An Assessment of the Economic, Revenue, and Societal Impacts of Colorado's Solar Industry

OCTOBER 2013

PREPARED BY

THE SOLAR FOUNDATION
Research and Education to Advance Solar Energy

FOR

COSEIA
Colorado Solar Energy Industries Association

SOLAR FRIENDLY COMMUNITIES

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1. Introduction/Summary

This report, produced by The Solar Foundation (TSF) for the Colorado Solar Energy Industries Association (COSEIA) in their capacity as the lead organization on the Solar Friendly Communities project funded through the U.S. Department of Energy's SunShot Initiative, represents a "deep dive" into the jobs, economic, and environmental impacts of the Colorado solar industry. This effort is unique from other economic impact studies not only by virtue of its narrow focus on the state of Colorado, but also through its use of some of the most comprehensive data sources known to exist for the U.S. solar industry.

Studies such as this both enhance and benefit from TSF's expertise in solar labor market and economic impact research. In 2010, TSF released a seminal, award-winning report entitled *National Solar Jobs Census 2010: A Review of the U.S. Solar Workforce*. The Census established the first credible national solar jobs baseline and provided policymakers with tangible proof that the solar industry is having a positive impact on the U.S. economy. Following the success of the original report, TSF conducted a Census for both 2011 and 2012. Most recently, Census 2012 found that the domestic solar industry employs over 119,000 solar workers.

Through research efforts such as the one documented herein, TSF strives to increase the use of solar energy by demonstrating the economic and other benefits of solar development to policymakers, industry stakeholders, and the general public. From this perspective, it is TSF's view that states from all across the country can benefit from studies similar to *An Assessment of the Economic, Revenue, and Societal Impacts of Colorado's Solar Industry* through the impact such efforts can have on informing decision making.

This report has identified a number of benefits resulting from solar photovoltaic (PV) development in Colorado to date:

- Direct, indirect, and induced employment impacts of approximately **10,790 job-years** (or full-time equivalents), leading to employee **earnings of over $534.1 million**;
- **Total economic output of $1.42 billion**;
- Aggregate state and local government **tax revenues of between $34.1 million and $59.7 million**, including property taxes ($3.1 million - $9.3 million), sales taxes ($18.7 million - $38.1 million), and income tax revenues of $12.3 million;
- Approximately **$24.3 million in environmental benefits** achieved through avoiding emissions of pollutants tied to conventional electricity production, and;
- **Savings of nearly 300 million gallons of water**, which would have otherwise been consumed as part of the electricity generation process.

In addition, this study includes projections of the future magnitude and value of these benefits under a scenario in which Colorado realizes the goal of COSEIA's "Million Solar Roofs" campaign: 3 gigawatts (GW) of total solar capacity by 2030.

2. State Solar Industry Context

The market for solar energy across the United States is growing rapidly, but Colorado has a particularly strong history with solar energy, both in its development and deployment. The U.S. Department of Energy's National Renewable Energy Laboratory, located in Golden, has been a major center for solar energy technology innovation and testing since 1977, operating for the first 14 years as the Solar Energy Research Institute.

Policy has also played a strong role in Colorado's solar history. While Colorado was the 14th state to pass a Renewable Portfolio Standard (RPS), a requirement that electricity suppliers source a certain quantity of their electricity from renewable energy, it was the first state to do so by popular referendum and not via a state legislature or regulatory body. Amendment 37, the measure creating Colorado's RPS, passed in 2004 with an overall renewables requirement of 10 percent by 2015 and included a solar "carve out" or mandate of 0.4 percent.[1] This requirement was doubled in 2007, and was followed by legislation in 2010 which brought the state's RPS to 30 percent by 2020, with a 3 percent distributed generation mandate (a technology-neutral requirement that took the place of the previous solar carve-out). Recent legislation expanded and increased renewable energy requirements for rural electric cooperatives as the original RPS applied to electric utilities serving more than 40,000 customers.

In response to the state RPS, Colorado's two investor-owned utilities began offering a performance-based incentive through which solar energy system owners receive $0.05 to $0.11/kWh for 10 to 20 years in exchange for the renewable energy credits (RECs) they produce.[2, 3] Thanks in part to these utility incentives and supportive state policies such as tax incentives and local rebate programs for solar energy, Colorado is several years ahead of schedule to meeting its RPS compliance targets.[4]

This progress is borne out in solar energy installation numbers for Colorado. In 2008, solar installations in the state jumped from 11.6 MW to 22.3 MW.[5] Just three years later, Coloradoans installed more than four times as much solar, ultimately reaching nearly 250 MW of cumulative installed solar photovoltaic (PV) capacity by the first quarter of 2013.[6]

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[1] Database of State Incentives for Renewable Energy, "Colorado Renewable Energy Standard." Last updated: 6/25/2013. Available at: www.dsireusa.org/solar/incentives/incentive.cfm?Incentive_Code=CO24R&re=1&ee=1

[2] Database of State Incentives for Renewable Energy, "Xcel Energy – Solar Rewards Program." Last updated: 7/15/2013. Available at: www.dsireusa.org/solar/incentives/incentive.cfm?Incentive_Code=CO12F&re=1&ee=1

[3] Database of State Incentives for Renewable Energy, "Black Hills Energy - Solar Power Program." Last updated: 8/08/2013. Available at: www.dsireusa.org/solar/incentives/incentive.cfm?Incentive_Code=CO35F&re=1&ee=1

[4] Xcel Energy, "Colorado 2012 Renewable Energy Standard Compliance Plan." July 2013. Available at: www.xcelenergy.com/About_Us/Rates_&_Regulations/Regulatory_Filings/CO_2012_Renewable_Energy_Standard_Compliance_Plan

[5] GTM Research/ Solar Energy Industries Association. Solar Market Insight Database.

[6] GTM Research/ Solar Energy Industries Association. Solar Market Insight Database.

3. Data

Data for this study were derived from a number of sources, and in the absence of clear-cut data for some of the desired impacts, assumptions were made when necessary. However, this study reflects the best estimates of the jobs, economic, and other impacts currently available for the Colorado solar industry. Figures on installed capacity and cost were primarily drawn from GTM Research/ Solar Energy Industries Association's (SEIA) *U.S. Solar Market Insight* (SMI) Colorado data for 2007-2013. Though the SMI database is one of the most comprehensive sources on installed capacity, it only disaggregates these figures by year and by market segment for the state as far back as 2010. For the pre-2010 period, installation data from the National Renewable Energy Laboratory's (NREL) Open PV database were used to derive the proportion of the total state solar market represented by each market segment each year. This proportion was then applied to the aggregate pre-2010 SMI numbers to estimate the distribution of installations by market segment for the years 2007, 2008, and 2009. In addition, details on utility-scale installations were derived from SEIA's *Major Projects List*.

SMI installation and cost data for solar PV are classified into three market segments: residential, non-residential, and utility. NREL's Jobs and Economic Development Impact (JEDI) models, used to estimate the jobs, earnings, and outputs for this study, recognize at least four distinct market segments: residential (0-10 kW), small commercial (10-100 kW), large commercial (100-1,000 kW), and utility (1,000 kW and greater). To promote consistency in inputs and better ensure the accuracy of outputs, SMI's "non-residential" market segment was divided into "small commercial" and "large commercial" sectors using proportions derived from Open PV capacity data. Open PV data was also used to estimate average system sizes used in the "Industry to Date Analysis."

