six crafts most commonly found on utility-scale PV work in the five counties where most of this work has previously taken place. The crafts (and their weighting based on their share of utility-scale PV work) are electricians (65%), laborers (15%), carpenters (8%), operating engineers (7%), and teamsters (1%). The five counties are Imperial, Kern, San Luis Obispo, Riverside, and San Bernardino. http://www.nrel.gov/analysis/jedi/ (accessed April 21, 2016), http://www.dir.ca.gov/OPRL/PWD/Index.htm (accessed March 29, 2016).

[8] In the case of some technologies there are construction economies of scale such that the number of jobs required per MW on smaller projects will be higher than on larger projects. The data in "Jobs per MW" in Exhibit 2 is the average of the projects we're studying, which vary in size.

[9] US Census Bureau, Economic Census, Construction, Geographic Area Series, Construction (NAICS Sector 23), EC1223A1, Construction: Geographic Area Series: Detailed Statistics for the State: 2012 (Table 1), http://www.census.gov/econ/census/help/sector/gas.html (accessed March 16, 2016).

[10] Our source for MW of energy capacity put-in-place is the California Energy Commission (CEC) http://www.energyalmanac.ca.gov/powerplants/ (accessed April 15, 2016). We have cross-checked this with the US Energy Information Commission (EIA) http://www.eia.gov/electricity/data/eia860/ (accessed April 21, 2015). Our numbers are slightly lower than the EIA for the following reasons:

1) The EIA has about 150 MW less solar than CEC data. This may be because the CEC is counts everything above 100 kW including onsite generation and the EIA does not count self-generation.

2) In contrast, the EIA has registered about twice as much geothermal as CEC (205.5MW in EIA, 105MW in CEC), all in Imperial County.

3) The EIA has 40 MW more of solar thermal compared to the CEC (32.5MW in San Bernardino and 7.5MW in Los Angeles counties).

4) The EIA has 140 MW more wind than the CEC data.

5) The EIA has 6 MW more of battery storage.

6) The EIA has 140 MW more wind (105 MW more in Kern, 43 MW more in Riverside, and 8 MW fewer in Solano).

[11] State of California Employment Development Department, Maps of Unemployment Rates and Jobs April 2016, http://www.labormarketinfo.edd.ca.gov/file/lfmonth/lf_geomaps.pdf (accessed June 10, 2016).

[12] State of California, Franchise Tax Board, California Median Income by County (2013 data), https://data.ftb.ca.gov/PIT-Charts/California-Median-Income-by-County/6gsn-ex6f, (accessed June 10, 2016).

[13] Wage and benefit data are an average of the collectively bargained rates by craft for Kern, Imperial, Riverside, San Bernardino, and San Luis Obispo counties where most of the utility-scale renewable energy construction has taken place, http://www.dir.ca.gov/OPRL/PWD/Index.htm, (accessed March 29, 2016).

[14] US Bureau of Labor Statistics, Current Employment Statistics, State and Local Employment, California, Statewide, Construction Employment, Seasonally Adjusted, Series Id: SMS06000002000000001, http://www.bls.gov/sae/ (accessed March 16, 2016).

[15] Nari Rhee, The Retirement Crisis: Is It Worse Than We Think? National Institute for Retirement Security, June 2013, pp. 2-3, http://www.nirsonline.org/storage/nirs/documents/Retirement%20Savings%20Crisis/retirementsavingscrisis_final.pdf, (accessed April 29, 2016).

[16] Among the top 25 occupations with apprenticeships, 95% were in construction apprentices. US Department of Labor, Employment and Training Administration, ApprenticeshipUSA, Data and Statistics, https://www.doleta.gov/oa/data_statistics.cfm, (accessed, May 22, 2016).

[17] The average five-year graduation rate in joint labor-management electrician apprenticeship programs in San Diego/Imperial, San Bernardino, Riverside, and Kern Counties over the period 2009 to 2013 was 62%. Because this is a five-year program, additional apprentices would have eventually graduated a couple of years later, leading to our assumption of a 70% eventual graduation rate. California Department of Industrial Relations, Division of Apprenticeship Standards, "Average completion rates for apprenticeship programs by industry: Completion Rates for Apprenticeship Committees, [2009-13]," July 1, 2015, http://www.dir.ca.gov/das/programsponsor.htm, (accessed April 21, 2015).

[18] Debbie Reed, Albert Yung-Hsu Liu, Rebecca Kleinman, Annalisa Mastri, Davin Reed, Samina Sattar, and Jessica Ziegler, "An Effectiveness Assessment and Cost-Benefit Analysis of Registered Apprenticeship in 10 States," Mathematica Policy Research, July 25, 2012, Mathematica Reference Number: 06689.090 and 40096, pp. xiv and xvi, http://www.mathematica-mpr.com/our-publications-and-findings/publications/an-effectiveness-assessment-and-costbenefit-analysis-of-registered-apprenticeship-in-10-states, (accessed March 29, 2016).

