SER Strategic Economic Research, LLC

ECONOMIC, ENVIRONMENTAL, & PUBLIC HEALTH BENEFITS OF RESIDENTIAL SOLAR IN COLORADO

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I. Executive Summary

The purpose of this report is to aid decision makers in evaluating the positive impact of residential net metered solar in the State of Colorado. The basis of this analysis is to study the direct, indirect, and induced impacts of residential solar on the state's total economic output, job creation, wages, the environment, and public health benefits.

Residential solar refers to solar photovoltaic (PV) panels which use sunlight to generate electricity installed on homes and residential buildings. These can be either rented or owned by the homeowner. The home consumes some or all of the electricity generated by the panels rather than purchasing all electricity from the local utility. During hours in which the panel is not generating electricity or the amount consumed is greater than the amount produced, the household purchases electricity from the local utility. If the panels produce more electricity than is consumed by the household during a period of time, that electricity gets fed back into the local power grid and flows to the nearest neighbor in need of electricity at that time. Net metering is a billing system that credits solar owners for the power that they generate and share with their neighbors. The term net metering specifically refers to a one-to-one credit system in which the amount of electricity provided to the utility is credited to the house at the same price as the household purchases electricity, also called "retail-rate." Net metered residential solar is typically governed at the state level.

The State of Colorado was home to more than 106,000 residential solar installations in 2022 (Statista, 2023). These residential solar installations in Colorado represent a total investment in excess of $938 million over the last 13 years. This residential solar development has resulted in the following:

Economic Impact, Environmental Benefits, and Public Health Benefits

Economic Impact

- Over $2.6 billion in new local Gross State Product (GSP) for the State of Colorado from net metered residential solar projects from 2011-2023
- 8,700 long-term jobs for Colorado from net metered residential solar projects from 2011-2023
- Over $742.5 million in labor earnings for the State of Colorado from residential solar projects

Environmental Benefits

- Over 3.2 million tons of total pollution reduction for the State of Colorado from net metered residential solar projects from 2014-2023

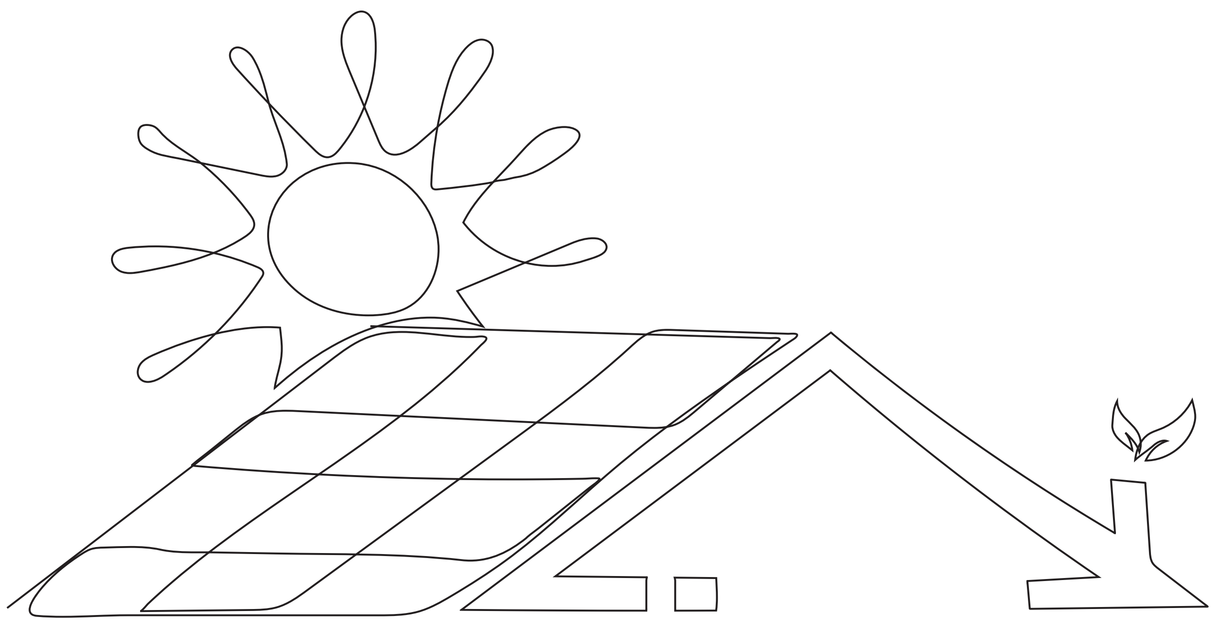
Public Health Benefits

- Over $30 million in estimated monetary value of statewide health incidence reduction in the State of Colorado from net metered residential solar projects from 2014-2023
- Between $89-$132 million in estimated monetary value of Colorado's emission reductions from net metered residential solar projects on national health from 2014-2023

II. Introduction

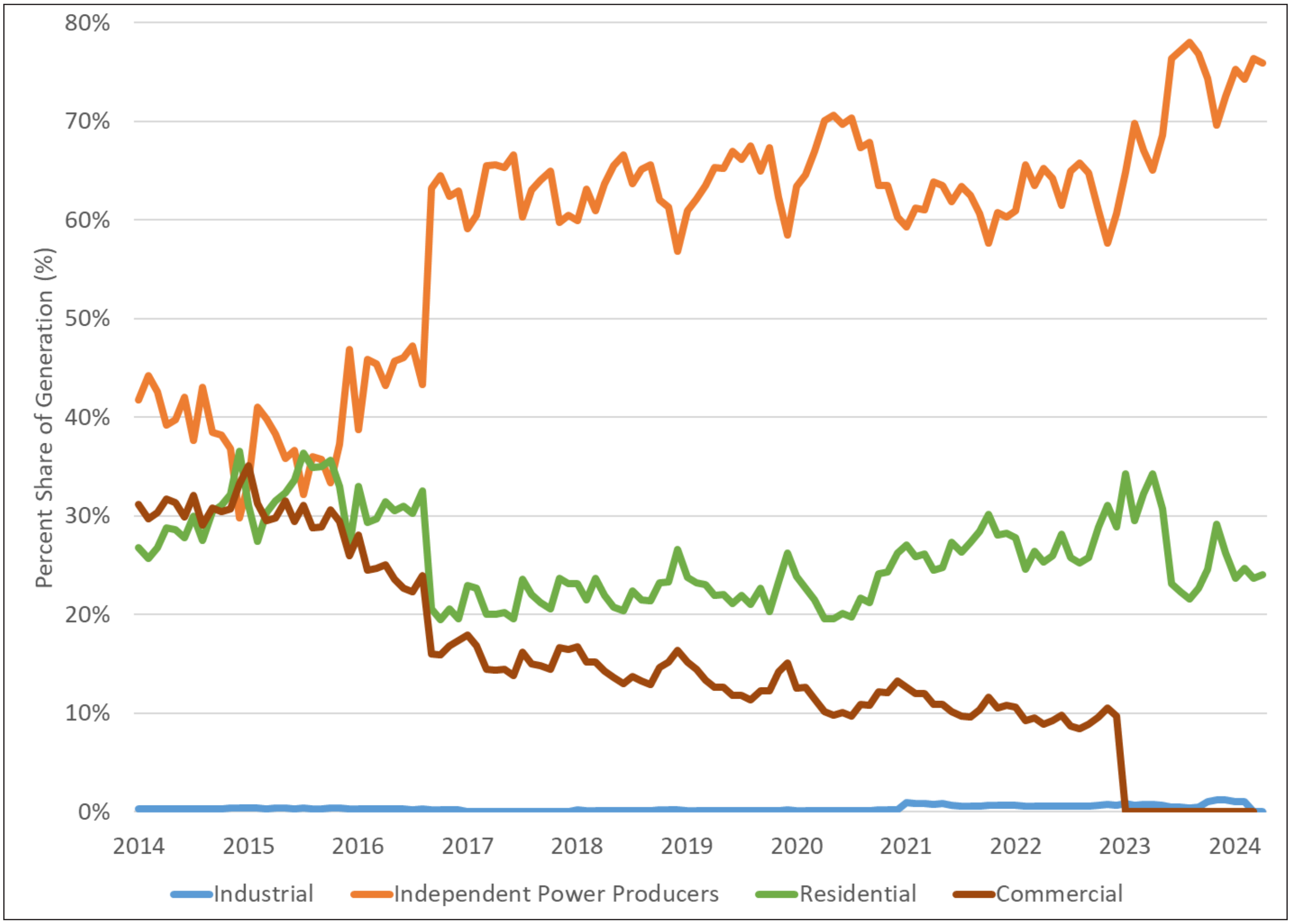
This report reviews the state of residential rooftop solar in Colorado, discusses the many benefits it provides, and provides evidence as to why Colorado should protect full retail-rate net metering for residential solar in the state. Using data from the Energy Information Administration (EIA), the Environmental Protection Agency (EPA), and the National Renewable Energy Laboratory (NREL), we estimate the economic impacts of net metered residential solar installations in Colorado since 2011 and environmental and public impacts since 2014.

The following sections provide background on the state of residential solar in Colorado; an analysis of the economic, environmental, and public health impacts of net metered residential solar installations; and policy recommendations for moving forward.



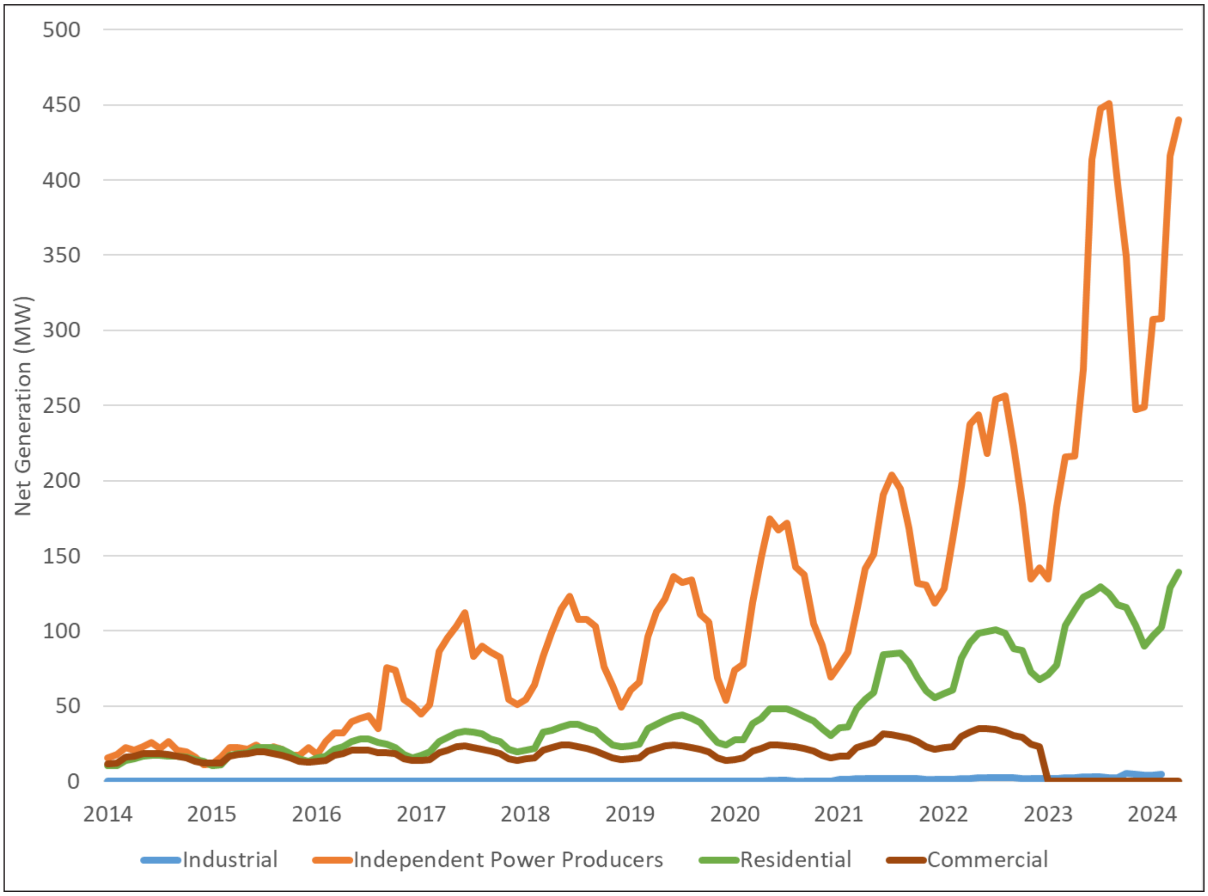
As of June 2024, the State of Colorado ranks 12th in the United States for annual solar capacity additions, increasing from 1,656 MW added in 2023 to 4,167 MW added in 2024 (SEIA, 2024). Approximately 9.9% of Colorado's electricity comes from solar generation (SEIA, 2024). As shown in Figure 1, around 76% of solar-generated electricity in Colorado comes from large-scale plants operated by independent power producers and 24% comes from small-scale residential solar (EIA, 2024). The share of net solar generation from the residential sector has fluctuated, but remained between 19 and 37% since 2014, with an average share of 26% from 2014 to 2024 (EIA, 2024). In the United States, 59% of solar-generated electricity comes from independent power producers and 20% from residential solar, with electric utility generators, commercial generators, and industrial generators providing the remaining solar generation (EIA, 2024). An estimated 86% of buildings in Colorado are viable for rooftop solar panel installation, with only 1% of the viable rooftop solar potential already tapped (Perry, 2024; Google Project Sunroof, 2018). As shown in Figure 2, total solar generation in Colorado has increased over the last 10 years, with independent power producers and residential producers contributing the most to net solar generation in Colorado (EIA, 2024).