Installed cost figures for 2010-2013 are weighted annual average installed costs for Colorado, derived from SMI data which, again, make no distinction in state-level data between small and large commercial segments. Installed costs for small commercial projects were assumed to be the weighted average installed costs for the state's commercial sector. Large commercial costs are estimates based on the national relationship between small and large commercial costs reported in the *U.S. Solar Market Insight: Year-in-Review* reports for 2011 and 2012. Installed costs for 2007-2009 were taken from Lawrence Berkeley National Laboratory's (LBNL) *Tracking the Sun V* and *VI*. Colorado-specific costs were used whenever possible, with national figures used when no state-specific cost data were available.

Data on county mill levies used in property tax revenue estimates were obtained from the Colorado Department of Local Affairs, Division of Property Taxation's *Annual Report to the Governor and General Assembly* for each year covered by this study. Current sales tax rates were taken from the most recent (July 2013) Colorado Department of Revenue, Taxpayer Service Division's *Colorado Sales/Use Tax Rates* (Form DR-1002), with historic rates (covering the 2007-2012 period) sourced from the Department of Revenue's July 2013 *History of Local Sales/Use Taxes* (Form DR-1250).

This study also quantifies environmental benefits associated with solar development in Colorado. Because solar PV systems primarily displace electricity generated from peaking facilities (typically natural gas plants), avoided emissions estimates used in this study are Colorado-specific averages (in

pounds or tons per megawatt-hours) derived from emissions reported for natural gas facilities in two sources. Estimates of avoided emissions of pollutants such as greenhouse gases, nitrogen oxides (NOx), and sulfur dioxide (SO_2) were derived from emissions data from Colorado natural gas plants as documented in the U.S. Environmental Protection Agency's (EPA) *Emissions & Generation Resource Integrated Database* (eGRID). Specifically, eGRID2012 and eGRID2010 (containing data for years 2009 and 2007, respectively) were used for the relevant analyses. Average emissions of particulate matter less than 2.5 microns (PM 2.5) were produced using data on total PM 2.5 emissions from Colorado natural gas plants listed in the *North American Power Plant Air Emissions* database compiled by the CEC Knowledge Network.

Savings of water resources were estimated using figures from *The Water-Energy Nexus: Adding Water to the Energy Agenda* (2011), a report published by EBG Capital and World Policy Institute, which provides average water use rates (in gallons per megawatt-hour) for natural gas, coal, hydroelectric, oil, solar PV, and wind power plants. As with emission rates, the water intensity figures used in this study are based on water consumption associated with electricity generation at natural gas plants.

4. Methodology

Two separate analyses of the jobs, earnings, economic, revenue, and environmental impacts of the Colorado solar industry were performed for this study. The first is a robust "Industry to Date Analysis" of the impacts of solar PV development in the state to date (2007 – Q1 2013), produced using the NREL JEDI Project PV Model, resources on current state policies, and data on the environmental impacts of solar development. The second, a "Scenario Analysis", uses the NREL JEDI Scenario PV Model[7] and the additional resources mentioned previously to project the employment, economic, tax revenue, and environmental benefits of attaining the goal set by the Colorado Solar Energy Industries Association in its "Million Solar Roofs" campaign, which seeks to install 3 gigawatts (GW) of solar energy in Colorado by 2030.[8]

A detailed discussion of methods can be found in the appendix of this report.

[7] Both models are available for download at www.nrel.gov/analysis/jedi/download.html
[8] For more on the "Million Solar Roofs" campaign, visit: http://gosolarcolorado.org/

5. Results and Discussion

This section presents the results of both the "Industry to Date Analysis" and the "Scenario Analysis" described in the Methodology section (see appendix). Results are grouped into three major categories: (1) jobs, earnings, and economic output; (2) tax revenue impacts, and; (3) environmental impacts.

5.1 ***Industry to Date Analysis***

5.1.1 *Jobs, Earnings, and Economic Output*

Jobs, earnings, and economic output estimates for the "Industry to Date Analysis" were generated using the JEDI Project PV model and cover direct, indirect, and induced impacts. In the context of the JEDI models, "jobs" refers to full-time equivalents (FTEs) or job-years, both of which represent full-time employment for one person for one year. "Earnings", as noted previously, constitute wages, salary compensation, and benefits paid to workers. "Economic Output" is an estimate of total economic activity, or the "value of production for all industry sectors",[9] resulting from annual investments in solar PV systems.

As shown in Tables 5.1 and 5.2 below, solar PV development in Colorado has supported the creation of 10,790 job-years from 2007 through the first quarter of 2013, with employees receiving over $534.1 million in wages, salary compensation, and benefits. During the same period, the growth of the state solar market has led to over $1.42 billion in economic output.[10]

[9] National Renewable Energy Laboratory. "Preliminary Analysis of the Jobs and Economic Impacts of Renewable Energy Projects Supported by the §1603 Treasury Grant Program." April 2012. Available at: www.nrel.gov/docs/fy12osti/52739.pdf

[10] Astute readers will note that the employment figures cited in this analysis differ from the state-level jobs estimates reported for Colorado by The Solar Foundation in its *State Solar Jobs Map* (www.solarstates.org). In general, this discrepancy in employment figures is largely attributable to the fact that the methods employed in the TSF Census (a survey-based data collection effort) are very different from those used in an economic input-output model.

Table 5.1: Annual Construction Period Jobs, Earnings, and Economic Output, Industry to Date Analysis

Year ***Job Type***	**Total Job-Years** (FTEs)	**Total Earnings** ($2012 Millions)	**Total Economic Output** ($2012 Millions)
2007			
Direct	294.10	$17.535	$29.274
Indirect	240.80	$12.358	$42.632
Induced	182.90	$8.099	$28.951
SUBTOTAL	717.8	$37.992	$100.857
2008			
Direct	569.40	$33.713	$56.957
Indirect	478.80	$24.699	$83.130
Induced	369.30	$15.907	$56.863
SUBTOTAL	1,417.50	$74.319	$196.951
2009			
Direct	478.70	$27.492	$46.404
Indirect	405.40	$20.287	$69.146
Induced	307.90	$12.997	$46.463
SUBTOTAL	1,192.00	$60.776	$162.013
2010			
Direct	839.10	$45.157	$76.067
Indirect	716.00	$33.567	$116.117
Induced	534.10	$21.364	$76.371
SUBTOTAL	2,089.20	$100.09	$268.555
2011			
Direct	1,303.60	$71.251	$119.888
Indirect	1,081.70	$51.250	$173.510
Induced	833.30	$33.332	$119.157
SUBTOTAL	3,218.60	$155.83	$412.555
2012			
Direct	631.50	$34.598	$59.186
Indirect	560.10	$27.082	$91.727
Induced	421.40	$16.862	$60.278
SUBTOTAL	1,613.00	$78.542	$211.191
2013[†]			
Direct	147.10	$7.927	$13.720
Indirect	137.90	$6.653	$22.957
Induced	100.00	$3.999	$14.295
SUBTOTAL	385.00	$18.579	$50.972
TOTALS			
Direct	4,263.50	$237.739	$401.442
Indirect	3,620.70	$175.947	$599.182
Induced	2,748.90	$112.592	$402.325
TOTAL	**10,633.10**	**$526.128**	**$1,403.092**

[†] Refers to Q1 2013 Only

Table 5.2: Cumulative Operation Period Jobs, Earnings, and Economic Output, Industry to Date Analysis

Job Type	**Total Job-Years** (FTEs)	**Total Earnings** ($2012 Millions)	**Total Economic Output** ($2012 Millions)
Direct	53.00	$3.239	$3.239
Indirect	48.25	$2.471	$8.730
Induced	55.85	$2.279	$8.148
TOTAL	**157.10**	**$7.989**	**$20.116**

5.1.2 *Tax Revenue Impacts*

Under this analysis, aggregate property tax revenues from locally-assessed systems range from $3.12 million to $9.32 million for 2007-Q1 2013. Table 5.3 below provides detailed results on property tax impacts by year. Revenue estimates for state-assessed systems are much less exact. Though requests for information on assessment processes and valuation rates for previous years were placed with the Colorado Division of Property Taxation, no response was received by the submission deadline for this report. Estimates of property tax revenues were derived for six state-assessed, utility-scale projects using valuation processes and rates for 2013. These methods yielded 20-year projected property tax revenues of $12.2 million (approximately $610,500 per year). Given the uncertainty of this figure, however, property tax revenues from these projects were not included in estimates of overall property tax impacts.

