



8.2 Megawatt Alamosa Photovoltaic (PV) Solar Array in Alamosa, Colorado - SunEdison & Zinn Photography.

Investing in the Sun

Economic and Environmental Benefits of Developing 1,000 Megawatts of Distributed Generation Solar in Colorado

Colorado is quickly becoming a leader in the “New Energy Economy” as the state pursues one of the most ambitious clean energy requirements in the country-- a 30% renewable electricity standard by 2020. Even under current law, Colorado is already ahead of the curve, requiring 20% of the state’s electricity to come from renewable resources, with 0.8% of total electricity coming from solar energy. The specific solar standard requires that half of the solar brought online must come from “distributed generation” (DG) solar that is located on-site at customers' homes and businesses. While both large-scale central station and DG solar have an important role in the state’s clean energy future, as the industry has developed over the past few years it has become clear that DG solar brings a particular set of benefits to Colorado. DG solar supports local business growth and allows every Coloradan to directly contribute to the New Energy Economy by producing their own clean electricity. DG solar also helps utilities reduce costs of purchasing expensive peak power electricity and updating grid infrastructure-- all cost savings that ultimately benefit ratepayers.

With the Colorado Legislature poised to dramatically increase the state's commitment to clean energy, Vote Solar and Environment Colorado examined the economic and environmental benefits that Colorado can expect from generating roughly 3% of electricity sales from DG solar, and expanding this requirement to include all electricity producers in the state. Such a goal roughly equates to 1,000 MW of DG solar energy by 2020, enough solar to power 146,000 Coloradan homes. Creating an aggressive DG requirement would unlock more of the state’s valuable solar energy resource, spurring job growth and associated environmental benefits.

Summary of Potential Benefits

JOBS	33,325 Total New Construction-Period Jobs
ECONOMIC DEVELOPMENT	\$4.3 Billion in Lifetime Economic Output
WATER SAVINGS	6.8 Billion Gallons of Water. Equal to the Annual Consumption of 3,300 homes.
CLEANER AIR	30 Million Tons of CO ₂ Avoided. Equivalent to Taking 669,730 Cars off the Road.

JOB CREATION AND ECONOMIC DEVELOPMENT

EMPLOYMENT

DG solar creates more jobs per megawatt than any other energy source.¹ According to the Colorado Solar Energy Industries Association’s calculations, more than 230 solar companies (both photovoltaic (PV) and solar thermal) are currently operating in the state in 2009, employing over 2,500 people. With an increased DG solar goal, the local solar industry will expand to become a major employer in the state. In short, an investment in DG solar is a direct investment in local jobs. Analysis using the Department of Energy’s JEDI (Jobs and Economic Development Impact) PV model indicates that a 1,000 MW DG solar program could support 217 permanent O&M jobs in the state by 2020¹ (See Appendix B for JEDI model assumptions and analysis). On average, 3,333 construction period jobs could be supported

On Average
over 3,000
Construction-
Period Jobs
Supported Each
Year
(see footnote)

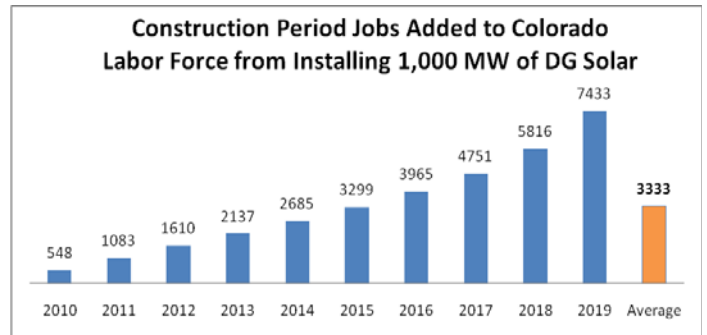
¹ Analysis assumes operation period jobs persist for the full 25-year life of the DG solar projects.

each year, with a peak of over 7,400 construction period jobs in year-ten of the program.^{2 3}

Projected Employment Impacts of Installing 1,000 MW DG Solar	Employment Benefits
Long-term O&M Jobs (total by 2020)	217
Construction Period Jobs (average per year)	3,333
Peak-Year Construction Period Jobs	7,433
Total Construction Period Jobs	33,325

ECONOMIC ACTIVITY GENERATED

In addition to job growth, the construction/installation and ongoing operation and maintenance of the PV systems would drive significant economic activity. Over a conservative 25-year projected lifetime, 1,000 MW of DG solar would add approximately \$1.72⁴ billion in total earnings to the state’s taxable income. The state could expect another \$4.27 billion in total economic output. Economic output refers to the total value of goods and services (intermediate and final) generated in the state as a result of the installation and operation of the DG solar systems. Additionally, Colorado could collect nearly \$457 Million in property taxes⁵ over that 25-year period and \$16.9 Million in sales taxes⁶ over the 10-year build up.