Figure 1 – Net solar generation share by sector in Colorado (percent share), January 2014-April 2024



Source: U.S. Energy Information Administration, Net solar generation from all sectors in Colorado monthly, January 2014-April 2024

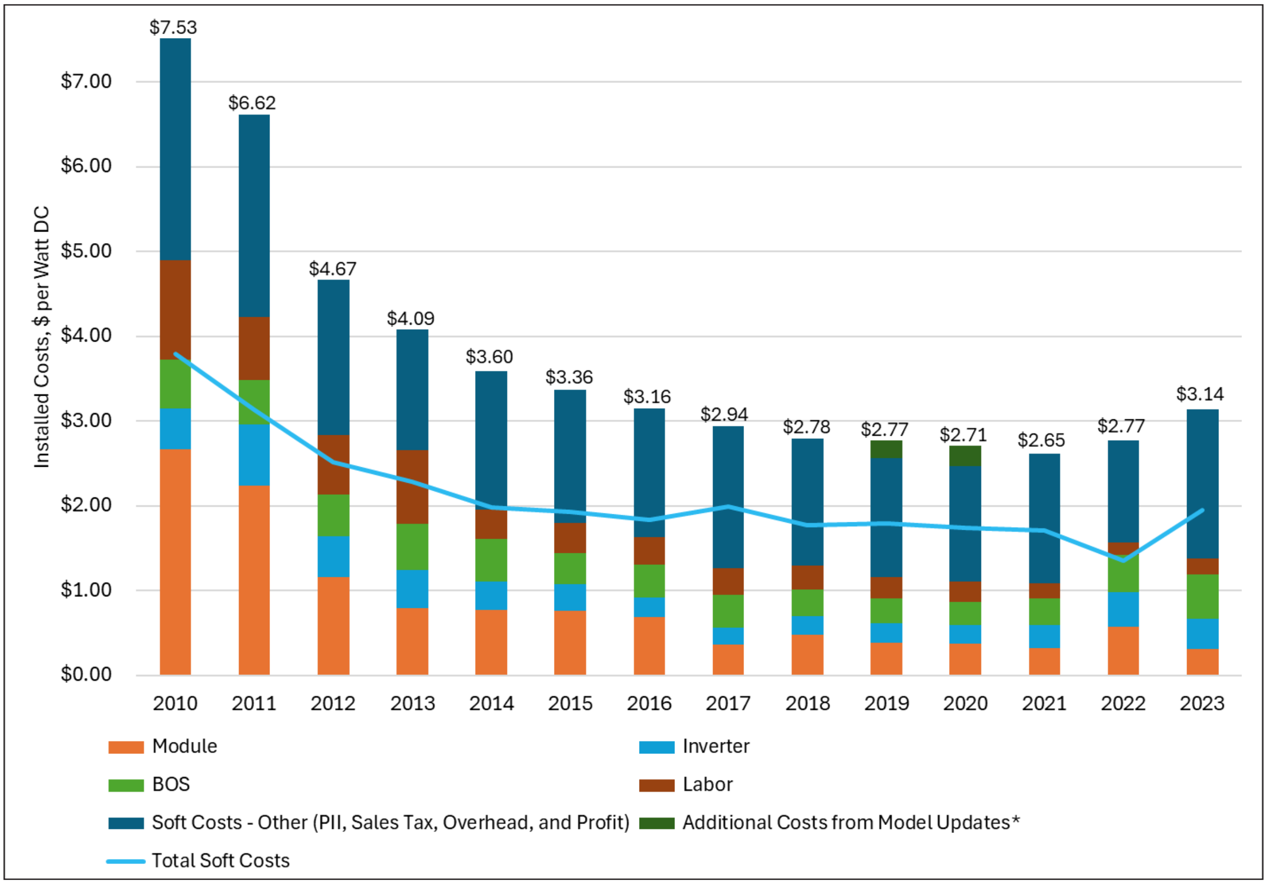
Figure 2 – Net solar generation by sector in Colorado (thousand megawatt hours), January 2014-April 2024



Source: U.S. Energy Information Administration, Net solar generation from all sectors in Colorado monthly, January 2014-April 2024

One barrier to adopting residential solar is the large financial investment required to cover hardware costs and costs from permitting, inspections, installation labor, and interconnection to the local grid (Doerfler and Toering, 2024). According to Figure 3, the average total cost of residential-scale rooftop solar in Colorado was $7.53/watt in 2010 and $3.14/watt in 2023, an overall decrease of $3.77/watt (NREL, 2023). Though the overall cost of installing rooftop solar panels has decreased significantly over time, changes in soft costs have been limited (SEIA, 2024). Without supportive policies and programs, low-income households are far less likely to lease or purchase solar due to these persistent costs and other financial barriers, despite the overall benefits (Doerfler and Toering, 2024). Bauner and Crago (2015) find that the projected savings of a solar PV array must be at least 60 percent greater than installation costs for the average United States household to invest.

Figure 3 – Installed Costs of Residential-Scale Solar in the United States from 2010 to 2023 (adjusted for inflation)



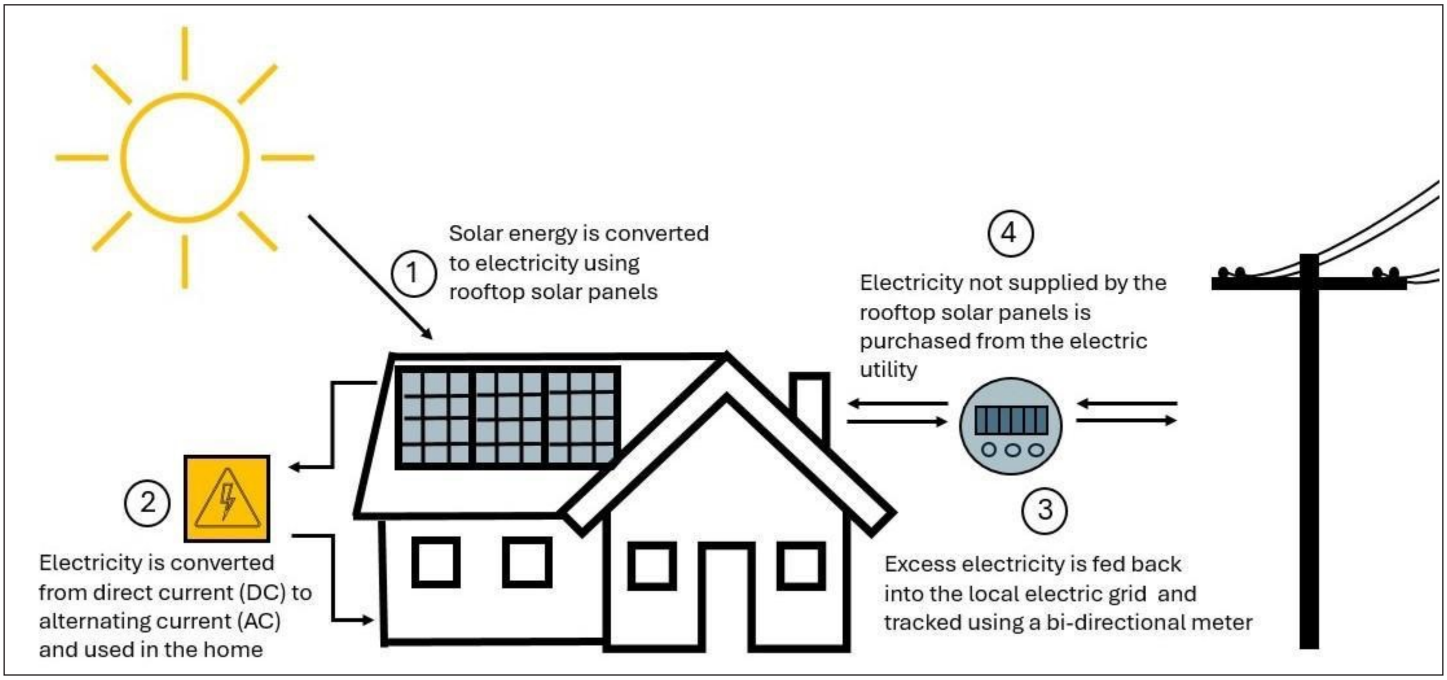
Source: National Renewable Energy Laboratory (NREL), U.S. Solar Photovoltaic System and Energy Storage Cost Benchmark: Q1 2020, Q1 2022, Q1 2023. Adjusted for inflation using 2019$.

In the United States, the median income of solar adopters was around $115,000 in 2020, which is nearly double the median income for all households of $63,000 a year (Barbose et. al., 2022). This median income has declined from $138,000 in 2010, indicating that solar is becoming more accessible to low- and moderate-income households, though more progress remains necessary (Barbose et. al., 2022).

Using cost data from EnergySage, Perry (2024) breaks down the average cost of solar panels in Colorado by system size, finding that a typical 5kW system costs $15,650 on average in the state. To encourage more people to invest in residential solar panels, the United States implemented a Federal Solar Investment Tax Credit, allowing an individual tax credit of up to 30% of total solar project costs if the system is purchased rather than leased. Adding the Tax Credit brings the average cost of residential solar panels in Colorado down to $11,581. Colorado also provides a Sales and Use Tax Exemption for Renewable Energy Equipment, and some utility companies offer cash rebates for residents installing solar panels (Perry, 2024).

Net metering is a billing mechanism that allows homeowners to generate and use their own electricity with solar panels, share any excess through the local electric grid, and receive credits on their monthly bill in exchange for that excess energy (Impact Energy, 2023). As shown in Figure 4, rooftop solar panels convert solar energy into direct current (DC) electricity. An inverter changes the electricity from DC to alternating current (AC), which can then be used in the home. Any excess electricity generated is fed into the local electric grid and tracked using a bi-directional meter that allows the utility to credit the homeowner for their excess generation, often monthly. When the solar panels are not actively generating electricity or generating less electricity than needed, the home uses electricity sold by the utility company. At the end of the month, the residential customer is billed for the electricity they purchased from the utility, minus the amount of excess generation they provided to the grid, reducing their electricity bill. The rate at which utilities credit excess solar generation depends on the state and utility, with some offering credits equal to the retail price of electricity (i.e., full retail rate or 1:1 net metering), some offering credits equal to the wholesale rate at which the utility purchases electricity from utility-scale generators, and some requiring a different percentage or mixture of rates based on other metrics.

Figure 4 – Net metered residential solar process

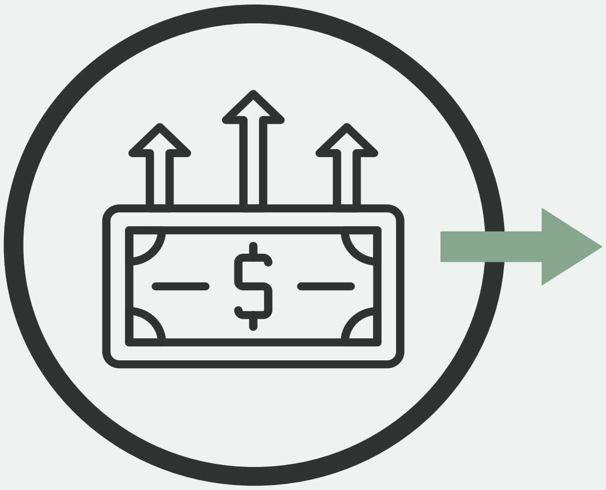


In 2004, Colorado voters passed renewable energy standard Amendment 37, the first statewide renewable energy standard adopted by public initiative in the country (Solar United Neighbors, n.d.). Amendment 37 required utilities to credit customers for their excess generation.