During the analysis period, sales taxes on solar energy equipment have provided municipal, county, and state governments with between $18.7 million and $38.1 million in aggregate revenue (see Table 5.4). As shown in Tables 5.5 and 5.6, workers filling positions created or supported by solar PV development have paid an estimated total of $12.3 million in personal income taxes since 2007.

Table 5.3: Aggregate Statewide Property Tax Revenue Impacts from Systems <2 MW_{AC}, Industry to Date Analysis

Year	**Property Tax Revenue Scenario**		
	Low *($2012)*	***Middle*** *($2012)*	***High*** *($2012)*
2007	$50,348	$124,898	$182,191
2008	$117,763	$294,548	$434,476
2009	$219,283	$521,878	$837,055
2010	$331,610	$692,100	$1,113,443
2011	$494,470	$1,013,025	$1,634,027
2012	$823,289	$1,334,764	$2,135,622
2013[†]	$1,078,998	$1,923,490	$2,988,072
TOTAL	**$3,115,760**	**$5,904,702**	**$9,324,887**

[†] Through Q1 2013 Only

Table 5.4: Aggregate Statewide Sales Tax Revenue Impacts, Industry to Date Analysis

Year	Sales Tax Revenue Scenario		
	Low *($2012)*	***Middle*** *($2012)*	***High*** *($2012)*
2007	$2,631,489	$3,525,685	$4,146,001
2008	$4,585,927	$6,144,251	$7,225,283
2009	$1,667,984	$2,965,306	$3,865,276
2010	$2,974,188	$5,287,444	$6,892,184
2011	$4,478,993	$8,012,420	$10,379,319
2012	$1,958,679	$3,482,097	$4,538,913
2013[†]	$434,242	$771,986	$1,006,283
TOTAL	**$18,731,502**	**$30,189,189**	**$38,053,260**

Table 5.5: Personal Income Tax Impacts for Construction Period Jobs, Industry to Date Analysis

Year	***Direct*** *($2012)*	***Indirect*** *($2012)*	***Induced*** *($2012)*	***Total*** *($2012)*
2007	$421,371	$280,213	$171,096	$872,680
2008	$815,798	$567,695	$335,985	$1,719,478
2009	$662,991	$464,393	$274,576	$1,401,960
2010	$1,084,735	$764,673	$451,304	$2,300,712
2011	$1,720,764	$1,172,713	$704,111	$3,597,588
2012	$836,259	$624,897	$356,267	$1,817,423
2013[†]	$190,503	$153,385	$84,465	$428,353
TOTAL	**$5,732,421**	**$4,027,969**	**$2,377,804**	**$12,138,194**

Table 5.6: Personal Income Tax Impacts for Operation Period Jobs, Industry to Date Analysis

Year	***Direct*** *($2012)*	***Indirect*** *($2012)*	***Induced*** *($2012)*	***Total*** *($2012)*
2007	$3,980	$2,645	$2,226	$8,852
2008	$7,544	$7,649	$6,465	$21,658
2009	$7,032	$6,267	$5,260	$18,559
2010	$17,428	$10,697	$8,850	$36,974
2011	$27,195	$15,507	$13,045	$55,747
2012	$13,536	$11,700	$9,587	$34,823
2013[†]	$3,941	$3,416	$2,711	$10,067
TOTAL	**$80,656**	**$57,881**	**$48,144**	**$186,680**

[†] Refers to Q1 2013 Only

5.1.3 *Environmental Impacts*

From the beginning of 2007 though the first quarter of 2013, solar energy systems in Colorado produced an estimated 1.33 million MWh of electricity. Using emission rates and avoided damage values presented in the Appendix, this clean electricity has produced an estimated $24.3 million worth of environmental benefits through reductions in emissions of greenhouse gases, PM 2.5, NOx, and SO_2. In addition, electricity from solar PV over this period has saved nearly 300 million gallons of water, which would have otherwise been used in generating electricity from conventional sources.

Table 5.7: Avoided Emissions and Damages, GHGs and PM 2.5, Industry to Date Analysis

Year	Cumulative Solar Production (MWh)	Greenhouse Gases		PM 2.5	
		Total Avoided Emissions (tonnes CO_2e)	Value of Avoided Emissions ($2012)	Total Avoided Emissions (tons)	Value of Avoided Emissions ($2012)
2007	17,473	8,099	$295,739	0.424	$2,990
2008	50,926	23,604	$861,947	1.237	$8,714
2009	81,005	36,937	$1,348,819	1.967	$13,860
2010	161,272	73,538	$2,685,350	3.917	$27,594
2011	296,897	135,381	$5,093,455	7.211	$50,800
2012	355,365	162,042	$6,275,817	8.631	$60,805
2013[†]	369,266	168,381	$6,707,641	8.968	$63,183
TOTALS	**1,332,204**	**607,983**	**$23,268,768**	**32.355**	**$227,946**

Table 5.8: Avoided Emissions and Damages, NOx and SO_2, Industry to Date Analysis

Year	Cumulative Solar Production (MWh)	NOx		SO_2	
		Total Avoided Emissions (tons)	Value of Avoided Emissions ($2012)	Total Avoided Emissions (tons)	Value of Avoided Emissions ($2012)
2007	17,473	4.421	$8,598	0.083	$106
2008	50,926	12.885	$25,060	0.242	$308
2009	81,005	24.919	$48,466	0.304	$387
2010	161,272	49.610	$96,491	0.605	$771
2011	296,897	91.331	$177,637	1.114	$1,419
2012	355,365	109.317	$212,619	1.334	$1,698
2013[†]	369,266	113.593	$220,936	1.386	$1,764
TOTALS	**1,332,204**	**406.077**	**$789,807**	**5.068**	**$6,453**

[†] Refers to Q1 2013 Only

Table 5.9: Water Consumption Savings, Industry to Date Analysis

Year	**Cumulative Solar Production** (MWh)	**Total Water Saved** (gallons)
2007	17,473	3,800,378
2008	50,926	11,076,405
2009	81,005	17,618,588
2010	161,272	35,076,673
2011	296,897	64,575,079
2012	355,365	77,291,830
2013[†]	369,266	80,315,381
TOTALS	**1,332,204**	**289,754,334**

5.2 ***Scenario Analysis***

5.2.1 *Jobs, Earnings, and Economic Output*

Should the Colorado solar industry attain the Million Solar Roofs Goal through the installation of 2,750 MW of solar PV from the remainder of 2013 through the end of 2030, it will have created almost 32,500 job-years and paid out over $1.9 billion in employee earnings (present value; 3% discount rate). This economic activity is expected to produce over $3.85 billion in total output. Detailed annual estimates of the jobs, earnings, and economic output impacts of this projected growth in solar PV in Colorado can be found in Tables 5.10 and 5.11 on the following page.