It is likely that such an investment in DG solar could bring solar and related manufacturing to Colorado. The economic impact of such manufacturing development is not included in this analysis, but would add significant additional benefits for the state.

Projected Economic Benefits 1,000 MW DG Solar	Total Benefits (\$2009)
Lifetime Earnings	\$1.719 billion
Lifetime Economic Output	\$4.267 billion
Lifetime Sales & Property Taxes Paid	\$474 million (\$457 Million in property tax, \$16.9 Million in sales taxes)

TYPES OF JOBS

The American Solar Energy Society’s recent report on job creation in Colorado’s New Energy Economy highlights the robust range of jobs a 1,000 MW DG solar program would support. Growth in the solar industry means jobs for electricians, builders, contractors, engineers, technicians and salespeople. From a job as a system installer who can make at least \$30K a year with a high school GED, to a power system engineer who can make more than \$75K with a master’s degree, solar creates jobs suitable for all education levels and salary requirements.ⁱⁱ

² Analysis assumes that construction period jobs are inherently short-term. One construction period job is defined as one 2,080-hour working period or one full-time job for 1 year. The annual construction period employment impact varies depending on the length of the construction/installation process and the number of individuals employed. Two construction period jobs can be satisfied by one worker working two years or two workers 1 year. Construction period jobs include direct, indirect and induced employment opportunities.

³ Employment benefits are presented as ‘gross jobs.’ If other fuel sources are displaced, there may be a correlated loss of jobs in other energy sectors. This analysis does not look at net job creation.

⁴ Earnings and economic output used in this report include direct, indirect and induced benefits.

⁵ Property tax revenue was calculated for commercial property only. An average property tax rate for commercial/industrial facilities was calculated using the 2009 renewable personal property rate, weighted by county and population. The statewide weighted average rate for 2010 was assumed to be \$26.182/kW.

⁶ Sales taxes were estimated assuming the state sales tax exemption remains in place for the full ten-year program. An evaluation of county and special district sales tax exemptions was completed for this analysis. The resulting sales tax rate was derived by taking the average tax rates by county, weighted by population, where no known solar exemption existed at the time of this analysis. The weighted average non-exempt sales tax rate used was .744%.

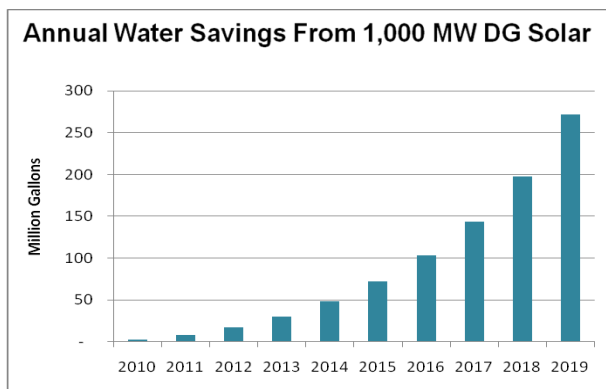
WATER SAVINGS

Colorado’s growing population, agricultural industry, and recreation sector all rely on the state’s limited water resources. Unlike most thermoelectric coal- or natural gas-fired power plants, solar PV does not use water in the electricity generation process⁷. Developing a stronger PV program would help meet Colorado’s water conservation needs: 1,000 MW of solar would save almost *6.8 billion gallons of water* over the lifetime of the PV panels. By 2019, annual water savings (approximately 271 million gallons) could meet the consumption needs of over 3,300 households. For the purposes of this study, we conservatively assume solar PV displaces electricity generated at a combined cycle natural gas plant. In reality, electricity from solar PV panels could displace electricity from even more water intensive resources such as coal, which uses up to three times as much water as natural gas plants.



VALUE OF WATER SAVED

Water conservation in Colorado is becoming increasingly important as rising demand drives the cost of this limited natural resource ever higher. In recent years, municipal utilities developing new water supplies along the Front Range have paid from \$28,000 to over \$61,000 per million gallons. Several cities along the Front Range now charge upwards of \$20,000 for a “tap” for a new house – the equivalent of over \$123,000 per million gallons.⁸



The monetary value of water depends on a host of factors, including whether it can be transferred to a city.