Currently, Colorado policy requires investor-owned utilities to offer net metering for residential systems sized up to 200% of the customer's average annual consumption. Colorado law requires electric cooperatives and municipally owned utilities to offer net metering for residential systems with capacity up to 10kW. Customers of investor-owned utilities, electric cooperatives, and municipally owned utilities receive monthly credits against their consumption for excess generation at a 1:1 ratio, which can be carried forward to the following month. Customers of investor-owned utilities may roll over credits for excess generation or receive compensation at the utility's hourly incremental cost at the end of each calendar year (Schelly, Louie, and Pearce, 2017).

In Colorado's "Greenhouse Gas Pollution Reduction Roadmap 2.0," Governor Jared Polis describes the significant changes made within the state since the first roadmap was implemented in January 2021, including a 95% completion rate of its short-term goals by December 2022. One goal outlined in the initial roadmap was to achieve a 50% reduction in greenhouse gas pollution by 2030, 80% of which was met by fall 2023. The second roadmap proposes an updated goal of reaching a 95% reduction in Colorado's greenhouse gas emissions by 2040 compared to 2005 emissions. Additionally, the state is projected to achieve near-zero emissions from local air pollution by 2040 ("Roadmap 2.0", n.d.).

Net metered residential solar will play an important role in achieving these greenhouse gas emission reduction targets while also ensuring equity during these transitions. Residential solar provides direct savings on energy bills for solar owners, reducing the amount of energy they need to purchase from the local utility and providing credits for the excess electricity their panels contribute to the local grid (Doerfler and Toering, 2024). By reducing the distance between the electricity generation site and the consumption site and in turn reducing wear and tear of the grid, residential solar also provides savings for all utility customers and ratepayers (Schelly, Louie, and Pearce, 2017). This decrease in stress on the grid lowers grid maintenance costs and helps avoid expensive utility upgrades.



To estimate economic impacts stemming from construction of net metered residential solar in Colorado for 2011[1] -2023, SER first gathered $/Wdc data from the Energy Information Agency (EIA) for net metered residential solar installations. Colorado specific residential solar cost data were found in the EIA's 2016-2018 U.S. Solar Photovoltaic BESS System Cost Benchmark Reports. Costs for 2011-2015 and 2019-2023 were calculated by applying national cost trends to the Colorado specific data set and extrapolating forward and backward for the missing study periods. Colorado's residential solar $/Wdc were lower than the national average for 2016-2018, and SER's extrapolation maintained this trend for the other study years.

$/Wdc were gathered or calculated for a myriad of solar cost categories, but only a select few are relevant for Colorado economic impacts. Money expected to have been spent at Colorado firms would have created economic impacts in Colorado, so money flowing out-of-state was not an input for SER's Colorado specific economic impact models. Major equipment categories like modules, inverters, and balance of system costs were excluded due to the assumption that these costs were spent outside of the study area. Soft costs such as installation labor, permitting, inspection, interconnection, customer acquisition, overhead, and sales tax were costs assumed to have been spent in Colorado and, therefore, included in economic modeling.

Monetary inputs for IMPLAN modeling were calculated by multiplying each category's $/Wdc by the amount of net metered residential solar added in Colorado each year from 2011-2023. Solar additions data were also sourced from the EIA. Table 1 shows the modeling inputs for each year of study in 2018 dollars.

Table 1 – IMPLAN inputs for Net Metered Residential Solar in Colorado (2018$)

Sector #	Sector Description	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
457	Architectural, engineering, and related services	$7,469,803	$10,716,993	$11,528,131	$20,870,248	$20,215,677	$14,148,922	$0	$27,471,918	$0	$22,071,493	$86,630,824	$42,357,687	$111,490,876
465	Advertising, public relations, and related services	$6,374,219	$9,145,149	$9,837,318	$17,809,242	$17,250,676	$12,073,722	$0	$25,344,066	$0	$20,361,934	$79,920,788	$39,076,851	$102,855,292
	Employee Compensation	$4,575,700	$7,666,176	$13,291,946	$12,854,571	$13,248,528	$8,607,613	$0	$17,544,957	$0	$13,461,581	$34,504,904	$18,168,033	$42,135,626
	Sales Tax	$631,859	$906,534	$975,147	$1,765,382	$1,710,013	$1,196,836	$0	$2,897,376	$0	$2,327,810	$9,136,679	$4,467,331	$11,758,589

[2] Colorado did not have an increase in megawatts of net metered residential solar in study years 2017 and 2019 according to EIA data and, therefore, inputs for those years were $0. SER made this decision so as to not overestimate impacts. Those years may have seen an increase in actual solar capacity, but as this was not captured by EIA, it was excluded from SER's analysis.

[3] Because 2023 IMPLAN data was not available at the time of publication, 2022 IMPLAN data was used to model 2023 cost data.

SER's economic analysis uses IMPLAN (IMpact analysis for PLANning). IMPLAN software and parameters are based on government data collected at federal, state, and local levels. IMPLAN is a leading provider of economic development software that is widely used by economists and economic development professionals. More information about IMPLAN can be found at http://implan.com.

IMPLAN is an input-output model that measures the spending patterns and location-specific economic structures that reflect expenditures supporting varying levels of employment, income, and output. That is, IMPLAN considers that the output of one industry can be used as an input for another. For example, when a PV system is installed, there are soft costs consisting of permitting, installation, and customer acquisition costs. These costs involve some purchases made at other businesses in Colorado. Those businesses are supported by soft cost spending and then use some of that spending to pay their employees. The employees can then use a portion of their compensation to purchase goods and services within their community. Likewise, when a developer pays workers to install the systems, those workers spend money in the local economy that boosts economic activity and employment in other sectors. The goal of economic impact analysis is to quantify all of those reverberations throughout the local and state economy.

The IMPLAN model utilizes state-specific industry multipliers in the analysis. This study analyzes the gross jobs that solar energy project development supports and does not analyze the potential loss of jobs due to declines in other forms of electric generation.

Economic impacts feature three different units: jobs, labor income, and output (Gross State Product or GSP). Because of the ripple effect from business activity in an economy, these units of impacts can be calculated in three different layers: direct, indirect, and induced. And each layer of impacts was calculated for the construction of net metered residential solar.

Direct impacts during the construction period refer to the changes that occur in the onsite construction industries in which the direct final demand (i.e. spending on construction labor and services) change is made. Final demands are goods and services purchased for their ultimate use by the end user. Examples of direct jobs from SER's analysis include Solar Installers, Business Operations Specialists, Operations Specialties Managers, etc.

The initial spending on the construction creates a second layer of impacts, referred to as "supply chain impacts" or "indirect impacts." Indirect impacts during construction consist of changes in inter-industry purchases resulting from the direct final demand changes and include construction spending on materials, goods, and offsite services, including those performed by Engineers, Surveyors, Designers, Material Moving Workers, Advertisers, etc.

Induced impacts during construction refer to the changes that occur in household spending as household income increases or decreases due to the direct and indirect effects of final demand changes. Included in this is local spending by employees working directly or indirectly on data centers construction who receive their paychecks and then spend money in the community. Additional local jobs and economic activity are supported by these purchases of goods and services. Examples of induced jobs include cashiers, restaurant servers, stockers, nurses, medical diagnostic technicians, etc. services.

Table 2 – Economic Impacts of Net Metered Residential Solar from 2011-2023 (2024$)

Impact	Employment	Labor Income	Output
Direct	1,548	$200,506,528	$1,079,953,912
Indirect	4,313	$374,117,384	$971,142,728
Induced	2,923	$167,885,536	$526,158,172
Total	8,784	$742,509,448	$2,577,254,811

SER modeling shows that net metered residential solar supported over 8,700 jobs, provided $742 million in labor earnings, and contributed $2.5 billion in Gross State Product (GSP) from 2011-2023.

Figure 5 - Labor Income and Output of Net Metered Residential Solar in Colorado from 2011-2023

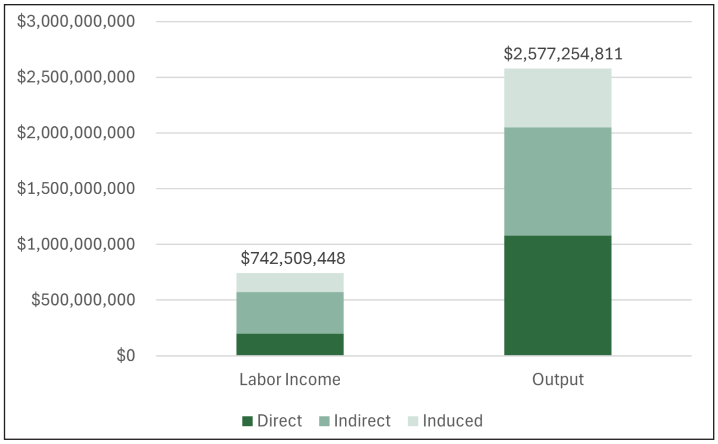
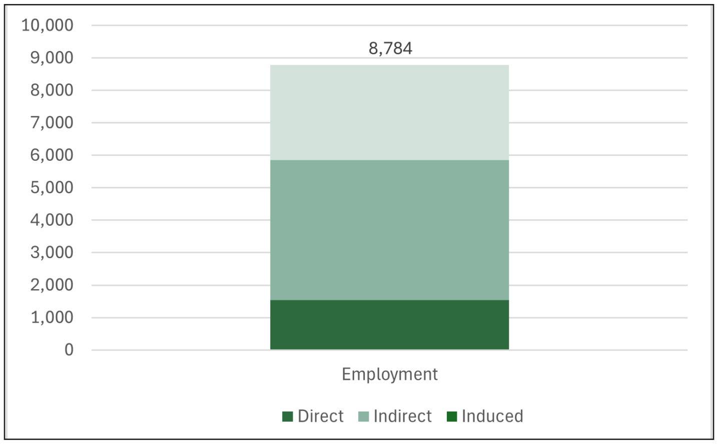
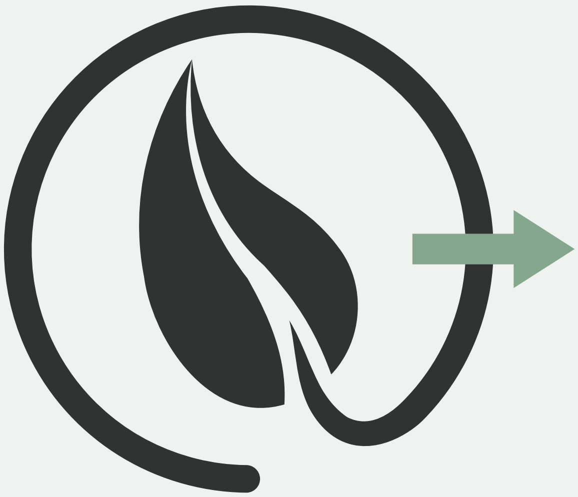


Figure 6 - Employment Resulting from Net Metered Residential Solar in Colorado from 2011-2023





Fossil fuel generators are the primary source of electricity in Colorado, with coal and natural gas making up over 63% of the state's generated electricity in 2023.[4] However, that percentage has steadily decreased every year since 2010, when fossil fuels made up 90% of Colorado's electricity supply.[5] This decrease coincides with the rise of renewable energy, including net metered residential solar, within the Colorado energy mix over the same period. Every kilowatt hour produced by a residential solar array is a kilowatt hour not needed from a fossil fuel plant resulting in emissions reductions from fossil fuel plants and less exposure to emissions for Colorado residents.

SER used the EPA's AVERT[6] (AVoided Emissions and geneRation Tool) and State Inventory Tool's (SIT) Stationary Combustion Module[7] to quantify the emissions reduction from net metered residential solar in Colorado from 2014-2023. AVERT was used to estimate reductions in nitrogen oxides (NOx), sulfur dioxides (SO2), particulate matter with diameter <= 2.5 micrometers (PM2.5), volatile organic compounds (VOCs), ammonia (NH3), and carbon dioxide (CO2). SIT's Stationary Combustion Module was used to estimate reductions in methane (CH4).

Use of AVERT started with SER gathering annual Colorado electricity generation[8] data from different power sources from the EIA. SER assumed any energy generation by net metered residential solar meant a reduction in generation from fossil fuel power plants since fossil fuels make up most of Colorado's generated energy mix. The annual net metered residential solar generation amounts in gigawatt hours were then used in AVERT to calculate the emissions reductions to Colorado for a particular year.