Table 5.10: Annual Construction Period Jobs, Earnings, and Economic Output, Scenario Analysis

Year	**Total Job-Years** (FTEs)				**Total Earnings** ($ Millions)				**Total Economic Output** ($ Millions)			
	Direct	***Indirect***	***Induced***	***TOTAL***	***Direct***	***Indirect***	***Induced***	***TOTAL***	***Direct***	***Indirect***	***Induced***	***TOTAL***
2013[11]	333.0	278.0	204.0	**815.0**	$26.5	$16.7	$9.9	**$53.1**	$35.6	$45.9	$28.8	**$110.3**
2014	355.0	296.0	217.0	**868.0**	$27.9	$17.6	$10.4	**$55.9**	$37.6	$48.2	$30.2	**$116.0**
2015	380.0	314.0	233.0	**927.0**	$29.4	$18.5	$10.7	**$58.6**	$39.7	$50.8	$31.9	**$122.4**
2016	405.0	334.0	248.0	**987.0**	$31.3	$19.5	$11.4	**$62.2**	$42.0	$53.3	$33.4	**$128.7**
2017	432.0	357.0	263.0	**1,052.0**	$32.9	$20.6	$12.1	**$65.6**	$44.3	$56.1	$35.3	**$135.7**
2018	460.0	380.0	281.0	**1,121.0**	$34.9	$21.7	$12.8	**$69.4**	$46.7	$59.0	$37.3	**$143.0**
2019	491.0	404.0	299.0	**1,194.0**	$36.8	$22.8	$13.3	**$72.9**	$49.3	$62.0	$39.2	**$150.5**
2020	524.0	429.0	320.0	**1,273.0**	$39.0	$24.0	$14.1	**$77.1**	$52.2	$65.2	$41.4	**$158.8**
2021	561.0	457.0	340.0	**1,358.0**	$41.3	$25.2	$14.9	**$81.4**	$55.2	$68.6	$43.6	**$167.4**
2022	598.0	487.0	363.0	**1,448.0**	$43.7	$26.5	$15.9	**$86.1**	$58.3	$72.3	$46.0	**$176.6**
2023	640.0	520.0	387.0	**1,547.0**	$46.3	$27.9	$16.6	**$90.8**	$61.5	$75.9	$48.4	**$185.8**
2024	685.0	554.0	414.0	**1,653.0**	$49.0	$29.4	$17.5	**$95.9**	$65.3	$80.2	$51.2	**$196.7**
2025	772.0	629.0	468.0	**1,869.0**	$54.5	$33.0	$19.7	**$107.2**	$72.6	$90.0	$57.2	**$219.8**
2026	883.0	723.0	535.0	**2,141.0**	$61.1	$37.5	$22.2	**$120.8**	$81.7	$102.3	$64.8	**$248.8**
2027	1,010.0	831.0	615.0	**2,456.0**	$68.7	$42.8	$25.3	**$136.8**	$92.2	$116.6	$73.5	**$282.3**
2028	1,179.0	972.0	718.0	**2,869.0**	$79.2	$49.4	$29.0	**$157.6**	$106.2	$134.8	$84.9	**$325.9**
2029	1,386.0	1,142.0	845.0	**3,373.0**	$91.9	$57.3	$33.6	**$182.8**	$123.3	$156.3	$98.4	**$378.0**
2030	1,627.0	1,341.0	992.0	**3,960.0**	$106.7	$66.6	$39.0	**$212.3**	$143.1	$181.6	$114.3	**$439.0**
TOTAL	12,721.0	10,448.0	7,742.0	**30,911.0**	$901.1	$557.2	$328.2	**$1,786.5**	$1,206.9	$1,519.1	$959.9	**$3,685.7**

Table 5.11: Cumulative Operation Period Jobs, Earnings, and Economic Output, Scenario Analysis

Total Job-Years (FTEs)				**Total Earnings** ($ Millions)				**Total Economic Output** ($ Millions)			
Direct	***Indirect***	***Induced***	***TOTAL***	***Direct***	***Indirect***	***Induced***	***TOTAL***	***Direct***	***Indirect***	***Induced***	***TOTAL***
1,005.0	309.0	265.0	**1,580.0**	$91.0	$17.7	$11.3	**$120.0**	$91.0	$40.6	$33.6	**$165.2**

[11] Refers to Q2-Q4 2013 only

5.2.2 *Tax Revenue Impacts*

Achieving a cumulative installed capacity of 3 GW of solar PV by 2030 will provide Colorado local governments with between $95.1 million and $263.3 million in aggregate property tax revenues (present value; 3% discount rate). In reviewing these revenue figures (provided in Table 5.12 below), it should be noted that JEDI assumes each solar PV system installed under this scenario to be less than 2 MW_{AC} in size. Under current Colorado property tax policies, all of these systems would be assessed locally using a state-mandated "threshold rate" (in $/$kW_{AC}$). State-assessed systems – those greater than 2 MW_{AC} – are valued at lower threshold rates the larger their capacity. Because of this, the installation of any new systems larger than 2 MW_{AC} will mean the revenue projections provided below will overestimate actual property tax revenues. The magnitude of this overestimate depends on the number of large systems (>2 MW_{AC}) that are ultimately installed.

Table 5.12: Aggregate Statewide Property Tax Revenue Impacts, Scenario Analysis

Year	Property Tax Revenue Scenario		
	Low	***Middle***	***High***
2013[12]	$1,086,636	$1,937,105	$3,009,224
2014	$1,237,973	$2,206,889	$3,428,323
2015	$1,458,612	$2,600,212	$4,039,335
2016	$1,713,114	$3,053,904	$4,744,129
2017	$2,005,391	$3,574,935	$5,553,532
2018	$2,342,275	$4,175,485	$6,486,466
2019	$2,731,466	$4,869,283	$7,564,255
2020	$3,181,196	$5,670,998	$8,809,691
2021	$3,700,397	$6,596,559	$10,247,516
2022	$4,300,572	$7,666,470	$11,909,582
2023	$4,996,797	$8,907,603	$13,837,639
2024	$5,801,006	$10,341,238	$16,064,739
2025	$6,734,355	$12,005,083	$18,649,462
2026	$7,815,668	$13,932,701	$21,643,946
2027	$9,067,526	$16,164,340	$25,110,717
2028	$10,522,334	$18,757,771	$29,139,519
2029	$12,208,182	$21,763,070	$33,808,141
2030	$14,164,357	$25,250,271	$39,225,381
TOTAL	**$95,067,856**	**$169,473,918**	**$263,271,596**

[12] This figure refers to total impacts throughout 2013, including taxes from systems already included for 2013 in the "Industry to Date Analysis", meaning some overlap exists in the figures. To isolate the incremental property tax revenue impact of the installed capacity projected for the remainder of 2013, one would merely take the difference of the 2013 figures cited above and their corresponding values in Table 5.3.

Table 5.13 below shows that under current state policies, purchases of solar energy equipment between now and 2030 will yield between $81.7 million and $133.5 million in municipal, county, and state sales tax revenues (present value; 3% discount rate). The analysis underlying these figures assumes that the current state sales tax exemption for solar energy equipment expires as planned in 2017, which accounts for the large increase in revenues between 2017 and 2018.