Assuming the water could be applied to a “high value” use (like a growing city); the value of the water saved in 2019 could be as high as \$33.3 million (2009 dollars). This value will only increase as rising pressure is put on the state’s finite water resource.

Monetary Value of Displacing Water Associated with Meeting 1,000 MW DG Solar Goal	
Acre-feet Saved	Dollar Value (\$\$ 2009)
Solar PV displaces electricity from a Combined Cycle Natural Gas Plant: 833 AF/yr Conserved	\$7.5 to \$33.3 Million

CLEANER AIR

Currently, 90% of Colorado’s electricity is produced from burning fossil fuels, primarily coal or natural gas.ⁱⁱⁱ This type of electricity generation produces a range of unavoidable harmful pollutants such as mercury, nitrogen monoxide, nitrogen dioxide, sulphur dioxide, nitrous oxide, and carbon dioxide. The result is a host of negative impacts from asthma and acid rain to water contamination and global climate change.

Equivalent to taking roughly **670,000** cars off the road

Solar energy is an effective pollution mitigation tool because it offsets dirtier fossil generation resources, such as natural gas and coal. By installing 1,000 MW of solar power on homes, businesses, and ranches across Colorado we avoid emitting millions of tons of the dangerous pollutants that are already

⁷ PV requires a minimal amount of water for cleaning panels, particularly for larger commercial installations.

⁸ The cities of Aurora, Broomfield, Castle Rock, Louisville, Thornton, and numerous others all charge over \$20,000 for a potable water tap fee; most cities assume a tap provides 160,000 gallons/year (0.5 AF/year) to a household.

clouding the state. Going solar cuts down Colorado's global warming pollution, improves public health, and significantly improves our quality of life.

REDUCING GLOBAL WARMING POLLUTANTS

Three byproducts of fossil-fuel based energy production - carbon dioxide, methane, and nitrous oxide - are also the three largest sources of global warming pollution. In Colorado, global warming will have many impacts, but perhaps most worrisome may be the loss of mountain snow pack. Rising temperatures will lead to less snow, which threatens our thriving ski industry and already constrained water resource during the summer months.

In 2008, the Governor issued an Executive Order establishing a goal of achieving an 80% reduction in global warming pollution from 2005 levels by 2050. Increasing electricity from solar energy would help the state achieve this important goal. The emissions reductions from installing 1,000 MW of DG solar would be equivalent to shutting down all existing electricity production in Colorado for 8 months or a single coal fired power plants for 8 years.^{iv} In total, the avoided emissions of CO2, methane and N2O would be equivalent to taking 669,730 cars off the road.

REDUCING HEALTH HAZARDS

Asthma and Other Chronic Bronchial Conditions -

Nitrogen oxides (known collectively as NOx) and sulphur dioxide (SO2) are harmful pollutants that are produced in the process of fossil fuel combustion. Emitted into the atmosphere, they form small

Particulate Matter (PM) that can be inhaled deeply, thus evading the human lungs' natural defenses. PM has been consistently linked with increased mortality from cardiopulmonary diseases, lung cancer and numerous other respiratory illnesses and associated morbidity. Long-term exposure to fine particle pollution has been found to be as dangerous as second hand smoke.^v

Asthma is an increasingly common childhood disease. Around 89,000 children in Colorado have asthma and complications from the condition lead to over half a million missed school days per year in the state.^{vi} PM is known to exacerbate the condition, leading to more asthma attacks and asthma-related illness. The rise in levels of fine particles may also be responsible for the rising incidence of the condition.

NOx is also a key contributor to Colorado's current ground level ozone problem, which increases the risk of serious chronic respiratory problems. The state's summertime levels already exceed federal health standards, and continued noncompliance could result in penalties. Installing 1,000 MW of solar would prevent the emission of over 75,000 tons of NOx and SO2.

Mercury Accumulation – Burning coal is responsible for 57% of man-made mercury, which accumulates in the earth and water. Exposed continuously to mercury in our streams and lakes, our fish build up concentrations of the toxic compound in their bodies. Approximately 30% of all lakes sampled in Colorado exceed the EPA fish tissue standard for mercury.^{vii} When consumed by humans and animals, mercury causes damage to the nerves, brain, kidney, and unborn children. Installing 1,000 MW of solar would prevent the emission of over 400 pounds of mercury per year helping to protect human health and making our lakes and fish safer.