SER used SIT's Stationary Combustion Module by inputting consumption data for a hypothetical scenario in which net metered residential solar generation was instead sourced from coal and natural gas based on their respective weights in the Colorado fossil fuel energy mix for a given year. The baseline emissions from the module were subtracted from this hypothetical scenario to find the reductions in Colorado methane emissions.

[4] Electricity Data Browser (eia.gov)- Net generation Colorado all sectors monthly
[5] Ibid
[6] AVoided Emissions and geneRation Tool (AVERT) | US EPA
[7] Download the State Inventory and Projection Tool | US EPA
[8] Electricity Data Browser (eia.gov)- Net generation Colorado all sectors monthly

For background context, Figure 7 and Tables 3 and 4 show Colorado specific emission levels over time.

Figure 7 – Colorado Emission Levels for VOCs, NOX, SO2, PM2.5 2014-2023 (tons)

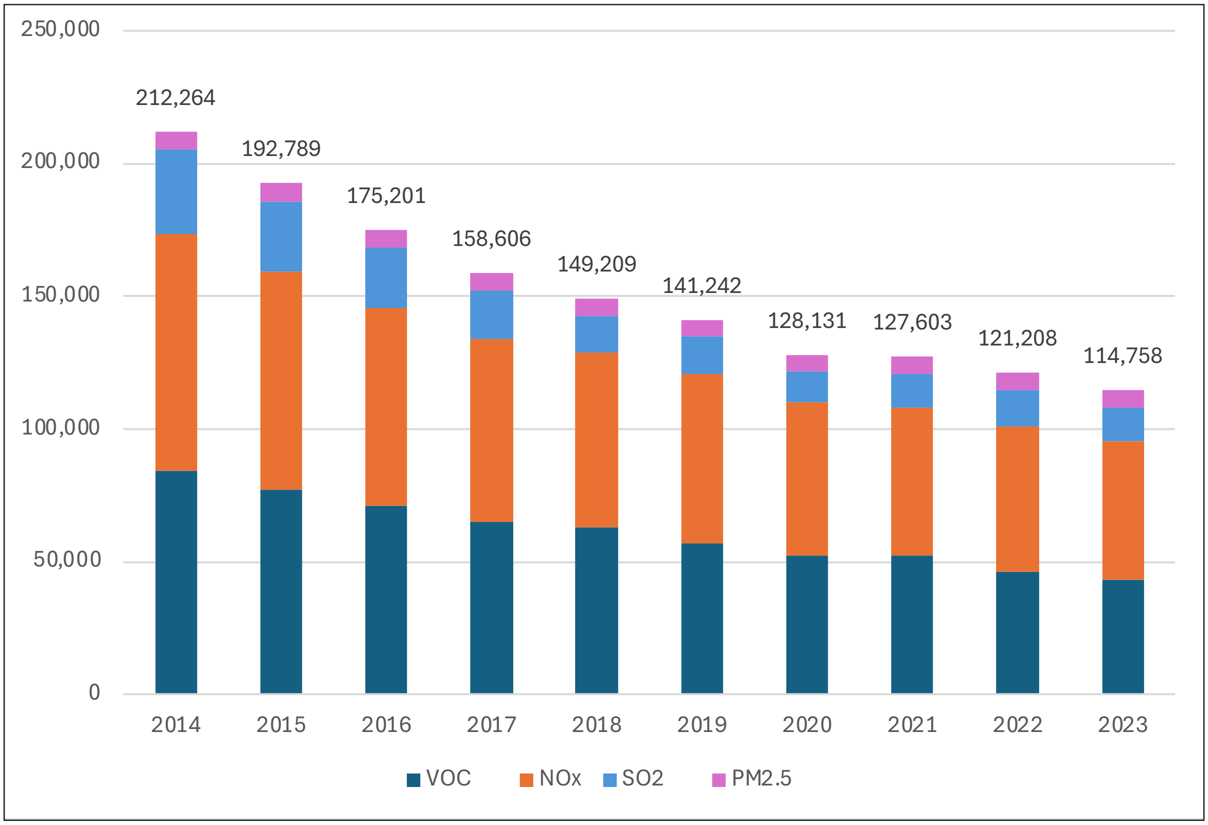


Figure 7 shows emissions data sourced from the Colorado Department of Public Health & Environment's Air Pollution Control Division.[9] Emissions are from over 26,000 uniquely identified facilities that the CDPHE has data for. Sums of emissions from VOCs, NOX, SO2, and PM2.5 have decreased by an annual average of 7% per year.

[9] Workbook: Emission Trends Criteria+BTEX (state.co.us)

Table 3 shows historical Colorado CO2 emissions data from the EIA. Coal burning accounts for the majority of CO2 emissions in any presented year, but its CO2 emissions decreased an average of 4% from 2014-2022. Natural gas CO2 emissions increased an average of 5% from 2014-2022 while total CO2 emissions have decreased an average of 3% from 2014-2022.

Table 3 – CO2 emissions from Colorado Electric Power Industry- Fossil Fuels 2014-2022 (tons)[10]

	2014	2015	2016	2017	2018	2019	2020	2021	2022
Coal	36,406,035	35,395,216	33,592,937	33,153,115	30,125,066	28,791,269	22,730,761	26,535,940	24,452,572
Natural Gas	5,986,65	5,835,636	6,163,022	6,210,422	8,124,034	8,579,289	9,305,712	7,747,044	8,298,199
Petroleum	16,535	9,921	9,921	9,921	15,432	11,023	8,818	29,762	30,865
Total	42,409,223	41,240,773	39,765,880	39,373,457	38,264,532	37,381,581	32,045,292	34,312,746	32,781,636

Table 4 shows the methane emissions attributable to the Colorado electric power industry's use of natural gas and coal for electricity generation. In 2014, 484 tons of methane were emitted by the electric power industry, but emissions decreased to 371 tons by 2023. Emissions were calculated by SIT's Stationary Combustion Module's default scenario.

Table 4 – Colorado Methane Emissions from Natural Gas and Coal Combustion 2014-2023 (tons)

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Coal	377	366	347	341	309	297	235	274	254	223
Natural Gas	107	104	110	111	145	153	161	133	143	149
Petroleum	484	470	457	452	454	450	396	407	397	371

Table 5 – Colorado Net Metered Residential Solar's Annual Gigawatt Hours 2014[11] -2023

Year	GWh
2014	177
2015	210
2016	265
2017	317
2018	366
2019	411
2020	473
2021	750
2022	1,006
2023	1,295

Table 5 shows the annual gigawatt hours of electricity generation by net metered residential solar from 2014-2023. The average annual increase in generation over the study period was 25%. These gigawatt hours were input into AVERT to estimate emissions reductions for their specific year. These gigawatt hours were also used to estimate the hypothetical increase in consumed BTUs used for coal and natural gas electricity production that were then input into SIT's Stationary Combustion Module.

[10] Colorado Electricity Profile 2022 - U.S. Energy Information Administration (EIA)
[11] Despite having capacity data for residential solar since 2010 to aid in economic impacts calculations, generation data from the EIA could only be found since 2014.

Table 6 shows the estimated reduction in measured pollutants from various models for Colorado. As generation from net metered residential solar increases, more tons of pollution reductions are estimated in later study years with 752,450 tons of avoided emissions in 2023. CO2 has an average annual emission reduction of 18%, CH4 has 19%, PM 2.5 has 20%, SO2 has 7%, NOx has 11%, VOC has 20%, and NH3 has 21%. From 2014-2023, SER calculated total pollution reductions to have been 3,215,439 tons due to net metered residential solar.

Table 6 – Estimated Annual Reduction in Colorado Pollutants (tons)

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Cumulative Pollutant Emission Reductions
CO2	121,000	144,000	170,000	184,840	226,890	244,890	283,170	465,240	620,780	751,850	3,212,660
CH4	0.66	0.78	0.98	1.17	1.35	1.51	1.74	2.77	3.71	4.75	19
PM2.5	2.6	2.9	3.4	4.0	6.6	7.4	5.8	11.6	17.8	26.4	88
SO2	64.8	59.5	71.1	51.5	63.6	58.8	59.7	67.2	170.0	188.2	854
NOx	100.7	148.4	112.4	110.1	128.1	134.3	150.5	166.8	309.6	353.2	1,714
VOC	N/A[12]	N/A	N/A	2.4	3.1	3.2	6.8	7.3	9.0	11.1	43
NH3	N/A	N/A	N/A	3.9	4.6	4.9	6.9	10.1	12.7	16.8	60
Total Annual Emission Reductions	121,169	144,212	170,188	185,013	227,097	245,100	283,401	465,506	621,303	752,450	

[12] AVERT did not calculate VOC and NH3 emissions reductions for 2014-2016 due AVERT v2.3 modeling constraints. AVERT v2.3 was the only version that could model 2014-2016 data. This does not mean VOC and NH3 emissions reductions were absent. They simply were not measured from 2014-2016. The EPA released AVERT v4.3 in 2017 which did consider VOC and NH3 emissions reductions, so v4.3 was used for study years 2017-2023. The average annual emission reduction increases for VOC and NH3 were calculated for 2017-2023.

Figure 8 – Colorado's Annual Reduction in CO2 vs. Net Metered Residential Solar's Electricity Production 2014-2023

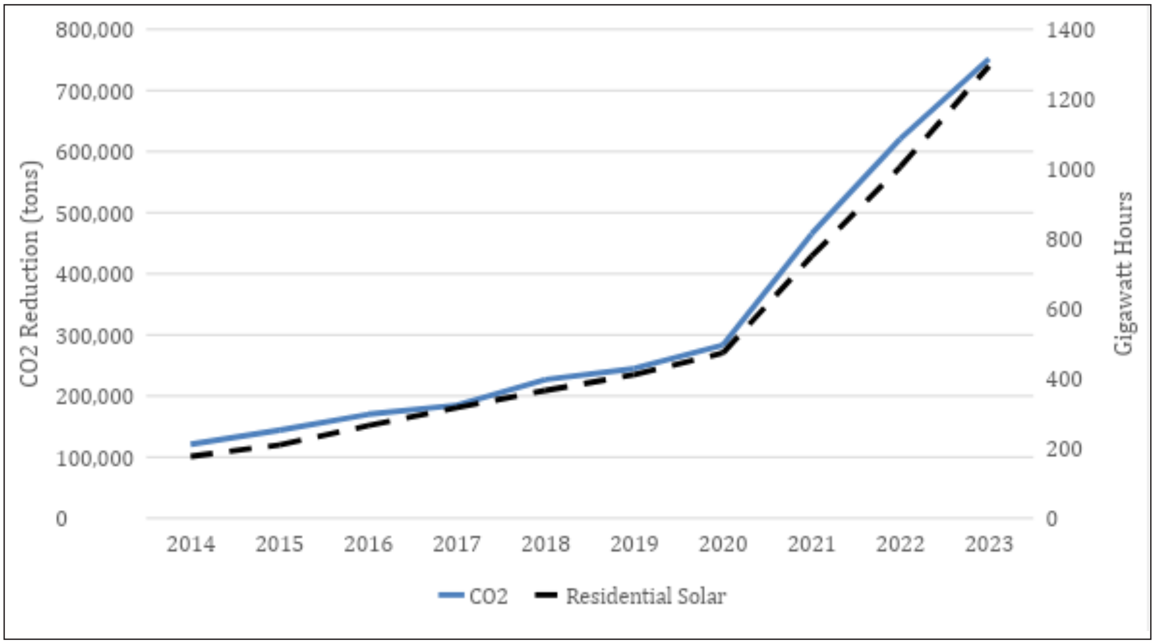


Figure 9 – Colorado's Annual Reduction in CH4, PM2.5, VOC, NH3 vs. Net Metered Residential Solar's Electricty Production 2014-2023