Table 5.13: Aggregate Statewide Sales Tax Revenue Impacts, Scenario Analysis

Year	Sales Tax Revenue Scenario		
	Low	***Middle***	***High***
2013[13]	$1,154,138	$2,051,801	$2,674,522
2014	$1,219,148	$2,167,374	$2,825,171
2015	$1,288,012	$2,289,800	$2,984,754
2016	$1,361,078	$2,419,694	$3,154,071
2017	$1,438,892	$2,558,031	$3,334,392
2018	$3,483,074	$4,666,641	$5,487,700
2019	$3,684,319	$4,936,272	$5,804,770
2020	$3,898,078	$5,222,668	$6,141,554
2021	$4,125,020	$5,526,726	$6,499,109
2022	$4,367,697	$5,851,866	$6,881,455
2023	$4,624,505	$6,195,938	$7,286,064
2024	$4,903,945	$6,570,334	$7,726,332
2025	$5,442,680	$7,292,134	$8,575,127
2026	$6,107,671	$8,183,093	$9,622,843
2027	$6,871,664	$9,206,695	$10,826,540
2028	$7,912,002	$10,600,547	$12,465,628
2029	$9,182,397	$12,302,629	$14,467,178
2030	$10,656,773	$14,278,007	$16,790,109
TOTAL	**$81,721,093**	**$112,320,248**	**$133,547,321**

Table 5.14, found on the following page, details anticipated income tax revenues associated with Construction Period jobs created in fulfilling the goal of the Million Solar Roofs campaign. Workers in direct, indirect, and induced jobs tied to the installation of new solar capacity through 2030 will pay a total of approximately $45.4 million (present value; 3% discount rate) in personal income taxes.

[13] Refers to Q2-Q4 2013 only

Table 5.14: Personal Income Tax impacts for Construction Period Jobs, Scenario Analysis

Year	*Direct*	*Indirect*	*Induced*	*Total*
2013[14]	$705,086	$413,506	$226,380	$1,344,972
2014	$742,370	$436,416	$237,421	$1,416,207
2015	$783,797	$458,739	$243,603	$1,486,139
2016	$833,723	$482,784	$259,616	$1,576,123
2017	$875,207	$511,193	$275,223	$1,661,623
2018	$930,752	$538,880	$292,247	$1,761,879
2019	$983,602	$565,425	$302,683	$1,851,710
2020	$1,043,380	$596,943	$320,693	$1,961,016
2021	$1,102,971	$626,396	$341,669	$2,071,036
2022	$1,169,953	$657,230	$363,845	$2,191,027
2023	$1,239,061	$691,911	$379,177	$2,310,149
2024	$1,311,002	$728,198	$398,697	$2,437,896
2025	$1,459,010	$818,898	$449,964	$2,727,872
2026	$1,630,798	$931,087	$509,033	$3,070,917
2027	$1,831,400	$1,063,129	$578,414	$3,472,943
2028	$2,113,436	$1,226,349	$662,176	$4,001,961
2029	$2,450,866	$1,421,132	$767,626	$4,639,624
2030	$2,843,154	$1,654,433	$890,066	$5,387,653
TOTAL	**$24,049,568**	**$13,822,649**	**$7,498,533**	**$45,370,747**

Workers filling direct, indirect, and induced jobs during the Operations Period also contribute, albeit to a much smaller degree, to state income tax revenues. For the remainder of 2013 through the end of 2030, it is estimated that these individuals will remit a combined $3.3 million (present value; 3% discount rate) in income taxes to the state government.

5.2.3 *Environmental Impacts*

Table 5.15 on the following page provides estimates of water savings and the quantity and values of avoided pollutant emissions. At an estimated 29.4 million MWh of cumulative solar electricity production through 2030, Colorado solar PV installations are estimated to deliver approximately $634.3 million (present value; 3% discount rate) in environmental benefits by reducing emissions of selected pollutants. Solar electricity produced over this timeframe will save nearly 6.4 billion gallons of water from being consumed in conventional electric generation processes.

[14] Refers to Q2-Q4 2013 only

Table 5.15: Avoided Emissions and Damages (All Pollutants) and Water Consumption Savings, Scenario Analysis

Year	Cumulative Solar Production (MWh)	Greenhouse Gases		PM 2.5		NOx		SO_2		Water Savings
		Total Avoided Emissions (tonnes CO_2e)	Present Value of Avoided Emissions	Total Avoided Emissions (tons)	Present Value of Avoided Emissions	Total Avoided Emissions (tons)	Present Value of Avoided Emissions	Total Avoided Emissions (tons)	Present Value of Avoided Emissions	Total Water Saved (millions of gallons)
2013[15]	411,545	187,659	$7,521,244	9.995	$70,847	126.599	$247,735	1.545	$1,978	89.511
2014	459,894	209,706	$8,538,111	11.169	$78,252	141.472	$273,628	1.726	$2,185	100.027
2015	515,269	234,957	$9,710,746	12.514	$86,657	158.507	$303,018	1.934	$2,420	112.071
2016	581,591	265,199	$11,118,581	14.125	$96,676	178.909	$338,053	2.183	$2,700	126.496
2017	659,580	300,761	$12,782,820	16.019	$108,368	202.900	$378,937	2.476	$3,026	143.459
2018	750,165	342,066	$14,728,948	18.219	$121,821	230.765	$425,979	2.816	$3,402	163.161
2019	857,566	391,040	$17,048,267	20.827	$137,646	263.804	$481,317	3.219	$3,844	186.521
2020	982,988	448,230	$19,774,811	23.873	$155,947	302.386	$545,311	3.690	$4,355	213.800
2021	1,131,151	515,791	$23,014,480	27.472	$177,371	347.964	$620,224	4.246	$4,953	246.025
2022	1,305,398	595,246	$26,848,233	31.703	$202,319	401.566	$707,462	4.900	$5,650	283.924
2023	1,509,454	688,293	$31,366,809	36.659	$231,231	464.338	$808,561	5.666	$6,457	328.306
2024	1,748,624	797,351	$36,696,037	42.468	$264,762	537.911	$925,809	6.564	$7,394	380.326
2025	2,030,982	926,103	$43,023,354	49.325	$303,946	624.770	$1,062,828	7.624	$8,488	441.738
2026	2,362,751	1,077,386	$50,501,385	57.383	$349,495	726.828	$1,222,101	8.869	$9,760	513.898
2027	2,751,521	1,254,660	$58,128,672	66.825	$402,280	846.422	$1,406,677	10.328	$11,234	598.456
2028	3,208,994	1,463,262	$68,374,263	77.935	$463,721	987.149	$1,621,522	12.046	$12,950	697.956
2029	3,745,667	1,707,979	$80,460,983	90.969	$534,994	1,152.240	$1,870,748	14.060	$14,940	814.682
2030	4,375,853	1,995,336	$94,729,296	106.274	$617,753	1,346.098	$2,160,136	16.426	$17,251	951.748
TOTALS	**29,388,990**	**13,401,023**	**$614,367,040**	**713.753**	**$4,404,086**	**9,040.628**	**$15,400,046**	**110.318**	**$122,987**	**6,392.105**

[15] This figure refers to total impacts throughout 2013, including those from systems already included for 2013 in the "Industry to Date Analysis", meaning some overlap exists in the figures. To isolate the incremental impact of the installed capacity projected for the remainder of 2013, one would merely take the difference of the 2013 figures cited above and their corresponding values in Tables 5.7, 5.8, and 5.9.