Clean Air Benefits	
Total Avoided Tons of CO2	30,268,283
Methane Avoided (lbs)	833,071
N2O Avoided (lbs)	766,897
Mercury Avoided (lbs)	437
NOx Avoided (tons)	37,472
SO2 Avoided (tons)	37,927



ECOSYSTEM HEALTH

The environment of the Rocky Mountain West is part of what makes Colorado an attractive place to live and visit--

and air pollution puts that environment at risk. Particulates dramatically reduce visibility, causing what has become a familiar haze over our many protected parks, forests, and wilderness. By adding solar, we are taking steps not only to preserve our most beautiful views for the future, but also protecting the main draw for our \$9.8 billion tourism industry.^{viii}

Colorado's wildlife also suffers from the pollutants caused by fossil fuel combustion. Increasing levels of contamination have been shown to cause genetic disorders and reproductive failure in many marine species. New research has found that nitrogen oxide increased fourfold over the past 20 years in lakes above timberline at Rocky Mountain National Park, changing lake biology. Along with mercury, it threatens the long-term survival of fish.

CONCLUSION

All across the country and around the world, the race is on to build renewable energy markets - vibrant new hubs of green job creation, renewed investment and economic opportunity. Now is the time for Colorado to strengthen its foundation for success in this new energy economy. Sound renewable energy policies enacted today will deliver benefits immediately and for generations to come.

Colorado has shown impressive early leadership by setting a strong renewable portfolio standard with a solar requirement. Ramping up the DG solar requirement would unlock more of the state's valuable solar energy resource, spurring job growth and associated environmental benefits. Setting a strong DG solar goal, combined with a skilled workforce, streamlined permitting, project finance assistance, and attractive tax policy will help to position Colorado as a leader in solar development. As this report shows, developing 1,000 MW of DG solar helps protect the state's environment, cuts global warming emissions and ensures that Colorado stays at the forefront of a thriving green energy economy.