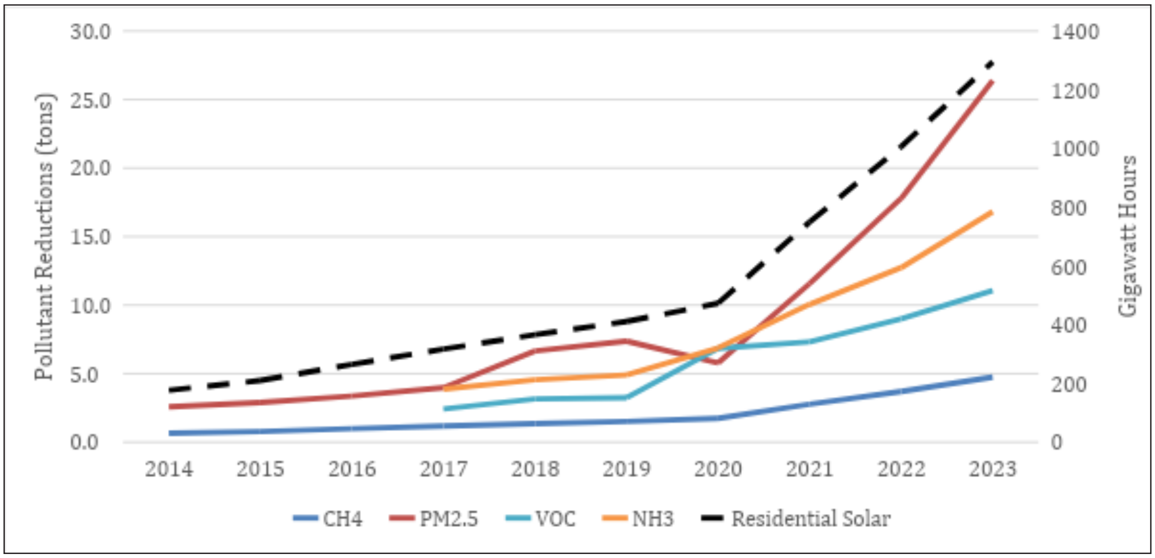


Figure 10 – Colorado's Annual Reduction in SO2 and NOx vs. Net Metered Residential Solar's Electricity Production 2014-2023

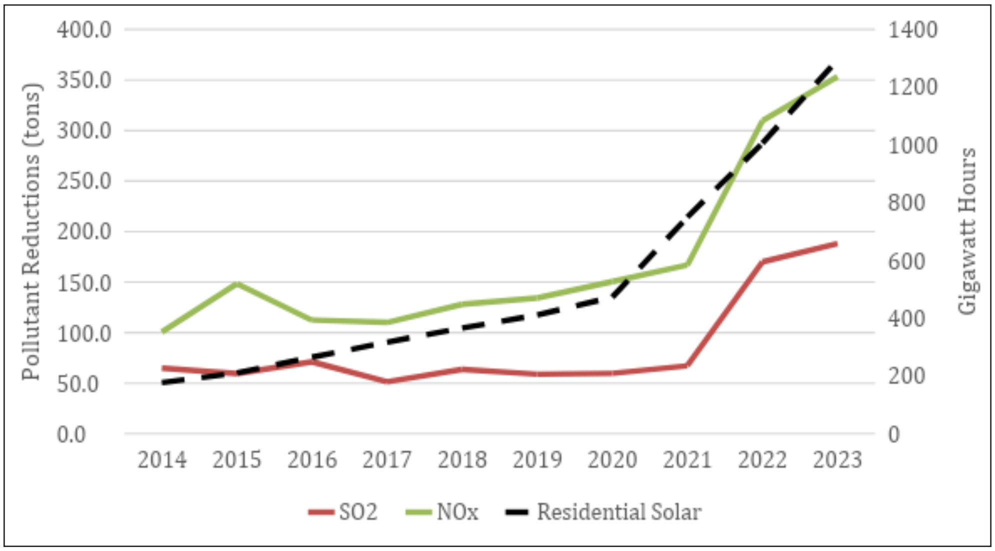
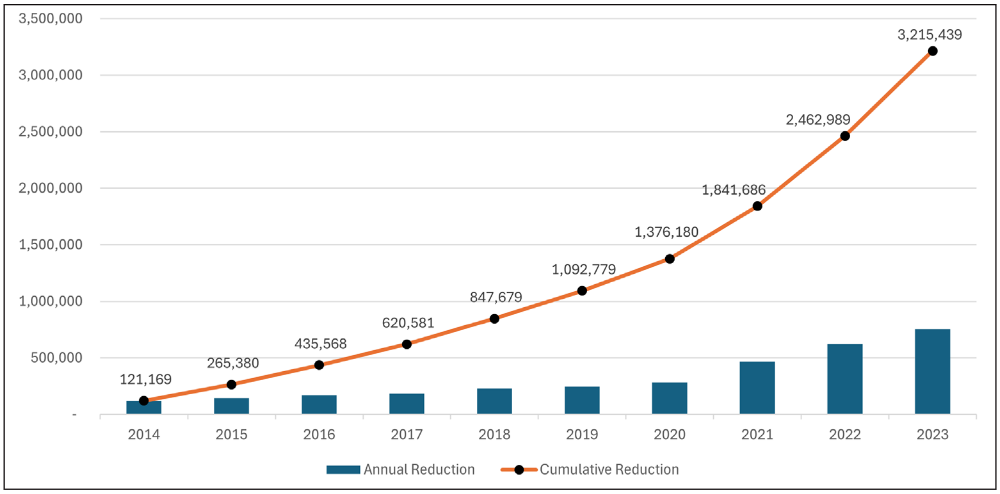
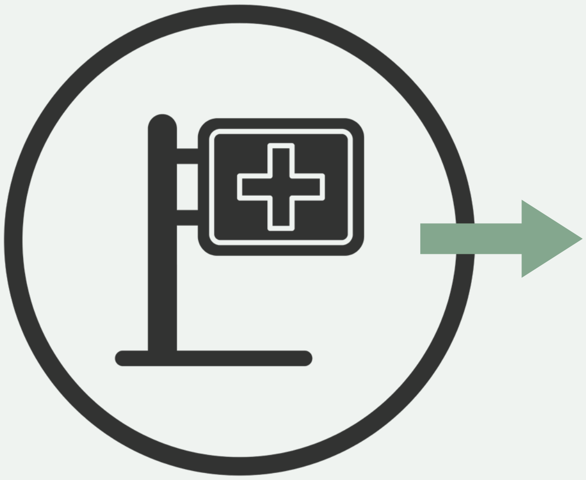


Figure 11 – Annual and Cumulative Reduction in Selected Colorado Pollutants 2014-2023 (tons)



In addition to the pollution reductions borne from the installation of net metered residential solar in Colorado, there is a decrease in water used to generate electricity from renewable sources compared to fossil fuels. For example, to produce 1 megawatt hour of electricity it takes a median of 669,000 gallons of water to cool a coal-fired plant and 385,000 gallons of water to cool a natural gas plant (Castillo, Gutierrez, and Gore, 2018). Residential solar PV systems do not require water for cooling, resulting in hundreds of thousands of water preservation per megawatt hour of electricity produced from residential solar instead of fossil fuels. productivity should relate to the cash rent for the land.

VII. Public Health Benefits



Because of the reduction in emissions within Colorado, residents experienced less adverse health incidences from harmful pollution from 2014-2023. SER used the Environmental Protection Agency's COBRA (CO-Benefits Risk Assessment) v5.1 software to estimate the reduction in adverse health effect incidences[13] and calculate the monetary value[14] of those reductions from net metered residential solar electricity generation from 2014-2023[15]. SER took output data from the AVERT models and input the files into COBRA. All monetary values are in 2023 dollars.

Though CO2 and CH4 are not offered as options for pollutant-specific reductions in health impact incidences through COBRA, each is widely regarded as negatively impacting public health (Turner et al., 2016; Jacobsen et al., 2019; Zhang et al., 2019; Butler et al., 2020; and Mar et al., 2022). Butler et al. (2020) find that methane is responsible for around 35% of today's tropospheric O3 burden, a secondary air pollutant associated with decreased lung function and premature mortality. Increased concentration of atmospheric CO2 is often associated with inflammation, decreased cognitive ability, and other negative physical and psychological health impacts (Jacobsen et al., 2019).

[13] "Incidence refers to the number of new cases of a health endpoint over a specified period of time. The change in incidence is not necessarily a whole number because COBRA calculates statistical risk reductions which are then aggregated over the population. For example, if 150,000 people experience a 0.001% reduction in mortality risk, this would be reported as 1.5 statistical lives saved. This statistical life, and its associated monetary value, represents the sum of many small risk reductions and does not correspond to the loss or value of an individual life."- https://cobra.epa.gov/

[14] "COBRA calculates the monetary value of each health endpoint based on data on the healthcare costs of the health endpoint and research into the willingness to pay to avoid the health endpoint"- https://cobra.epa.gov/

[15] COBRA provides users with default pollution baseline scenarios for 2016, 2023, and 2028. SER used 2016's baseline for study years 2010-2016 and 2023's baseline for 2017-2023.

Table 7 – Colorado Reductions in Health Impact Incidences 2014-2023

	Pollutant	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Cumulative Total	Annual Average
Mortality	PM2.5 + O3	0.11	0.14	0.12	0.13	0.15	0.155	0.165	0.205	0.38	0.455	2.01	20%
Mortality, All Cause[16]	PM2.5	0.045	0.055	0.05	0.06	0.065	0.065	0.065	0.095	0.175	0.225	0.9	22%
Mortality, O3 Short-term Exposure	O3	0	0	0	0	0	0	0	0	0.01	0.01	0.02	0%
Mortality, O3 Long-term Exposure	O3	0.06	0.08	0.06	0.07	0.08	0.08	0.1	0.11	0.2	0.22	1.06	18%
Nonfatal Heart Attacks	PM2.5	0.01	0.02	0.01	0.02	0.02	0.02	0.02	0.03	0.06	0.08	0.29	37%
Infant Mortality	PM2.5	0	0	0	0	0	0	0	0	0	0	0	0%
Hospital Admits, All Respiratory	PM2.5 + O3	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.04	0.04	0.18	22%
Hospital Admits from PM2.5	PM2.5	0	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.12	17%
Hospital Admits from O3	O3	0	0.01	0	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.1	0%
ER Visits, Respiratory	PM2.5 + O3	0.19	0.26	0.2	0.23	0.26	0.26	0.29	0.34	0.63	0.71	3.37	19%
Respiratory Visits from PM2.5	PM2.5	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.09	0.12	0.46	26%
Respiratory Visits from O3	O3	0.17	0.23	0.18	0.2	0.22	0.22	0.26	0.29	0.53	0.59	2.89	18%
Asthma Onset	PM2.5 + O3	0.65	0.87	0.69	0.8	0.88	0.89	1	1.2	2.2	2.5	11.68	19%
Asthma Onset from PM2.5	PM2.5	0.1	0.12	0.12	0.13	0.15	0.15	0.15	0.23	0.41	0.53	2.09	23%
Asthma Onset from O3	O3	0.54	0.74	0.57	0.66	0.73	0.74	0.86	0.97	1.8	2	9.61	19%
Asthma Symptoms	PM2.5 + O3	100	140	110	120	130	130	150	180	330	380	1770	19%
Albuterol Use	PM2.5	20	24	22	23	27	27	27	40	73	94	377	21%
Chest Tightness	O3	23	32	25	27	30	30	35	39	72	79	392	18%
Cough	O3	28	38	29	32	35	35	41	46	85	93	462	17%
Shortness of Breath	O3	12	16	12	14	15	15	18	20	36	40	198	17%
Wheeze	O3	22	30	23	25	28	28	33	37	68	75	369	18%
ER Visits, Asthma	O3	0	0	0	0	0	0	0	0	0	0	0	0%
Lung Cancer Incidence	PM2.5	0	0	0	0	0	0	0	0.01	0.01	0.01	0.03	0%
Hospital Admits, Cardiovascular	PM2.5	0	0	0	0	0	0	0	0.01	0.01	0.01	0.03	0%
Hospital Admits, Alzheimer's	PM2.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.04	0.16	20%
Hospital Admits, Parkinson's	PM2.5	0	0	0	0	0	0	0	0	0.01	0.01	0.02	0%
Stroke Incidence	PM2.5	0	0	0	0	0	0	0	0	0.01	0.01	0.02	0%
Hay Fever/Rhinitis Incidence	PM2.5 + O3	4.3	5.7	4.5	4.9	5.5	5.5	6.3	7.4	14	15	73.1	18%
Hay Fever/Rhinitis from PM2.5	PM2.5	0.67	0.8	0.75	0.81	0.93	0.93	0.95	1.4	2.5	3.3	13.04	22%
Hay Fever/Rhinitis from O3	O3	3.6	4.9	3.8	4.1	4.6	4.6	5.3	6	11	12	59.9	17%
Cardiac Arrest, Out of Hospital	PM2.5	0	0	0	0	0	0	0	0	0	0	0	0%
ER Visits, All Cardiac	PM2.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.04	0.16	20%

[16] COBRA features two methods for calculating reductions in mortality incidences from PM 2.5 exposure. The average of the results from these two methods are reported in this study and in Table 9, which displays the monetary value of reductions in health incidences.

Table 7 shows increasing reductions in adverse health incidences during the study period. Mortality incidences decreased 2.01 incidences over the study period, respiratory ER visits decreased 3.37 incidences, and asthma symptoms decreased 1,770 incidences. Table 8 shows an annual average reduction increase for minor restricted activity days of 21%, school loss days of 17%, and work loss days of 22% from 2014-2023. The table also shows 608 total reductions in minor restricted activity days, 882 total reductions in school loss days, and 103 total reductions in work loss days from 2014-2023.

Table 8 – COBRA Estimated Minor Restricted Activity Days, School Loss Days, and Work Loss Days for Colorado 2014-2023

	Pollutant	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Cumulative Total	Annual Average
Minor Restricted Activity Days	PM2.5	32	38	35	38	43	43	44	65	120	150	608	21%
School Loss Days	O3	53	73	56	60	67	67	78	88	160	180	882	17%
Work Loss Days	PM2.5	5.4	6.4	6	6.4	7.4	7.4	7.5	11	20	26	103.5	22%

Figure 12 – COBRA Estimated Reductions in Minor Restricted Activity Days, School Loss Days, and Work Loss Days for Colorado 2014-2023

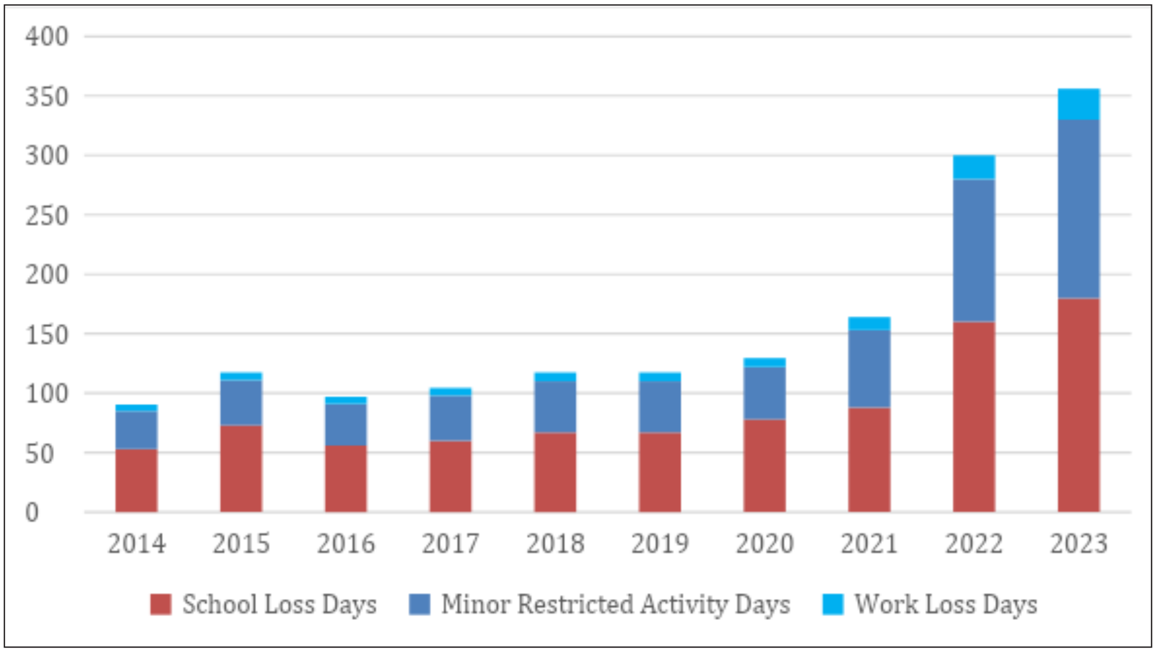
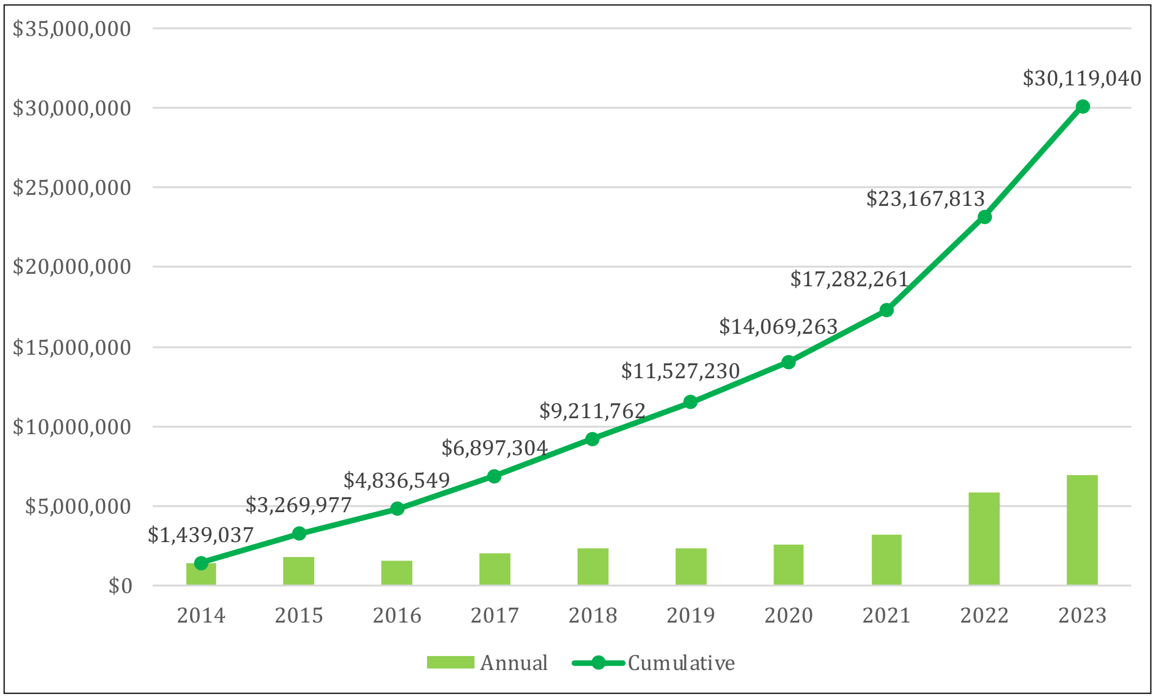


Table 9 shows the total monetary value of mortality incidence reductions being over $28 million from 2014-2023. Mortality reductions make up the majority of the monetary value of annual total health incidence reductions in any year. The cumulative total monetary value from 2014-2023 for all measured Colorado health incidence reductions is over $30 million.

Table 9 – COBRA Estimated Monetary Value of Colorado Health Incidence Reductions

	Pollutant	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
Mortality	PM2.5 + O3	$1,350,000	$1,750,000	$1,450,000	$1,950,000	$2,150,000	$2,200,000	$2,400,000	$3,000,000	$5,550,000	$6,550,000	$28,350,000
Mortality, All Cause	PM2.5	$565,000	$680,000	$635,000	$805,000	$940,000	$940,000	$945,000	$1,375,000	$2,550,000	$3,250,000	$12,685,000
Mortality, O3 Short-term Exposure	O3	$34,000	$46,000	$36,000	$48,000	$53,000	$54,000	$62,000	$70,000	$130,000	$140,000	$673,000
Mortality, O3 Long-term Exposure	O3	$760,000	$1,000,000	$810,000	$1,100,000	$1,200,000	$1,200,000	$1,400,000	$1,600,000	$2,900,000	$3,200,000	$15,170,000
Nonfatal Heart Attacks	PM2.5	$920	$1,100	$1,000	$1,600	$1,800	$1,800	$1,800	$2,700	$4,900	$6,300	$23,920
Infant Mortality	PM2.5	$4,400	$5,300	$4,900	$5,500	$6,400	$6,400	$6,500	$9,800	$17,000	$23,000	$89,200
Hospital Admits, All Respiratory	PM2.5 + O3	$160	$200	$170	$250	$280	$280	$300	$400	$720	$890	$3,650
Hospital Admits from PM2.5	PM2.5	$93	$110	$100	$140	$160	$160	$160	$240	$430	$560	$2,153
Hospital Admits from O3	O3	$66	$89	$71	$110	$120	$120	$140	$160	$290	$320	$1,486
ER Visits, Respiratory	PM2.5 + O3	$270	$360	$290	$370	$410	$420	$480	$560	$1,000	$1,200	$5,360
Respiratory Visits from PM2.5	PM2.5	$34	$40	$37	$48	$55	$55	$56	$82	$150	$190	$747
Respiratory Visits from O3	O3	$240	$320	$250	$330	$360	$360	$420	$470	$870	$960	$4,580
Asthma Onset	PM2.5 + O3	$43,000	$58,000	$46,000	$61,000	$67,000	$68,000	$77,000	$91,000	$170,000	$190,000	$871,000
Asthma Onset from PM2.5	PM2.5	$6,900	$8,200	$7,700	$10,000	$12,000	$12,000	$12,000	$18,000	$31,000	$41,000	$158,800
Asthma Onset from O3	O3	$36,000	$49,000	$38,000	$51,000	$56,000	$56,000	$65,000	$74,000	$140,000	$150,000	$715,000
Asthma Symptoms	PM2.5 + O3	$29,000	$39,000	$30,000	$38,000	$42,000	$42,000	$49,000	$55,000	$100,000	$110,000	$534,000
Albuterol Use	PM2.5	$11	$13	$12	$15	$17	$17	$17	$26	$47	$60	$235
Chest Tightness	O3	$7,900	$11,000	$8,300	$10,000	$11,000	$11,000	$13,000	$15,000	$28,000	$31,000	$146,200
Cough	O3	$9,300	$13,000	$9,800	$12,000	$14,000	$14,000	$16,000	$18,000	$33,000	$36,000	$175,100
Shortness of Breath	O3	$4,000	$5,500	$4,200	$5,200	$5,800	$5,800	$6,800	$7,600	$14,000	$15,000	$73,900
Wheeze	O3	$7,500	$10,000	$7,900	$9,800	$11,000	$11,000	$13,000	$14,000	$26,000	$29,000	$139,200
ER Visits, Asthma	O3	$1	$1	$1	$1	$1	$1	$1	$1	$3	$3	$13
Lung Cancer Incidence	PM2.5	$84	$100	$94	$130	$150	$150	$150	$220	$400	$520	$1,998
Hospital Admits, Cardiovascular	PM2.5	$60	$71	$67	$100	$120	$120	$120	$170	$310	$400	$1,538
Hospital Admits, Alzheimer's	PM2.5	$120	$140	$140	$210	$240	$240	$240	$350	$650	$830	$3,160
Hospital Admits, Parkinson's	PM2.5	$30	$35	$33	$50	$58	$58	$59	$85	$160	$200	$768
Stroke Incidence	PM2.5	$93	$110	$100	$160	$180	$180	$180	$270	$490	$630	$2,393
Hay Fever/Rhinitis Incidence	PM2.5 + O3	$4,100	$5,500	$4,400	$5,500	$6,100	$6,100	$7,000	$8,300	$15,000	$17,000	$79,000
Hay Fever/Rhinitis from PM2.5	PM2.5	$650	$780	$730	$900	$1,000	$1,000	$1,100	$1,600	$2,800	$3,700	$14,260
Hay Fever/Rhinitis from O3	O3	$3,500	$4,700	$3,700	$4,600	$5,100	$5,100	$5,900	$6,700	$12,000	$14,000	$65,300
Cardiac Arrest, Out of Hospital	PM2.5	$26	$31	$29	$39	$45	$45	$46	$67	$120	$160	$608
ER Visits, All Cardiac	PM2.5	$15	$18	$17	$23	$27	$27	$27	$40	$73	$94	$361
Minor Restricted Activity Days	PM2.5	$3,500	$4,200	$3,900	$4,700	$5,400	$5,400	$5,500	$8,200	$15,000	$19,000	$74,800
School Loss Days	O3	$79,000	$110,000	$83,000	$100,000	$110,000	$110,000	$130,000	$150,000	$270,000	$300,000	$1,442,000
Work Loss Days	PM2.5	$1,500	$1,800	$1,700	$2,000	$2,300	$2,300	$2,400	$3,500	$6,300	$8,200	$32,000
Total PM Health Effects		$583,436	$702,048	$655,559	$830,615	$969,952	$969,952	$975,355	$1,420,350	$2,629,830	$3,354,844	$13,091,941
Total O3 Health Effects		$855,601	$1,128,892	$911,014	$1,230,140	$1,344,506	$1,345,516	$1,566,677	$1,792,648	$3,255,723	$3,596,383	$17,027,099
Total Health Effects		$1,439,037	$1,830,940	$1,566,573	$2,060,755	$2,314,458	$2,315,468	$2,542,032	$3,212,998	$5,885,553	$6,951,227	$30,119,040

Figure 13 – Annual and Cumulative Monetary Value of Health Incidence Reductions in Colorado 2014-2023



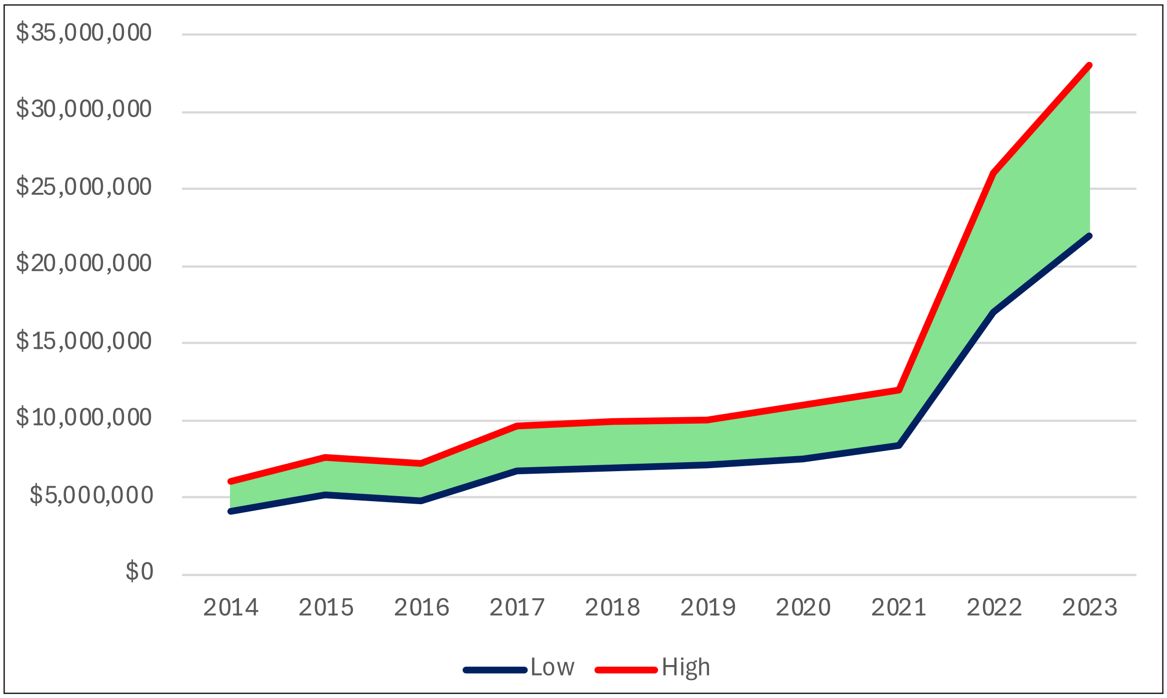
Reductions in health impacts from Colorado net metered residential solar electricity generation are not solely contained to Colorado. These impacts permeate throughout the region and county, and COBRA can estimate a national health impact in monetary values for each year.

Table 10 – National Level Monetary Value of Health Impacts 2014-2023

	Low Scenario	High Scenario
2014	$4,100,000	$6,100,000
2015	$5,200,000	$7,600,000
2016	$4,800,000	$7,200,000
2017	$6,700,000	$9,600,000
2018	$6,900,000	$9,900,000
2019	$7,100,000	$10,000,000
2020	$7,500,000	$11,000,000
2021	$8,400,000	$12,000,000
2022	$17,000,000	$26,000,000
2023	$22,000,000	$33,000,000
Total	$89,700,000	$132,400,000

Table 10 shows the COBRA estimated monetary value of Colorado emissions reductions due to net metered residential solar for the United States being $89.7-$132.4 million from 2014-2023. impact in monetary values for each year.

Figure 14 –High and Low National Monetary Values from Colorado Health Incidence Reductions 2014-2023



VIII. Policy Recommendations

To equitably achieve Colorado's goal of 50% reduction in greenhouse gas emissions by 2030 while supporting a robust local economy and delivering substantial benefits to all Coloradans, the state should continue supporting full retail rate net metering for distributed solar customers. The State of Colorado has seen the economic growth of $2.6 billion in new local Gross State Product (GSP), 8,700 jobs, and $742 million in labor earnings from net metered residential rooftop solar over the last 13 years. The State of Colorado has also experienced over 4,681 tons of total pollution reductions and over $50 million in estimated monetary value of health incidence from net metered residential solar projects between 2014-2023. Additionally, the net metered residential solar installations from 2014-2023 in Colorado have contributed over $153-$226 million in estimated monetary value of national health improvement due to Colorado's emission reductions. Finally, though these benefits were not quantified by this study, additional residential solar generation increases grid reliability and reduces the burden of the rapidly increasing population on local utilities.

Retail-rate net metering is a critical mechanism for supporting continued residential solar adoption and, if threatened, can cause significant unintended repercussions for installation rates (Doerfler and Toering, 2024). Should installation rates falter, the economic, environmental, and public health benefits quantified in this study would decrease for future years, negatively impacting all Coloradans.

The negative repercussions of changing credit systems have been felt by states that have reduced net metering credits for excess rooftop solar generation or introduced fixed charges for net metered customers. In 2023, the state of California reduced net metered residential solar rates by around 80% in an attempt to limit the "oversupply" of distributed solar during non-peak hours (Kreutz and Louie, 2024). California experienced a rush of residential rooftop solar installations before the end of 2023, but the first quarter of 2024 revealed a decrease in solar installations in California by 66% compared to the same quarter in 2022 (Kreutz and Louie, 2024; SEIA, 2024). Similarly, when Nevada added a monthly fixed charge for residential distributed solar PV systems, payback periods increased and the state experienced a decrease in residential solar adoption (Gagnon, Sigrin, and Gleason, 2017). The Salt River Project (SRP) in Arizona reduced the value of net metering credits and experienced a decrease in adoption rates by 95% from 2015 to 2016 (Solar United Neighbors of Arizona, 2024).

Further, potential distributed solar customers are less likely to move forward with their projects if they believe the associated energy bills savings to be threatened by restrictive legislation, even if that legislation does not pass (Doerfler and Toering, 2024).

Retail-rate net metering reduces payback periods for solar owners, making the cost of going solar less intimidating by enabling solar owners to see net savings within a reasonably foreseeable period of time after beginning operation. Sigrin and Drury (2014) suggest that more attractive payback periods would lead to more residential solar adoption.

In conclusion, retail-rate net metering is an essential ingredient for residential rooftop solar adoption and should continue to be offered throughout Colorado. Full retail-rate net metering will maximize the economic, environmental, and public health benefits of rooftop solar for Colorado, while anything less would yield lower benefits for the state and its residents.

Table 11 – Occupational Description and Future Outlook

Occupation Code	Occupation Title	Description	Work Environment	Current Employment	Job Growth, 2021-2031 (percent)
11-1021	General and Operations Managers	Plan, direct, or coordinate the operations of public or private sector organizations, overseeing multiple departments or locations. Duties and responsibilities include formulating policies, managing daily operations, and planning the use of materials and human resources, but are too diverse and general in nature to be classified in any one functional area of management or administration, such as personnel, purchasing, or administrative services. Usually manage through subordinate supervisors. Excludes First-Line Supervisors.	Top executives work in nearly every industry, for both small and large organizations. They often have irregular schedules, which may include working evenings and weekends. Travel is common, particularly for chief executives.	3,328,200	209,800 (7%)
13-1082	Project Management Specialists and Business Operations Specialists	Analyze and coordinate the schedule, timeline, procurement, staffing, and budget of a product or service on a per project basis. Lead and guide the work of technical staff. May serve as a point of contact for the client or customer. Excludes “Management Occupations” (11-0000), “Logisticians” (13-1081), “Meeting, Convention, and Event Planners” (13-1121), and “Production, Planning, and Expediting Clerks” (43-5061).	Project management specialists usually work in an office setting. Although project management specialists may collaborate on teams, some work independently. Project management specialists also may travel to their clients’ places of business.	781,400	56,300 (7%)
13-1111	Management Analysts	Conduct organizational studies and evaluations, design systems and procedures, conduct work simplification and measurement studies, and prepare operations and procedures manuals to assist management in operating more efficiently and effectively. Includes program analysts and management consultants. Excludes “Computer Systems Analysts” (15-1211) and “Operations Research Analysts” (15-2031).	Management analysts may travel frequently to meet with clients. Some work more than 40 hours per week.	950,600	108,400 (11%)
17-2071	Electrical Engineers	Research, design, develop, test, or supervise the manufacturing and installation of electrical equipment, components, or systems for commercial, industrial, military, or scientific use. Excludes “Computer Hardware Engineers” (17-2061).	Electrical and electronics engineers work in industries including research and development, engineering services, manufacturing, telecommunications, and the federal government. Electrical and electronics engineers generally work indoors in offices. However, they may have to visit sites to observe a problem or a piece of complex equipment.	303,800	9,800 (3%)
37-3011	Landscaping and Groundskeeping	Landscape or maintain grounds of property using hand or power tools or equipment. Workers typically perform a variety of tasks, which may include any combination of the following: sod laying, mowing, trimming, planting, watering, fertilizing, digging, raking, sprinkler installation, and installation of mortarless segmental concrete masonry wall units. Excludes “Farmworkers and Laborers, Crop, Nursery, and Greenhouse” (45-2092).	Most grounds maintenance work is done outdoors in all weather conditions. Some work is seasonal, available mainly in the spring, summer, and fall. The work may be repetitive and physically demanding, requiring frequent bending, kneeling, lifting, or shoveling.	1,299,000	61,300 (5%)
41-3091	Sales Representatives of Services	Sell services to individuals or businesses. May describe options or resolve client problems. Excludes “Advertising Sales Agents” (41-3011), “Insurance Sales Agents” (41-3021), “Securities, Commodities, and Financial Services Sales Agents” (41-3031), “Travel Agents” (41-3041), “Sales Representatives, Wholesale and Manufacturing” (41-4010), and “Telemarketers” (41-9041).	Wholesale and manufacturing sales representatives work under pressure because their income and job security depend on the amount of merchandise they sell. Some sales representatives travel frequently.	1,597,600	63,300 (4%)
43-3031	Bookkeeping, Accounting and Auditing	Compute, classify, and record numerical data to keep financial records complete. Perform any combination of routine calculating, posting, and verifying duties to obtain primary financial data for use in maintaining accounting records. May also check the accuracy of figures, calculations, and postings pertaining to business transactions recorded by other workers. Excludes “Payroll and Timekeeping Clerks” (43-3051).	Most accountants and auditors work full time. Overtime hours are typical at certain periods of the year, such as for quarterly audits or during tax season.	1,449,800	81,800 (6%)
47-1011	First-Line Supervisors of Construction Trades	Directly supervise and coordinate activities of construction or extraction workers.	N/A	735,500	29,900 (4%)

Table 11 – Occupational Description and Future Outlook (Cont.)

47-2061	Construction Laborers	Perform tasks involving physical labor at construction sites. May operate hand and power tools of all types: air hammers, earth tampers, cement mixers, small mechanical hoists, surveying and measuring equipment, and a variety of other equipment and instruments. May clean and prepare sites, dig trenches, set braces to support the sides of excavations, erect scaffolding, and clean up rubble, debris, and other waste materials. May assist other craft workers. Construction laborers who primarily assist a particular craft worker are classified under "Helpers, Construction Trades" (47-3010). Excludes "Hazardous Materials Removal Workers" (47-4041).	Most construction laborers and helpers typically work full time and do physically demanding work. Some work at great heights or outdoors in all weather conditions. Construction laborers have one of the highest rates of injuries and illnesses of all occupations.	1,572,200	69,500 (4%)
47-2073	Operating Engineers and Other Construction Equipment Operators	Operate one or several types of power construction equipment, such as motor graders, bulldozers, scrapers, compressors, pumps, derricks, shovels, tractors, or front-end loaders to excavate, move, and grade earth, erect structures, or pour concrete or other hard surface pavement. May repair and maintain equipment in addition to other duties. Excludes "Extraction Workers" (47-5000) and "Crane and Tower Operators" (53-7021).	Construction equipment operators may work even in unpleasant weather. Most operators work full time, and some have irregular work schedules that include nights.	466,900	22,000 (5%)
47-2111	Electricians	Install, maintain, and repair electrical wiring, equipment, and fixtures. Ensure that work is in accordance with relevant codes. May install or service street lights, intercom systems, or electrical control systems. Excludes "Security and Fire Alarm Systems Installers" (49-2098).	Almost all electricians work full time. Work schedules may include evenings and weekends. Overtime is common.	711,200	50,200 (7%)
47-2231	Solar Photovoltaic Installers	Assemble, install, or maintain solar photovoltaic (PV) systems on roofs or other structures in compliance with site assessment and schematics. May include measuring, cutting, assembling, and bolting structural framing and solar modules. May perform minor electrical work such as current checks. Excludes solar PV electricians who are included in "Electricians" (47-2111) and solar thermal installers who are included in "Plumbers, Pipefitters, and Steamfitters" (47-2152).	Most solar panel installations are done outdoors, but PV installers sometimes work in attics and crawl spaces to connect panels to the electrical grid. Installers also must travel to jobsites.	17,100	4,600 (27%)
47-3013	Helpers – Electricians	Help electricians by performing duties requiring less skill. Duties include using, supplying, or holding materials or tools, and cleaning work area and equipment. Construction laborers who do not primarily assist electricians are classified under "Construction Laborers" (47-2061). Apprentice workers are classified with the appropriate skilled construction trade occupation (47-2011 through 47-2231).	Most construction laborers and helpers typically work full time and do physically demanding work. Some work at great heights or outdoors in all weather conditions. Construction laborers have one of the highest rates of injuries and illnesses of all occupations.	1,572,200	69,500 (4%)
49-9071	Maintenance and Repair Workers, General (Operations)	Perform work involving the skills of two or more maintenance or craft occupations to keep machines, mechanical equipment, or the structure of a building in repair. Duties may involve pipe fitting; HVAC maintenance; insulating; welding; machining; carpentry; repairing electrical or mechanical equipment; installing, aligning, and balancing new equipment; and repairing buildings, floors, or stairs. Excludes "Facilities Managers" (11-3013) and "Maintenance Workers, Machinery" (49-9043).	General maintenance and repair workers often carry out many different tasks in a single day. They could work at any number of indoor or outdoor locations. They may work inside a single building, such as a hotel or hospital, or be responsible for the maintenance of many buildings, such as those in an apartment complex or on a college campus.	1,539,100	76,300 (5%)
51-1011	First-Line Supervisors of Production and Operating Workers	Directly supervise and coordinate the activities of production and operating workers, such as inspectors, precision workers, machine setters and operators, assemblers, fabricators, and plant and system operators. Excludes team or work leaders.	N/A	646,800	12,200 (2%)
51-8013	Power Plant Operators	Control, operate, or maintain machinery to generate electric power. Includes auxiliary equipment operators. Excludes "Nuclear Power Reactor Operators" (51-8011).	Most power plant operators, distributors, and dispatchers work full time. Many work rotating 8- or 12-hour shifts.	43,700	(6,500) (-15%)
53-7062	Laborers and Freight, Stock and Material Movers	Manually move freight, stock, luggage, or other materials, or perform other general labor. Includes all manual laborers not elsewhere classified. Excludes "Construction Laborers" (47-2061) and "Helpers, Construction Trades" (47-3011 through 47-3019). Excludes "Material Moving Workers" (53-7011 through 53-7199) who use power equipment.	Most hand laborers and material movers work full time. Because materials are shipped around the clock, some workers, especially those in warehousing, work overnight shifts.	6,473,000	358,300 (6%)

X. Glossary

Bb

Battery Energy Storage Systems (BESS)

An array of hundreds or thousands of small batteries that enable energy from renewables, like solar and wind, to be stored and released at a later time.

Cc

Consumer Price Index (CPI)

An index of the changes in the cost of goods and services to a typical consumer, based on the costs of the same goods and services at a base period.

Dd

Direct impacts

During the construction period: the changes that occur in the onsite construction industries in which the direct final demand change is made.
During operating years: the final demand changes that occur in the onsite spending for the solar operations and maintenance workers.

Ee

Equalized Assessed Value (EAV)

The product of the assessed value of property and the state equalization factor. This is typically used as the basis for the value of property in a property tax calculation.

Ff

Farming profit

The difference between total revenue (price multiplied by yield) and total cost regarding farmland.

Full-time equivalent (FTE)

A unit that indicates the workload of an employed person. One FTE is equivalent to one worker working 2,080 hours in a year. One half FTE is equivalent to a half-time worker or someone working 1,040 hours in a year.

Hh

HV line extension

High-voltage electric power transmission links used to connect generators to the electric transmission grid.

Ii

IMPLAN (IMpact analysis for PLANning)

A business who is the leading provider of economic impact data and analytic applications. IMPLAN data is collected at the federal, state, and local levels and used to create state-specific and county-specific industry multipliers.

Indirect impacts

Impacts that occur in industries that make up the supply chain for that industry.
During the construction period: the changes in inter- industry purchases resulting from the direct final demand changes, including construction spending on materials and wind farm equipment and other purchases of good and offsite services.
During operating years: the changes in inter-industry purchases resulting from the direct final demand changes.

Induced impacts

The changes that occur in household spending as household income increases or decreases as a result of the direct and indirect effects of final demand changes.

Inflation

A persistent rise in the general level of prices related to an increase in the volume of money and resulting in the loss of value of currency. Inflation is typically measured by the CPI.

Mm

Median Household Income (MHI)

The income amount that divides a population into two equal groups, half having an income above that amount, and half having an income below that amount.

Millage rate

The tax rate, as for property, assessed in mills per dollar.

Multiplier

A factor of proportionality that measures how much a variable changes in response to a change in another variable.

MW

A unit of power, equal to one million watts or one thousand kilowatts.

MWac (megawatt alternating current)

The power capacity of a utility-scale solar PV system after its direct current output has been fed through an inverter to create an alternating current (AC). A solar system's rated MWac will always be lower than its rated MWdc due to inverter losses. AC is the form in which electric energy is delivered to businesses and residences and that consumers typically use when plugging electric appliances into a wall socket.

MWdc (megawatt direct current)

The power capacity of a utility-scale solar PV system before its direct current output has been fed through an inverter to create an alternating current. A solar system's rated MWdc will always be higher than its rated MWac.

Nn

Net economic impact

Total change in economic activity in a specific region, caused by a specific economic event.

Net Present Value (NPV)

Cash flow determined by calculating the costs and benefits for each period of investment.

National Renewable Energy Laboratory's (NREL) Jobs and Economic Development Impacts (JEDI) Model

An input-output model that measures the spending patterns and location-specific economic structures that reflect expenditures supporting varying levels of employment, income, and output.

Oo

Output

Economic output measures the value of goods and services produced in a given area. Gross Domestic Product is the economic output of the United States as a whole.

Pp

PV (photovoltaic) system

Solar modules, each comprising a number of solar cells, which generate electrical power.

Rr

Real Gross Domestic Product (GDP)

A measure of the value of goods and services produced in an area and adjusted for inflation over time.

Real-options analysis

A model used to look at the critical factors affecting the decision to lease agricultural land to a company installing a solar powered electric generating facility.

Ss

Stochastic

To have some randomness.

Tt

Tax rate

The percentage (or millage) of the value of a property to be paid as a tax.

Total economic output

The quantity of goods or services produced in a given time period by a firm, industry, county, or country.

Uu

Utility-scale solar

Solar powered-electric generation facilities intended for wholesale distribution typically over 5MW in capacity.

XI. References

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Education

Doctor of Philosophy, Economics, Temple University, Philadelphia, Pennsylvania, May 1995.

Bachelor of Arts, Mathematics and Honors Economics, Temple University, Magna Cum Laude, May 1985.

Experience

2011-present Strategic Economic Research, LLC
President

- Performed economic impact analyses on policy initiatives and energy projects such as wind energy, solar energy, natural gas plants and transmission lines at the county and state level
- Provided expert testimony before state legislative bodies, state public utility commissions, and county boards
- Wrote telecommunications policy impact report comparing Illinois to other Midwestern states

1996-2023 Illinois State University, Normal, IL
Professor Emeritus – Department of Economics (2023 - present)
Full Professor – Department of Economics (2010-2023)
Associate Professor - Department of Economics (2002-2009)
Assistant Professor - Department of Economics (1996-2002)

- Taught Regulatory Economics, Telecommunications Economics and Public Policy, Industrial Organization and Pricing, Individual and Social Choice, Economics of Energy and Public Policy and a Graduate Seminar Course in Electricity, Natural Gas and Telecommunications Issues
- Supervised as many as 5 graduate students in research projects each semester
- Served on numerous departmental committees

1997-2023 Institute for Regulatory Policy Studies, Normal, IL
Executive Director (2005-2023)
Co-Director (1997-2005)

- Grew contributing membership from 5 companies to 16 organizations
- Doubled the number of workshop/training events annually
- Supervised 2 Directors, Administrative Staff and internship program
- Developed and implemented state-level workshops concerning regulatory issues related to the electric, natural gas, and telecommunications industries

2006-2018 Illinois Wind Working Group, Normal, IL
Director

- Founded the organization and grew the organizing committee to over 200 key wind stakeholders
- Organized annual wind energy conference with over 400 attendees
- Organized strategic conferences to address critical wind energy issues
- Initiated monthly conference calls to stakeholders
- Devised organizational structure and bylaws

2007-2018 Center for Renewable Energy, Normal, IL
Director

- Created founding document approved by the Illinois State University Board of Trustees and Illinois Board of Higher Education
- Secured over $150,000 in funding from private companies
- Hired and supervised 4 professional staff members and supervised 3 faculty members as Associate Directors
- Reviewed renewable energy manufacturing grant applications for Illinois Department of Commerce and Economic Opportunity for a $30 million program
- Created technical "Due Diligence" documents for the Illinois Finance Authority loan program for wind farm projects in Illinois

- Published 40 articles in leading journals such as AIMS Energy, Renewable Energy, National Renewable Energy Laboratory Technical Report, Electricity Journal, Energy Economics, Energy Policy, and many others
- Testified over 80 times in formal proceedings regarding wind, solar and transmission projects
- Raised over $7.7 million in grants
- Raised over $2.7 million in external funding

Sawyer D. Keithley
Strategic Economic Research
Economic Analyst

Education

Master of Applied Economics (M.S.), Sequence in Electricity, Natural Gas, and Telecommunications, Illinois State University, Normal, Illinois, 2024.

Bachelor of Science in Managerial Economics (B.S.), Minor in Business Administration, Illinois State University, Normal, Illinois, 2022.

Experience

2019-present Strategic Economic Research, LLC, Bloomington, IL
Economic Analyst

- Gather county- and state-specific data for descriptive and economic analysis.
- Perform jobs and economic development impact analysis using IMPLAN and JEDI software.
- Write and edit narratives for reports.
- Performed economic impact modeling using JEDI and IMPLAN tools
- Lead a team in historical property tax gathering for improved forecasting accuracy.

2022-2024 Institute for Regulatory Policy Studies, Normal, IL
Graduate Assistant

- Supervise a team of graduate students managing two annual seminars.
- Manage a ledger of event registrations and company purchases.
- Create and distribute conference materials.
- Prepare tables, graphs, fact sheets, and written reports summarizing research results.

2023 Nicor Gas, Rates Department, Southern Company
Research Intern

- Conduct independent research to update the cost factors used for feasibility studies.
- Gather historical and current information about the natural gas industry and analyze patterns in legislation surrounding the future of natural gas.
- Write a summary report for project findings.

2020-2021 US Department of Agriculture, Rural Development
Pathways Student InternResearch Intern

- Communicate with potential customers regarding the following loans: Single-family Housing, Multi-family Housing, Community Facilities, and Water and Environmental Programs.
- Process and organize loan applications.
- Create and administer a water and waste rates survey in cities, towns, and townships in rural Northern Illinois.

Christopher Thankan
Strategic Economic Research, LLC
Economic Analyst

Education

Bachelor of Science in Sustainable & Renewable Energy (B.S.), Minor in Economics, Illinois State University, Normal, IL, 2021

Experience

2021-present Strategic Economic Research, LLC, Bloomington, IL
Economic Analyst

- Create economic impact results on numerous renewable energy projects Feb 2021-Present
- Utilize IMPLAN multipliers along with NREL's JEDI model for analyses
- Review project cost Excel sheets
- Conduct property tax analysis for different US states
- Research taxation in states outside research portfolio
- Complete ad hoc research requests given by the president
- Hosted a webinar on how to run successful permitting hearings
- Research school funding and the impact of renewable energy on state aid to school districts
- Quality check coworkers JEDI models
- Started more accurate methodology for determining property taxes that became the main process used

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