6. Appendix – Detailed Methodology

6.1 *Industry to Date Analysis*

Estimates of the jobs, earnings, and economic output impacts of solar PV development in Colorado to date were generated using the NREL JEDI Project PV Model. Outputs are divided into two sets of impacts. "Construction Period" impacts include the results of spending on labor, materials, and induced impacts while the project is being developed and installed. "Operation Period" impacts refer to the effects of spending required to operate and maintain these systems throughout their useful life. Within these two periods, outputs are further apportioned across three job categories: "Direct Jobs", such as project development positions and onsite laborers; "Indirect Jobs", created through supply chain impacts on associated industries, and; "Induced Jobs", supported by reinvestment and spending of income by individuals holding direct and indirect jobs.[16]

This input-output modeling tool has been used several times in the past to evaluate the economic impacts of renewable energy development by various universities, government agencies, and national laboratories.[17] Minimum inputs required by the model are the state and year in which the systems were installed, the market segment to which the systems belong (i.e., residential – both retrofit and new construction, small commercial, large commercial, and utility), technology type and tracking, average system size (kW_{DC}), number of systems installed, and both installed and operations and maintenance costs ($/kW_{DC}$). Users also have the option to set parameters governing local content, project finance, sales and property tax rates, and company payroll.

As mentioned previously (see "Data" section), assumptions of installed capacity by market segment by year were developed using a combination of SMI and Open PV data. These assumptions are detailed in Table 6.1.

[16] More information on these impacts can be found on the "Interpreting Results" page of the JEDI website: www.nrel.gov/analysis/jedi/results.html

[17] More information about the JEDI models can be found at www.nrel.gov/analysis/jedi/about_jedi.html

Table 6.1: Installed Capacity Assumptions, Industry to Date Analysis

	Market Segment				Totals
	Residential (0-10 kW)	***Small Commercial (10-100 kW)***	***Large Commercial (100-1,000 kW)***	***Utility (>1,000 MW)***	
2007					
Total Capacity (MW)	2.63	0.78	0	8.22	11.63
Avg. System Size (kW)	4.54	23.7	0	8220	
# of Systems	579	33	0	1	613
2008					
Total Capacity (MW)	5.81	1.68	9.67	5.19	22.35
Avg. System Size (kW)	4.44	51.44	641.83	1730	
# of Systems	1309	33	15	3	1360
2009					
Total Capacity (MW)	7.17	1.72	4.62	6.71	20.22
Avg. System Size (kW)	4.90	29.75	917.50	1677.50	
# of Systems	1463	58	5	4	1530
2010					
Total Capacity (MW)	18.65	0.92	4.48	29.61	53.66
Avg. System Size (kW)	5.35	20.94	102.74	5922	
# of Systems	3486	44	44	5	3579
2011					
Total Capacity (MW)	13.8	8.87	19.73	48.4	90.8
Avg. System Size (kW)	5.87	59.35	152.13	16133.33	
# of Systems	2351	149	130	3	2633
2012					
Total Capacity (MW)	17.7	3.52	17.16	1.52	39.9
Avg. System Size (kW)	5.93	30.8	235.36	1520	
# of Systems	2985	114	73	1	3173
2013[†]					
Total Capacity (MW)	7.3	1.7	1.4	0	10.4
Avg. System Size (kW)	5.72	19.57	238.95	0	
# of Systems	1276	87	6	0	1369
Cumulative					
Total Capacity (MW)	73.06	19.19	57.06	99.65	248.96
# of Systems	13449	518	273	17	14257

Table 6.2, on the following page, lists the installed cost assumptions used in this analysis and the sources from which each were derived.

[†] Refers to Q1 2013 Only

Table 6.2: Installed Cost Assumptions, Industry to Date Analysis ($/Watt)

	Market Segment				Source
	Residential (0-10 kW)	***Small Commercial (10-100 kW)***	***Large Commercial (100-1,000 kW)***	***Utility (>1,000 MW)***	
2007					
	$8.30	$9.10	$7.40	$7.40	Tracking the Sun V
2008					
	$7.70	$7.30	$7.40	$7.40	Tracking the Sun VI
2009					
	$6.60	$5.70	$7.50	$7.50	Tracking the Sun VI
2010					
	$5.78	$5.02	$4.47	$4.05	Solar Market Insight
2011					
	$6.03	$5.28	$4.96	$3.28	Solar Market Insight
2012					
	$4.92	$4.60	$4.32	$2.60	Solar Market Insight
2013					
	$4.30	$3.48	$3.27	$2.14	Solar Market Insight

Local content assumptions differed based on market segment. For residential and small commercial installations, it was assumed that 50% of materials and equipment used to install, operate, and maintain these systems were purchased locally. Assuming that larger systems would be more likely to attract out-of-state project developers and engineering, procurement, and construction (EPC) firms, the locally purchased percentage assumption decreased for both the large commercial (25%) and utility (0%) market segments. These same percentages were also used to estimate the local share of debt financing. A review of SEIA's *National Solar Database* revealed that Colorado has a number of companies involved in the manufacture of mounting equipment, inverters, and other electrical components.

JEDI default values were used for all other inputs, including technology type and tracking, operations and maintenance costs, project finance parameters, and company payroll assumptions. Due to the complexity of sales and property tax policies governing solar PV in Colorado, these revenue impacts are evaluated using separate processes.[18]

Colorado contains 64 counties, each with its own sales and property tax rates and some with their own tax exemptions or rebates for solar.[19] Rather than undertake the laborious task of identifying rates and policies for each county in the state, the scope of this effort was limited to the 24 counties in Xcel Energy's service territory, which combined account for approximately 90% of all non-utility installed solar capacity in the state. Once obtained, sales and property tax rates for these counties were sorted for each year of analysis, with the smallest,

[18] All monetary outputs provided by JEDI were reported by the model in 2012 dollars. Monetary values for sales and property tax revenues were adjusted using the GDP chain-type price index values provided in the U.S. Energy Information Administration's *2013 Annual Energy Outlook*: www.eia.gov/forecasts/aeo/er/table1.cfm

[19] Colorado Revised Statutes (CRS) §30-11-107.3 and §31-20-101.3 authorize County and Municipal governments (respectively) to offer property and sales tax credits or rebates for renewable energy property. However, of the two dozen counties and municipalities contacted during the research phase of this project, only a small number indicated they offered any sort of incentive for sales or property taxes. Because low-mid-and high estimates are given, the presence of any "local option" exemptions or rebates is expected to only meaningfully impact the low-end estimate, if at all.

median, and highest values from each annual range used to develop low-medium-high estimates of aggregate sales and property tax revenues statewide. Rates used in this analysis are detailed in Tables 6.3 and 6.4.

All grid-connected residential solar energy systems, including those owned by a third party up to 100 kW, are exempt from Colorado property taxes. Systems under 2 MW_{AC} are locally assessed as personal property according to a cost-based valuation formula established by the Division of Property Taxation. Use of this formula requires knowledge of a number of variables, including the generating capacity of the project (kW_{AC}), Renewable Energy Assessment Threshold Analysis rates for each year, the year in which the project was installed (providing the basis for the "percent good" for the system, used to adjust for depreciation), and a "level of value" adjustment factor (which for solar PV is 1.00). This formula yields an "estimated actual value" for the system, to which the state assessment ratio for personal property (29%) is then applied.[20] This process applies to systems installed on and after January 1, 2008. Prior to this date, taxable renewable energy systems (including solar PV) were assessed like any other personal property. In this case, the original installed cost – adjusted to current year values and depreciated over a 20 year economic life – would have been used to assess the value of these systems, rather than the aforementioned "threshold rates".[21] For the sake of simplicity of analysis, it is assumed that locally-assessed solar PV systems are wholly subject to these taxes from the year they are installed.