APPENDIX A: Market Segmentation Assumptions

1 Gigawatt Solar Program - Hypothetical Market Segmentation													TOTAL
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
Allocation (% of Prog. Target Installed/Yr)		1.0%	2.1%	3.3%	4.8%	6.6%	8.8%	11.4%	14.9%	19.8%	27.3%		
Total MW Installed / Yr.		9.64	20.67	33.41	48.32	66.04	87.54	114.38	149.26	197.64	273.10	-	
Weighted Avg Non-Exempt Sales Tax Rate	0.744%	0.744%	0.744%	0.744%	0.744%	0.744%	0.744%	0.744%	0.744%	0.744%	0.744%	0.744%	
Comm/Ind Avg Weighted Property Tax/kW (2MW & Under)	\$ 26.18	\$ 26.71	\$ 27.24	\$ 27.78	\$ 28.34	\$ 28.91	\$ 29.48	\$ 30.07	\$ 30.68	\$ 31.29	\$ 31.92		
Property Tax Assessed Value % Increase	12.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%		
Residential - Retro kW Target		3,663.1	7,750.4	12,362.1	17,637.1	23,775.1	30,640.3	38,888.6	49,256.7	61,267.1	79,198.5	-	
Avg Sys Size (kW _{DC})		4.9	5.1	5.3	5.5	5.7	6.0	6.2	6.4	6.7	7.0	7.3	
% Change in System Size			4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	
Number of Systems Installed		747.6	1,520.9	2,332.5	3,199.9	4,147.6	5,139.6	6,272.3	7,639.0	9,136.2	11,355.9	-	
Allocation (% of Total kW _{DC} Installed)		38.0%	37.5%	37.0%	36.5%	36.0%	35.0%	34.0%	33.0%	31.0%	29.0%	27.0%	
Avg Installed Cost (\$/kW _{DC})	\$ 7.00	\$ 6.44	\$ 5.92	\$ 5.45	\$ 5.01	\$ 4.61	\$ 4.24	\$ 3.90	\$ 3.59	\$ 3.31	\$ 3.04	\$ 3.04	
% Change in Installed Cost		8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	
Annual Direct O&M Costs (\$/kW _{DC})	\$ 10.00	\$ 9.50	\$ 9.03	\$ 8.57	\$ 8.15	\$ 7.74	\$ 7.58	\$ 7.43	\$ 7.36	\$ 7.28	\$ 7.21	\$ 7.21	
% Change in Direct O&M Cost		5%	5%	5%	5%	5%	2%	2%	1%	1%	1%		
Residential - New kW Target		192.8	516.7	1,002.3	1,691.2	2,641.7	4,377.2	6,862.7	10,448.4	17,787.2	30,040.8	-	
Avg Sys Size (kW _{DC})		2.5	2.7	2.9	3.1	3.4	3.7	4.0	4.3	4.6	5.0	5.4	
% Change in System Size			8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	
Number of Systems Installed		77.1	191.4	343.7	537.0	776.7	1,191.6	1,729.9	2,438.6	3,844.0	6,011.2	-	
Allocation (% of Total kW _{DC} Installed)		2.0%	2.5%	3.0%	3.5%	4.0%	5.0%	6.0%	7.0%	9.0%	11.0%	13.0%	
Avg Installed Cost (\$/kW _{DC})	\$ 7.00	\$ 6.44	\$ 5.92	\$ 5.45	\$ 5.01	\$ 4.61	\$ 4.24	\$ 3.90	\$ 3.59	\$ 3.31	\$ 3.04	\$ 3.04	
% Change in Installed Cost		8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	
Annual Direct O&M Costs (\$/kW _{DC})	\$ 10.00	\$ 9.50	\$ 9.03	\$ 8.57	\$ 8.15	\$ 7.74	\$ 7.58	\$ 7.43	\$ 7.36	\$ 7.28	\$ 7.21	\$ 7.21	
% Change in Direct O&M Cost		5%	5%	5%	5%	5%	2%	2%	1%	1%	1%		
Small Commercial kW Target		1,253.2	2,686.8	4,343.4	6,281.7	8,585.5	11,380.7	14,869.2	19,404.1	25,692.7	35,502.8	-	
Avg Sys Size (kW _{DC})		25	26.5	28.1	29.8	31.6	33.5	35.5	37.6	39.8	42.2	44.8	
% Change in System Size			6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	
Number of Systems Installed		50.1	101.4	154.6	211.0	272.0	340.2	419.3	516.2	644.8	840.6	-	
Allocation (% of Total kW _{DC} Installed)		13.0%	13.0%	13.0%	13.0%	13.0%	13.0%	13.0%	13.0%	13.0%	13.0%	13.0%	
Avg Installed Cost (\$/kW _{DC})	\$ 7.00	\$ 6.44	\$ 5.92	\$ 5.45	\$ 5.01	\$ 4.61	\$ 4.24	\$ 3.90	\$ 3.59	\$ 3.31	\$ 3.04	\$ 3.04	
% Change in Installed Cost		8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	
Annual Direct O&M Costs (\$/kW _{DC})	\$ 12.00	\$ 11.40	\$ 10.83	\$ 10.29	\$ 9.77	\$ 9.29	\$ 9.10	\$ 8.92	\$ 8.83	\$ 8.74	\$ 8.65	\$ 8.65	
% Change in Direct O&M Cost		5%	5%	5%	5%	5%	2%	2%	1%	1%	1%		
Large Commercial kW Target		3,566.7	7,647.0	12,362.1	17,878.7	24,435.6	32,391.2	42,319.9	55,227.2	73,125.3	101,046.3	-	
Avg Sys Size (kW _{DC})		500	540.0	583.2	629.9	680.2	734.7	793.4	856.9	925.5	999.5	1,079.5	
% Change in System Size			8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	
Number of Systems Installed		7.1	14.2	21.2	28.4	35.9	44.1	53.3	64.4	79.0	101.1	-	
Allocation (% of Total kW _{DC} Installed)		37.0%	37.0%	37.0%	37.0%	37.0%	37.0%	37.0%	37.0%	37.0%	37.0%	37.0%	
Avg Installed Cost (\$/kW _{DC})	\$ 6.00	\$ 5.52	\$ 5.08	\$ 4.67	\$ 4.30	\$ 3.95	\$ 3.64	\$ 3.35	\$ 3.08	\$ 2.83	\$ 2.61	\$ 2.61	
% Change in Installed Cost		8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	
Annual Direct O&M Costs (\$/kW _{DC})	\$ 12.00	\$ 11.40	\$ 10.83	\$ 10.29	\$ 9.77	\$ 9.29	\$ 9.10	\$ 8.92	\$ 8.83	\$ 8.74	\$ 8.65	\$ 8.65	
% Change in Direct O&M Cost		5%	5%	5%	5%	5%	2%	2%	1%	1%	1%		
Utility kW Target		964.0	2,066.8	3,341.1	4,832.1	6,604.2	8,754.4	11,437.8	14,926.3	19,763.6	27,309.8	-	
Avg Sys Size (kW _{DC})		1,000	1,100.0	1,210.0	1,331.0	1,464.1	1,610.5	1,771.6	1,948.7	2,143.6	2,357.9	2,593.7	
% Change in System Size			10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	
Number of Systems Installed		1.0	1.9	2.8	3.6	4.5	5.4	6.5	7.7	9.2	11.6	-	
Allocation (% of Total kW _{DC} Installed)		10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	
Avg Installed Cost (\$/kW _{DC})	\$ 5.50	\$ 5.06	\$ 4.66	\$ 4.28	\$ 3.94	\$ 3.62	\$ 3.33	\$ 3.07	\$ 2.82	\$ 2.60	\$ 2.39	\$ 2.39	
% Change in Installed Cost		8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	
Annual Direct O&M Costs (\$/kW _{DC})	\$ 12.00	\$ 11.40	\$ 10.83	\$ 10.29	\$ 9.77	\$ 9.29	\$ 9.10	\$ 8.92	\$ 8.83	\$ 8.74	\$ 8.65	\$ 8.65	
% Change in Direct O&M Cost		5%	5%	5%	5%	5%	2%	2%	1%	1%	1%		
Annual MWs Installed		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
Residential		9,639.8	20,667.7	33,411.0	48,320.8	66,042.0	87,543.9	114,378.1	149,262.7	197,635.9	273,098.1	-	
Non-Residential		3,855.9	8,267.1	13,364.4	19,328.3	26,416.8	35,017.5	45,751.2	59,705.1	79,054.4	109,239.3	-	
TOTAL		5,783.9	12,400.6	20,046.6	28,992.5	39,625.2	52,526.3	68,626.9	89,557.6	118,581.5	163,858.9	1,000,000.0	