[19] US Bureau of Labor Statistics, Occupational Employment Statistics, Occupational Employment and Wages, May 2014, 47-2231 Solar Photovoltaic Installers, http://www.bls.gov/oes/current/oes472231.htm, (accessed March 17, 2016); Construction Electrician/Construction Wireman Wage and Fringe Benefits, California Bay Area Region For Locals 6, 180, 234, 302, 332, 551, 595W, and 617 Effective January 1, 2015 to May 31, 2015, http://www.ibew234.org/filemanager/UserFiles/File/CECW/CECWforCA-BayAreaJanuary2015.pdf, (accessed March 29, 2016). Note: while the solar installer data are national and the electrician data are for the Bay Area, the solar installer data are 65% from California.

[20] The comparison of these wage profiles is only approximate because in the case of pre-apprentices and apprentices, their wages rise in lockstep with their experience on the job and with their classroom training. In the case of solar installers, the data reflect the distribution of solar-installer wages, but there is no guarantee that any one solar installer will necessarily rise up the career path depicted in Exhibit 10 from bottom to top with increased experience and training. In some companies that will be the case, in others it won't be. Some installers will have to rely upon market mobility and opportunity to harvest a payoff from increased experience and training.

[21] US Bureau of Labor Statistics, Job Openings and Labor Turnover Survey (JOLTS), JOLTS Databases, http://www.bls.gov/jlt/data.htm; Labor Force Statistics from the Current Population Survey, CPS Databases, Labor Force Statistics, http://www.bls.gov/cps/data.htm, (accessed March 3, 2016).

[22] Jaewhan Kim and Peter Philips, "Health Insurance and Worker Retention in the Construction Industry," Journal of Labor Research (2010) 31:20–38.

[23] Workers Defense Project, "Build a Better Texas, Construction Working Conditions in the Lone Star State," January, 2013, p. 57, http://www.workersdefense.org/Build%20a%20Better%20Texas_FINAL.pdf, (accessed October 26, 2015).

[24] Workers Defense Project, "Build a Better Texas, Construction Working Conditions in the Lone Star State," January, 2013, p. 31, http://www.workersdefense.org/Build%20a%20Better%20Texas_FINAL.pdf, (accessed October 26, 2015).

[25] Internal Revenue Service, Forms 990, 990-EZ, and 990-PF, Exempt Organizations Business Master File Extract (EO BMF), https://www.irs.gov/charities-non-profits/exempt-organizations-business-master-file-extract-eo-bmf, (accessed May 30, 2016); Cihan Bilginsoy, "Registered Apprentices and Apprenticeship Programs in the U.S. Construction Industry between 1989 and 2003: An Examination of the AIMS, RAIS, and California Apprenticeship Agency Databases," University of Utah, Department of Economics, Working Paper No: 2005-09, May 2005.

[26] US Bureau of Labor Statistics, Injuries, Illnesses and Fatalities, State Occupational Injuries, Illnesses and Fatalities, Census of Fatal Occupational Injuries, California and Texas, 2012 to 2014, http://www.bls.gov/iif/state_archive.htm#TX, (accessed March 16, 2016).

[27] US Census Bureau, Economic Census, Construction, Geographic Area Series, Construction (NAICS Sector 23), EC1223A1, Construction: Geographic Area Series: Detailed Statistics for the State: 2012 (Table 1), http://www.census.gov/econ/census/help/sector/gas.html, (accessed March 16, 2016); US Bureau of Labor Statistics, Injuries, Illnesses and Fatalities, State Occupational Injuries, Illnesses and Fatalities, Census of Fatal Occupational Injuries, California, Florida, Oregon, Texas and Washington, 2012, http://www.bls.gov/iif/state_archive.htm#TX, (accessed March 16, 2016); US Department of Labor, Employment and Training Administration, ApprenticeshipUSA, Data and Statistics, Registered Apprenticeship National Results, Fiscal Year 2012 State Totals, Updated January 20, 2015, https://www.doleta.gov/OA/data_statistics2012.cfm, (accessed March 16, 2016).

[28] Defined benefit pension programs have two main advantages: 1) they spread the risk of retirement income across all participants within the program reducing the potential costs of either retiring when the stock market is down or living longer than expected, and 2) retirement savings are collectively managed by professionals with consequent economies of scale and expert money management. However, the general shift to defined contribution programs has shifted these risks onto the individual which has eroded the retirement readiness of many Americans. Nari Rhee, "The Retirement Savings Crisis: Is It Worse than We Think?" National Institute on Retirement Security, June 2013, p. 1, http://www.nirsonline.org/index.php?option=com_content&task=view&id=768&Itemid=48, (accessed April 22, 2016).

The Donald Vial Center on Employment in the Green Economy carries out research and public education focused on jobs, workforce, and labor issues related to climate policy and the emerging green economy.

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