Systems greater than 2 MW_{AC} are assessed at the state level using an income-based approach that estimates annualized property tax revenues over 20 years. This formula requires inputs including facility capacity factor, total plant capacity, base energy purchase rate and any escalators included in the power purchase agreement (PPA) entered into with the off-taker, an inflation factor, and "threshold rates" similar to those used in the locally-assessed process, but declining in value with increases in facility capacity. It is possible, however, to obtain a "thumbnail estimate" of property tax revenue impacts using only the nameplate capacity of the facility and county mill rate. Due to limitations in the availability of formula inputs (especially PPA rates), the "thumbnail" approach was used for state-assessed systems in this analysis. State-assessed renewable energy property is not assessed until the year after it begins operations.[22]

In addition to their own value, solar PV systems may add value to the properties on which they are sited. Any increased value in these properties, which are often subject to property taxation themselves, in turn represent an increase in the total property tax base. It remains to be seen, however, how much (if any) value solar PV systems add to the properties on which they are installed. It has been noted elsewhere that the Denver

[20] Colorado Department of Local Affairs, Division of Property Taxation. "Personal Property Manual." July 2013. Available at: www.colorado.gov/cs/Satellite?blobcol=urldata&blobheadername1=Content-Disposition&blobheadername2=Content-Type&blobheadervalue1=inline%3B+filename%3D%22ARL+Volume+5-July+2013.pdf%22&blobheadervalue2=application%2Fpdf&blobkey=id&blobtable=MungoBlobs&blobwhere=1251865853855&ssbinary=true

[21] Michael Krueger, Property Tax Specialist – Colorado Department of Local Affairs, Division of Property Taxation. Personal communication. August 18, 2013.

[22] Colorado Department of Local Affairs, Division of Property Taxation. "2013 Renewable Energy Tax Factor Instructions for Renewable Properties Values by the State Assessed Properties Section." January 2013. Available at: www.colorado.gov/cs/Satellite?blobcol=urldata&blobheadername1=Content-Disposition&blobheadername2=Content-Type&blobheadervalue1=inline%3B+filename%3D%222013+Qualified+SA+Renewables.pdf%22&blobheadervalue2=application%2Fpdf&blobkey=id&blobtable=MungoBlobs&blobwhere=1251847732466&ssbinary=true

Assessor's Office has been unable to establish the magnitude, or even the existence, of any value increases.[23] Given this, it is assumed for the purpose of this analysis that solar PV systems do not add value to these properties.

Table 6.3: Average County Mill Levies, Industry to Date Analysis

Year	Average County Property Tax Rates		
	Low	*Median*	*High*
2007	0.028720	0.071246	0.103928
2008	0.028073	0.070216	0.103573
2009	0.027501	0.065451	0.104978
2010	0.031634	0.066023	0.106217
2011	0.032222	0.066014	0.106481
2012	0.041659	0.067540	0.108064
2013[24]	0.037872	0.067513	0.104879

Exemptions and incentives also exist for sales taxes applied to solar PV equipment. Since 2009, solar PV equipment has been exempt from Colorado state sales taxes. This policy is currently set to remain in effect until 2017. Because sales taxes apply only to equipment purchases, but only data on installed costs for each year were available (which include labor and soft costs in addition to equipment and materials), it was necessary to estimate the percentage of installed costs attributable to equipment purchases. The JEDI Project PV model provides such estimates for each market segment. A weighted average of these percentages was calculated based on how much of new annual installed capacity was attributed to each market segment. These weighted average percentages were then applied to aggregate spending on solar installations each year (calculated as the product of total annual installed capacity and installed costs) to derive the total equipment and material cost basis for sales taxes.

Table 6.4: Estimated Sales Tax Rates, Industry to Date Analysis

Year	County-level Sales Tax Rates		
	Low	*Median*	*High*
2007	0.0515	0.0690	0.08114
2008	0.0515	0.0690	0.08114
2009	0.0225	0.0400	0.05214
2010	0.0225	0.0400	0.05214
2011	0.0225	0.0403	0.05214
2012	0.0225	0.0400	0.05214
2013[25]	0.0225	0.0400	0.05214

Sales tax rates reported in Table 6.4 are county-level rates, calculated as the sum of each year's county sales taxes, state sales taxes (where they apply), and an average municipal sales tax rate (estimated using sales tax rates for each municipality in a given county, taken from Form DR-1250).

[23] North Carolina Solar Center and Meister Consultants Group. "Property Taxes and Solar PV Systems: Policies, Practices, and Issues." July 2013. Available at: www.icleiusa.org/action-center/report-property-taxes-and-solar-pv-systems-policies-practices-and-issues

[24] Note that this is an average of rates from 2007-2012

[25] Note that this an average of rates from 2007-2012

Revenues from personal income taxes were also estimated as part of this analysis. Jobs and earnings outputs for direct, indirect, and induced employment impacts from the JEDI Project PV model were used to estimate average earnings per employee. Because the earnings output from the JEDI models include "total payroll costs, including wages, salary compensation, and benefits paid to workers",[26] it was necessary to isolate the wages and salary portion using a "benefits ratio" derived from quarterly *Employer Costs for Employee Compensation* reports produced by the Bureau of Labor Statistics.[27] In the years covered by this analysis, benefits constitute approximately 30% of employee compensation. The earnings outputs from JEDI were reduced by this amount to estimate average income per employee.

Colorado has a flat tax rate of 4.63% and offers personal exemptions of $3,900 per individual included on a tax return.[28] With an average household size of 2.5 individuals,[29] it was estimated that an average exemption of $9,750 would apply to each worker. Average income per employee was then reduced by the average exemption amount, and the difference multiplied by the state income tax rate to estimate average income taxes paid per employee. This figure, in turn, was multiplied by the number of workers per category (direct, indirect, and induced) to produce total income taxes paid by employees each year by market segment.

The Industry to Date Analysis also includes estimates of environmental benefits resulting from solar electricity production in the state. Annual solar electricity production was estimated using NREL's PVWatts Calculator.[30] Average system sizes by market segment by year were used for the "DC System Size (kW)" input, with all other parameters set at their default inputs. System production was calculated for three Colorado cities (Boulder, Colorado Springs, and Grand Junction), which were then averaged to obtain a statewide production estimate. This average system production (in kilowatt-hours) was then converted into total production (in megawatt-hours) by multiplying by the number of systems in the corresponding market segment. Total production estimates were then adjusted by a 0.5% annual degradation rate. Once these adjustments were made to total production estimates for each year preceding a given year, that year's production was then added to the sum of the total production from all previous years to obtain a cumulative production estimate for that year. For example, 2.63 MW of residential capacity was installed in Colorado in 2007. Using the process described above, it was estimated that these systems would produce 17,473 MWh of solar electricity in their first year of operation. Because the analysis begins in the year 2007, there is no production from previous years to adjust by the degradation rate. In 2008, 5.81 MW of residential capacity was installed in the state, producing 33,541 MWh in their first year of operation. Because this is new *annual* capacity, this total production needs to be added to the previous year's production estimate – as systems installed in the previous year are still producing electricity - (adjusted for degradation, 17,473 MWh x 0.995 = 17,385 MWh) to determine overall solar electricity production for 2008, and so on for the following years.