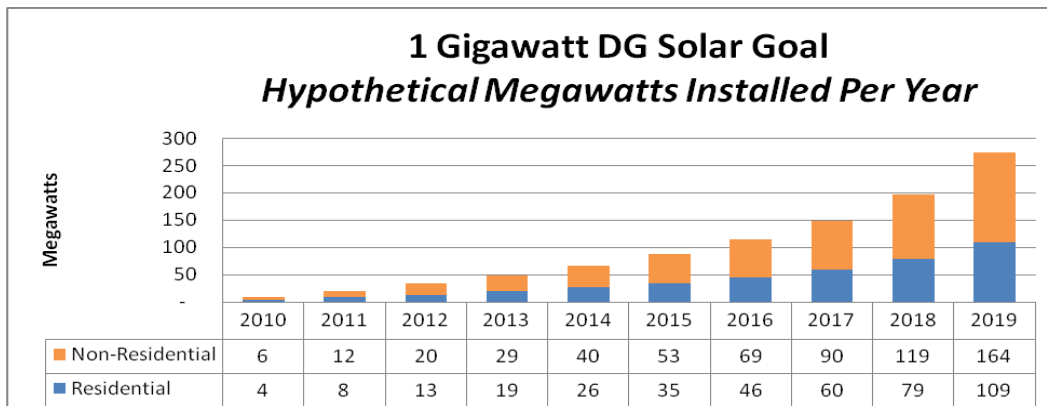
APPENDIX B: Methodology- JEDI Model Description

The model used in this analysis is the Job and Economic Development Impact (JEDI) model developed by the National Renewable Energy Laboratory (NREL) for distributed generation solar projects. This model uses the IMPLAN Professional input-output economic model. This type of economic model shows the effects of a series of expenditures throughout the economy in a given region. In this instance, the model shows the jobs, earnings and total economic output in the state created by the construction and operation of a solar project.

This analysis was performed for 1000 MWs of DG solar. The JEDI model was run for each year in each market segment (existing residential, new construction residential, small commercial, large commercial, and utility-scale), and the results for the 50 runs were tallied together. Sales and property taxes were calculated separately and inputted into the model for each run. All financial results are presented in 2009 dollars.

APPENDIX C: HYPOTHETICAL 1,000 MW DG SOLAR BUILD-UP

The following economic and environmental benefit analysis is based on a gradual increase of DG solar installed across the state over ten years (See Appendix A for detailed installation assumptions). For this report we chose a *hypothetical* build-out scenario where 40% of the solar installations would be small-scale systems on homes and businesses, and 60% would be commercial-scale applications, such as a 1-MW free-standing solar array. Note that the assumptions used in this report **are not intended** to be viewed as a suggestion for actual market segmentation under a 1,000 MW solar goal. The *actual* breakdown in residential and commercial scale solar installations under a 1,000 MW DG solar goal would be determined by policy decisions.



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