[26] National Renewable Energy Laboratory. "Preliminary Analysis of the Jobs and Economic Impacts of Renewable Energy Projects Supported by the §1603 Treasury Grant Program." April 2012. Available at: www.nrel.gov/docs/fy12osti/52739.pdf
[27] U.S. Bureau of Labor Statistics. "Employer Costs for Employee Compensation Archived News Releases." Available at: www.bls.gov/schedule/archives/ecec_nr.htm
[28] Federation of Tax Administrators. "State Individual Income Taxes." January 2013. Available at: www.taxadmin.org/fta/rate/ind_inc.pdf
[29] U.S. Census Bureau. "Profile of General Population and Housing Characteristics." 2010. Available at: http://factfinder2.census.gov/faces/nav/jsf/pages/community_facts.xhtml
[30] National Renewable Energy Laboratory. "PVWatts Calculator." Available at: http://pvwattsbeta.nrel.gov

To estimate avoided emissions, it was assumed that each MWh of solar generation offsets one MWh of electricity from peaking facilities fueled by natural gas. Average emissions rates for greenhouse gases, NOx, and SO_2 were estimated using eGRID2012 and eGRID2010 data for Colorado natural gas plants. PM 2.5 emissions rates were estimated using data from the CEC Knowledge Network. Average annual emissions rates for each of these pollutants are listed in Table 6.5 below.

Table 6.5: Average Pollution Emission Rates, Industry to Date Analysis

Year	Pollutant			
	GHGs (CO_2e) *(lbs/MWh)*	***PM 2.5*** *(tons/MWh)*	***NOx*** *(tons/MWh)*	***SO_2*** *(tons/MWh)*
2007	1021.85	2.42864E-05	0.000253	4.75518E-06
2008	1021.85	2.42864E-05	0.000253	4.75518E-06
2009	1005.28	2.42864E-05	0.000308	3.75373E-06
2010	1005.28	2.42864E-05	0.000308	3.75373E-06
2011	1005.28	2.42864E-05	0.000308	3.75373E-06
2012	1005.28	2.42864E-05	0.000308	3.75373E-06
2013	1005.28	2.42864E-05	0.000308	3.75373E-06

Applying these rates to overall solar electricity production for each year yields an estimate for total avoided emissions. The monetary value of these avoided emissions was calculated using "social cost" or total emission damage estimates from two sources. The value of avoided greenhouse gas emissions was estimated using the "Revised Social Cost of CO_2" (at a 3.0% discount rate) produced in May 2013 by the Interagency Working Group on Social Cost of Carbon of the U.S. Government.[31] Starting in 2010, values are adjusted annually to reflect the 3.2% average annual growth rate for the 2010-2020 period reported in the study. Damage estimates per ton of PM 2.5, NOx, and SO_2 are Colorado-specific values reported in a study published by Colorado State University (CSU) in 2010.[32] Table 6.6 lists all values (adjusted to 2012 dollars using the GDP chain-type price index) by pollutant type.

Table 6.6: Social Cost and Expected Damage Values for Selected Pollutants, Industry to Date Analysis

Year	Pollutant			
	GHGs (CO_2e) *($2012/tonne)*	***PM 2.5*** *($2012/ton)*	***NOx*** *($2012/ton)*	***SO_2*** *($2012/ton)*
2007	$36.52	$7,045.28	$1,944.97	$1,272.92
2008	$36.52	$7,045.28	$1,944.97	$1,272.92
2009	$36.52	$7,045.28	$1,944.97	$1,272.92
2010	$36.52	$7,045.28	$1,944.97	$1,272.92
2011	$37.62	$7,045.28	$1,944.97	$1,272.92
2012	$38.73	$7,045.28	$1,944.97	$1,272.92
2013	$39.84	$7,045.28	$1,944.97	$1,272.92

[31] Interagency Working Group on Social Cost of Carbon, United States Government. "Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866." May 2013. Available at: www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf

[32] Keske, C.M.H., Iverson, T., and Graff, G. "Designing a Technology-Neutral, Benefit-Pricing Policy for the Electric Power Sector in Colorado." December 2010. Available at: http://instaar.colorado.edu/uploads/publications/keske-et-al-2010-geo-tech-report.pdf

Values listed in the table above for PM 2.5 and NOx are weighted damage estimates, rather than any single value documented in the CSU report. For PM 2.5, damage estimates vary by county. For the nine counties that were "out of compliance" with NAAQS 2008 Ozone standard between 2007 and 2009, the mean damage estimate was $19,051/ton ($2010). The mean for the remaining counties was $794/ton ($2010). Because these non-compliant "Front Range" counties account for approximately one-third of all solar installed in Colorado (according to Open PV data), state-wide damages are estimated as ($19,051 * 0.33) + ($794 * 0.67) = $6,818.8/ton ($2010). Adjusting for inflation yields a 2012 dollar value of $7,045.28/ton. Weighted average damages for NOx were calculated in a similar fashion. For urban areas, damages were estimated at $2,261/ton, with damages for rural areas at $1,696/ton (both in 2010 dollars). Here, state-wide damages are estimated as ($2,261 * 0.33) + ($1,696 * 0.67) = $1,882.45/ton ($2010). Adjusting for inflation yields a 2012 dollar value of $1,944.97/ton. The statewide median damage value for SO_2 is $1,232/ton ($1,272.92/ton in 2012 dollars).

Water savings were also calculated as part of this analysis. As it is assumed that solar PV displaces electricity generated using natural gas, the corresponding average water intensity figure from *The Water-Energy Nexus: Adding Water to the Energy Agenda* (217.5 gal/MWh) was used to estimate overall water savings.

6.2 *Scenario Analysis*

The NREL JEDI Scenario PV Model[33] provides estimates of the jobs, earnings, and economic output of attaining the Million Solar Roofs campaign, as well as annual estimates of installed capacity and costs required to determine sales, property, and income tax revenues and environmental impacts. Running the JEDI Scenario PV Model requires only a few basic inputs: geographic location, start and end years of analysis, a deployment goal (i.e., the number of megawatts of capacity to be installed between the start and end dates), and a distribution of this goal across market segments. For the Colorado "Scenario Analysis", a start and end dates of 2013 and 2030, respectively, were chosen in accordance with the timeline for the Million Solar Roofs campaign. To meet the goal of the campaign, 2,750 MW of solar PV will need to be installed by 2030. This deployment goal was divided among market segments roughly according to the current composition of the Colorado solar market (25% Residential, 6% Small Commercial, 19% Large Commercial, and 50% Utility).

Based on these inputs, the JEDI Scenario PV Model automatically produces estimates of installed capacity (based on a constant rate of annual increase) and costs for each year. No changes were made to these defaults for the "Scenario Analysis".

The annual installed capacity and cost estimates produced by JEDI were then used to estimate tax revenues and environmental impacts according to the processes outlined above for the "Industry to Date Analysis". Due to uncertainties in future rate changes, tax revenue estimates (including property, sales, and income) in the "Scenario Analysis" were produced using averages of actual tax rates from each year in the "Industry to Date Analysis". For example, future property tax revenues for the remainder of 2013 through 2030 were estimated using county mill levies averaged over the 2007-2012 period. Where they both apply and are known, any expected changes to current policies are assumed to occur as planned (e.g., the sunset of the state sales tax incentive in 2017). To account for the time value of money, all monetary values were converted into nominal year dollars using the GDP chain-type price index, and then converted to present value at a 3% discount rate.

Estimates of environmental benefits in the "Scenario Analysis" are based on the same figures listed in Tables 6.5 and 6.6.[34] The only exception to this is the Social Cost of Carbon estimate, which is expected to increase at annual growth rates of 3.2% from 2010-2020 and 2.1% from 2020-2030.[35] The "Scenario Analysis" also uses the same estimate of water intensity employed in the "Industry to Date Analysis".

[33] Available for download at www.nrel.gov/analysis/jedi/download.html

[34] Use of these figures assumes no changes in relevant emission rates and avoided damage values from the present onward.

[35] Interagency Working Group on Social Cost of Carbon, United States Government. "Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866." May 2013. Available at: www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf