THE ECONOMIC IMPACT OF DISTRIBUTED SOLAR IN THE APS SERVICE TERRITORY, 2016-2035

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- *Executive Budget Office State of Arizona*
- *The Fiesta Bowl*
- *First Things First*
- *Freeport McMoRan*
- *Glendale Community College*
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- *HonorHealth*
- *Intel Corporation*
- *iState Inc.*
- *The McCain Institute*
- *Maricopa Community Colleges*
- *Maricopa Integrated Health System*
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- *Public Service New Mexico (PNM)*
- *Raytheon*
- *Republic Services, Inc.*
- *Rio Tinto*
- *Rosemont Copper Mine*
- *Salt River Project (SRP)*
- *Science Foundation Arizona (SFAZ)*
- *Tenet Healthcare*
- *The Tillman Foundation*
- *Turf Paradise*
- *Valley METRO Light Rail*
- *Tenet Healthcare*
- *Twisted Adventures Inc.*
- *Vote Solar Initiative*
- *Waste Management Inc.*
- *Yavapai County Jail District*

Executive Summary

- This study examines the economic impact of three distributed (rooftop) solar deployment scenarios in the APS service territory for the study period 2016-2035, including the legacy effects of each scenario throughout the (assumed) 30 year economic life of distributed solar systems.[1]

- When considered in the round from a purely financial perspective, it concludes that all three potential distributed solar deployment scenarios will have a detrimental effect on the State of Arizona and Maricopa County economies, all other things being equal.

- Additional distributed solar is estimated to lower gross state product (GSP) by approximately $4.8 billion to $31.5 billion (2015 $), dependent on the scenario.

- Additional distributed solar deployment is also estimated to result in the net loss of 16,595 to 116,558 job years' private non-farm employment over the entire study period, dependent on the scenario.

- Any benefits emanating from each scenario are at best temporary, only coincident with the timing of the solar installations, and quickly counteracted by their long-run/legacy effects.

- In all three scenarios, the total amount of money paid by distributed generation and central station generation electricity consumers, 2016-2060, is greater than the amount which would have been paid had they all alternatively continued to draw electricity from the utility's central grid.

- That is, in each distributed solar scenario, electricity consumers as a whole will pay more for the same amount of electricity consumed, and therefore have less money to spend in other parts of the economy.

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[1] The study assumes that the cost of a 2035 distributed solar installation will only be paid off in full in 2065, thereby accounting for legacy effects. If the economic life of an installation is less than 30 years, the negative economic consequences will be greater.

LITERATURE REVIEW

- The study begins with a comprehensive literature review to assess state-of-the-art methods in economic impact analysis.

- Seidman's methodological approach is initially positioned in a 3 x 2 matrix classification of economic impact studies, illustrated below.

Seidman's 3 x 2 Classification of Economic Impact Models

COUNT GROSS	PARTIAL GROSS	GENERAL GROSS
COUNT NET	PARTIAL NET	GENERAL NET

- ***Gross*** studies only consider the direct positive impacts of increased economic activity in a specific sector.

- ***Net*** studies represent a more thorough form of economic modeling as they also account for the trade-offs in the economy which result from incentivizing one specific sector.

- ***Counts*** are usually survey-based or theoretical capacity installation quantifications of the number of direct employees within one specific sector.

- ***Partial*** models consider the wider effects of levels of activity in one specific sector, including the indirect and induced effects of the direct change, but do not consider the feedback effects of changed levels of activity in that sector – for example, the effect on wages in the labor market.

- ***General*** models offer the most comprehensive economy-wide analysis, taking into account all of the economic interconnections and feedback effects. They also yield the most significant ***Gross*** and ***Net*** impacts.

- A critique of fourteen contemporary solar economic impact studies identifies only one example of a general equilibrium analysis – that is, Cansino, Cardenete, Gonzalez and Pablo-Romero's (2013) study of Andalusia. However, this is a gross, rather than net analysis, because the authors combine renewables and non-renewables as a single sector, thereby preventing any substitution between conventional and renewable forms of generation, and effectively only allowing for positive direct demand shocks in their modeling.

- Nine of the fourteen critiqued papers adopt the partial model approach, but six of these are gross, rather than net, studies.

Positioning Seidman's Approach Relative to Fourteen Contemporary Economic Impact Studies

	Counts	**Partial Models**	**General Models**
Gross *Only positive or negative impacts*	• Pollin and Garrett-Peltier, 2009 • ETIC, 2016	• AECOM, 2011 • Loomis, Jo & Alderman ,2013 • Motamedi & Judson, 2012 • VSI and Clean Energy Project Nevada, 2011 • VSI, 2013 • Comings et al. , 2014	• Cansino et al. 2013
Net *Both positive and negative impacts*	• Alvarez et al., 2009 • Frondel et al., 2009	• NYSERDA, 2012 • Treyz et al., 2011 • Berkman et al.,2014 • **SEIDMAN 2016**	

- In the absence of an existing CGE model for the State of Arizona, and taking into account time and cost constraints, Seidman implements a ***Partial Net*** REMI analysis of solar deployment in the APS service territory, 2016-2035, as the next best alternative.

ECONOMIC IMPACT ANALYSIS

- The capital costs and financing implications of each distributed solar deployment scenario are first estimated by APS, validated by Seidman, and allocated by economic sector using NREL's JEDI model for distributed solar installations throughout the supply chain in the State of Arizona.

- APS also supplied data describing the financial impact of each solar deployment scenario on its operating cash flow, future central station generation investments, and retail electricity rates.

- The changes in investment included in the economic impact model are:

  - The annual installed costs of distributed solar capacity, 2016-2035;[2] and
  - APS' deferred or avoided central station generation investments, 2016-2035.

- The long-term legacy costs of the investment included in the economic impact model are:

  - The customer financing costs of distributed solar installations, 2016-2060;[3] and
  - Consumer electricity rate savings, due to the deferred or avoided central station generation, 2016-2060.

- The results for each scenario take into account the direct, indirect and induced economic impacts of the distributed solar deployment, and the 30-year legacy effects reflecting the economic life of the solar installations and deferred central station generation.

- Using an Arizona-specific REMI model, the economic impact of the low case scenario, which assumes 1,300 MW_{dc} of nameplate distributed solar PV installations by 2035 in the APS service territory, is as follows:[4]

LOW CASE SCENARIO	**Total Private Non-Farm Employment (Job Years)[5]**	**Gross State Product (Millions 2015 \$)**	**Real Disposable Personal Income (Millions 2015 \$)**
State of Arizona	-16,595	-\$4,806.6	-\$1,787.3
Maricopa County	*-15,685*	*-\$4,491.8*	*-\$1,862.4*

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[2] APS assumes an initial $2.50 a watt.

[3] Based on the assumed 30 year economic life of the distributed system, the customer financing costs of solar installations, 2016-2035, will not be completed until 2065. The REMI model used currently only provides economic impact estimates up to and including 2060, but Seidman does not believe that this will materially affect the conclusions in the analysis. If the economic life of an installation is less than 30 years, the negative economic consequences are in all probability greater than the estimates presented in this study.

[4] Total effects for each economic measure may not tally due to rounding-up.

[5] A job year is equivalent to one person having a full-time job for exactly one year.

- If the low case distributed solar deployment scenario actually transpires, the State of Arizona is estimated to *lose* 16,595 job years of employment, plus over $4.8 billion gross state product, and $1.8 billion real disposable personal income (both 2015 $).

- The low case distributed solar scenario therefore estimates negative impacts for all three economic impact measures assessed for the study period, including legacy effects, in the State of Arizona and Maricopa County.

- The economic impact of the expected or medium case scenario, which assumes 5,000 MW_{dc} of nameplate distributed solar PV installations by 2035 in the APS service territory, is as follows:[6]

EXPECTED CASE SCENARIO	**Total Private Non-Farm Employment (Job Years)[7]**	**Gross State Product (Millions 2015 $)**	**Real Disposable Personal Income (Millions 2015 $)**
State of Arizona	-76,308	-$21,613.3	-$7,956.4
Maricopa County	*-71,344*	*-$20,149.9*	*-$8,087.9*

- If the expected or medium case distributed solar deployment scenario actually transpires, the State of Arizona is estimated to *lose* 76,308 job years of employment, plus over $21.6 billion gross state product, and approximately $8 billion real disposable personal income (both 2015 $).

- The expected or medium case distributed solar scenario's negative impacts for all three economic measures are approximately 4.5 times greater than the low case scenario's impacts in the State of Arizona for the 2016-2035 study period, including legacy effects.

- The economic impact of the high case scenario, which assumes 7,600 MW_{dc} of nameplate distributed solar PV installations by 2035 in the APS service territory, is as follows:[8]

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[6] Total effects for each economic measure may not tally due to rounding-up.

[7] A job year is equivalent to one person having a full-time job for exactly one year.

[8] Total effects for each economic measure may not tally due to rounding-up.

HIGH CASE SCENARIO	Total Private Non-Farm Employment (Job Years)[9]	Gross State Product (Millions 2015 $)	Real Disposable Personal Income (Millions 2015 $)
State of Arizona	-116,558	-$31,454.4	-$11,901.4
Maricopa County	*-108,857*	*-$29,346.7*	*-$12,091.2*

- If the high case distributed solar deployment scenario actually transpires, the State of Arizona is estimated to *lose* 116,558 job years of employment, plus $31.5 billion gross state product, and $11.9 billion real disposable personal income (both 2015 $).

- The high case distributed solar scenario's negative impacts for all three economic measures are 6.5 to 7 times greater than the low case scenario's impacts in the State of Arizona for the 2016-2035 study period, including legacy effects.

- The high case distributed solar scenario's negative impacts for all three economic measures are also 46% to 53% greater than the expected or medium case scenario's impacts in the State of Arizona for the 2016-2035 study period, including legacy effects.

- Seidman's APS study therefore clearly demonstrates that increased adoption of distributed solar generation represents a loss to the Arizona economy in the low, expected and high distributed solar deployment scenarios. This is because the overall cost of provision of electricity to the State of Arizona will rise when referenced against a base case where electricity continues to be provided by central station generation.

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[9] A job year is equivalent to one person having a full-time job for exactly one year.

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1.0 Introduction

The purpose of this study is to calculate the total (net) economic impact of an APS distributed solar NEM program in Arizona up to and including 2035.

1.1. Net Metering

Net metering (NEM) encourages consumers to invest in renewable energy technologies by crediting them for distributed generation at the same tariff they pay for purchasing centrally-generated power.

Originating in Idaho and Arizona in the early 1980s, this utility resource usage and payment scheme allows customer meters to effectively run backwards whenever their own generation is in excess of their level of consumption.

Customers use their generation to offset their consumption over an entire billing period, and only pay for their net power purchase per month: that is, the amount of electricity consumed minus the amount of electricity generated. NEM credits are, de facto, based on current centrally-generated power tariffs.

Some suggest that NEM unfairly passes on the fixed costs of building and operating a transmission grid used by participants to non-participating customers. This is because residential and small business' utility rates volumetrically recover all costs, including those that are fixed. Advocates typically counter this criticism by arguing that NEM customers bring benefits to the grid that equal or exceed the fixed costs they avoid paying for through self-generation, including job creation and other economic impacts.

NEM is currently available in Arizona for a wide range of distributed generation renewables, including solar PV, solar thermal, wind, biomass, biogas, hydroelectric, geothermal, combined heat and power, and fuel cell technologies. The Arizona Corporation Commission (ACC) has not set a firm kilowatt-based limit on system size capacity. It simply stipulates that a system size cannot exceed 125% of a customer's total connected load or electric service drop capacity. There is also no aggregate capacity limit for net-metered systems in Arizona. However, each utility is obliged to file an annual report listing the net metered facilities and their installed capacity for the previous calendar year. Approximately 38,000 of APS' current 1.2 million customer base have distributed solar.

1.2. Economic Impact Analysis

An economic impact analysis measures the effect of a policy, program, project, activity or event on a national, state or local economy, with particular emphasis on three types of effects or impacts. These are the *direct*, *indirect* and *induced* impacts:

- ***Direct*** impacts include the initial capital investment when a business, policy or program is launched, and the people directly employed to manufacture a product, provide a service or deliver a program.
- ***Indirect*** impacts are the economic growth or decline resulting from inter-industry transactions or supplier purchases, such as a distributed solar installation company's purchase of solar modules.
- ***Induced*** impacts occur when the workers either directly or indirectly associated with an organization, policy or program spend their incomes in the local economy, when suppliers place upstream demands on other producers, and when state and local governments spend new tax revenues.

The indirect and induced economic impacts are second order expenditures and jobs created as a result of the initial "injection" of expenditure and direct jobs. For example, a utility employee hired to administer a NEM program would represent a *direct* job. Purchases made by a utility are *indirect* impacts; and the income that the utility or supplier companies' employees spend in the local economy will in turn create revenues/income for a variety of other businesses, generating *induced* effects.

The second and later rounds of indirect and induced expenditure are not self-perpetuating in equal measure. Through time, they become smaller as more of the income/expenditures "leak" out of the examined economy.[10] The cumulative effect of the initial and latter rounds of expenditure is known as the multiplier effect. There is no one "magic" multiplier estimate for every conceivable scenario. Due to the inter-linked nature of the State of Arizona's economy and its links to the rest of the U.S. (and the world), the eventual ripple effects depend on numerous factors.[11]

A full understanding of the total impact that a specific energy policy will have on an economy is therefore rather more complex than just an extrapolation of direct impacts.

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[10] For example, in the form of savings, or payments on goods and services produced outside of the state.

[11] In very simple terms, what matters is the size of the direct impact, where it occurs (that is, which county/state and which sector of the economy) and the duration of the impact.

1.3. Study Overview

To help position APS' service territory study and provide a context for its findings, Section 2 begins with an overview of economic impact modelling approaches to renewable energy, summarized in the form of a 3 x 2 matrix.

Fourteen published analyses drawn primarily, but not exclusively, from the U.S., and additional insights from Canada, Germany, and Spain (listed in Table 1) are reviewed by Seidman in Section 3, with a particular focus on assumptions, methods and conclusions.

Examining the varying magnitude of the employment and gross state product (GSP) impacts for each of the different types of study defined by the economic impact model matrix in Section 4, a clear rationale for Seidman's approach to assess the economic impact of distributed solar deployment in the APS service territory is also provided.

Sections 5 – 9 then examine the economic impact of three distributed (rooftop) solar deployment scenarios in the APS service territory for the study period 2016-2035 in the State of Arizona and Maricopa County. The analyses include the legacy effects of each scenario throughout the (assumed) 30 year economic life of the solar systems.[12]

Section 5 introduces the 3 solar deployment scenarios assessed for APS. These are:

- A low case scenario, which assumes 1,300 MW_{dc} of nameplate distributed solar PV installations by 2035 in the APS service territory, which will increase APS' total number of distributed solar customers to approximately 150,000 accounts;
- An expected or medium case scenario, which assumes 5,000 MW_{dc} of nameplate distributed solar PV installations by 2035 in the APS service territory, which will increase APS' total number of distributed solar customers to approximately 690,000 accounts; and

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[12] Based on the assumed 30 year economic life of the distributed system, the customer financing costs of solar installations, 2016-2035, will not be completed until 2065. The REMI model used currently only provides economic impact estimates up to and including 2060, but Seidman does not believe that this will materially affect the conclusions in the analysis. If the economic life of an installation is less than 30 years, the negative economic consequences are in all probability greater than the estimates presented in this study.

- A high case scenario, which assumes 7,600 MW_{dc} of nameplate distributed solar PV installations by 2035 in the APS service territory, which will increase APS' total number of distributed solar customers to approximately 1,050,000 accounts.

Table 1: Economic Impact Analyses Critiqued as Part of Current Study

Geography	Title & Author(s)
California	*AECOM (July 2011)* Economic and Fiscal Impact Analysis of Residential Solar Permitting Reform
California	*Vote Solar Initiative (April 2013*) Economic and Job Creation Benefits of SB 43/AB 1014
Illinois	*Loomis, Jo and Alderman (December 2013)* Economic Impact Potential of Solar Photovoltaics in Illinois
Montana	*Comings, Fields, Takahashi and Keith (June 2014)* Employment Effects of Clean Energy Investment in Montana
Montana	*Energy and Telecommunications Interim Committee (January 2016)* Quantifying the Economic Impacts of Net Metering in Montana
Massachusetts	*Motamedi and Judson (March 2012)* Modeling the Economic Impacts of Solar PV Development in Massachusetts
Missouri & U.S.	*Treyz, Nystrom and Cui (October 2011)* A Multiregional Macroeconomic Framework for Analyzing Energy Policies
Nevada	*Vote Solar Initiative and Clean Energy Project (2011)* Economic and Job Creation Benefits of the Nevada Solar Jobs Now Proposal of 2011
New York	*NYSERDA (January 2012)* New York Solar Study
Rhode Island	*Berkman, Lagos and Weiss (2014)* Distributed Generation Contracts Standard Program and Renewables Energy Fund: Jobs, Economic and Environmental Impact Study
Andalusia	*Cansino, Cardenete, Gonzalez, and Pablo-Romero (2013)* Economic Impacts of Solar Thermal Electricity Technology Deployment on Andalusian Productive Activities: A CGE Approach
Germany	*Frondel, Ritter, Schmidt and Vance (2009)* Economic Impacts from the Promotion of Renewable Energy Technologies - The German Experience
Ontario	*Pollin and Garrett-Peltier (2009*) Building the Green Economy: Employment Effects of Green Energy Investments for Ontario
Spain	*Alvarez, Jara, Julian and Bielsa (March 2009)* Study of the Effects on Employment of Public Aid to Renewable Energy Sources

Section 6 describes the simulation results for the low distributed solar deployment scenario.

Section 7 presents the simulation results for the expected distributed solar deployment scenario.

Section 8 describes the simulation results for the high distributed solar deployment scenario.

Conclusions are offered in Section 9.

2.0 Economic Impact Assessment Methods

There are a number of different approaches to an economic impact assessment. These are codified in Figure 1 below.

Figure 1: Classification of Economic Impact Models

COUNT GROSS	PARTIAL GROSS	GENERAL GROSS
COUNT NET	PARTIAL NET	GENERAL NET

Figure 1 illustrates two key distinctions among economic impact studies.

The first distinction is between gross studies and net economic impact studies. Studies that are ***Gross*** in nature only consider the direct *positive* impacts of increased economic activity – in this case, solar generation. ***Net*** studies represent a more rounded form of economic assessment because they also account for the trade-offs in the economy which result from incentivizing one specific sector, such as the *negative* impacts on utilities and reduced spending and investment in other economic activities associated with increased solar activity.

For example, a gross study might consider the positive effects of the installation of 100MW utility-scale solar on the level of economic activity alone, while a net study of the same installation would additionally allow for the negative economic impacts such as the decreased use of conventional forms of generation if these were displaced, and the net changes in residential, commercial and industrial energy bills. Consider also the installation of a distributed solar system by a homeowner. To meet a $30,000 cost of installation, the homeowner will forego spending the same $30,000 on something else, such as perhaps a new or refurbished swimming pool at their property. There are obviously positive economic effects associated with the homeowner's investment in a distributed solar system, which would be captured in a gross economic study. However, in this example, there are also negative effects associated with the loss of investment in the swimming pool, which are only ever considered alongside the positive benefits of the solar installation as part of a *net* study.

Nine gross and five net studies are examined in Section 3. The gross studies are:

- California: AECOM, 2011
- California: Vote Solar Initiative, 2013
- Illinois: Loomis, Jo & Alderman, 2013
- Massachusetts: Motamedi & Judson, 2012
- Montana: Comings, Fields, Takahashi and Keith (Synapse Energy Economics), 2014
- Montana: ETIC, (2016)
- Nevada: Vote Solar Initiative, 2011
- Andalusia: Cansino, Cardenete, Gonzalez and Pablo-Romero, 2013
- Ontario: Pollin and Garrett-Peltier, 2009

The net studies are:

- Missouri & U.S.: Treyz, Nystrom and Cui, 2011
- New York: NYSERDA, 2012
- Rhode Island: Berkman, Lagos and Weiss (the Bratton Group), 2014
- Germany: Frondel, Ritter, Schmidt and Vance, 2009
- Spain: Alvarez, Jara, Julian and Bielsa, 2009

The second key distinction is between simple counts, partial (equilibrium) modeling, and macroeconomic (or general equilibrium) modeling.

Counts are typically tallies of direct measures of economic activities, such as jobs, investments, or sales, without any attempt to capture the impacts of the inter-relationships with other economic sectors. As a result, counts can be more or less extensive in terms of their reach. Some just concentrate on counting the number of direct employees or assessing the level of sales within a specific economic sector, while others seek information about a sector's entire supply chain. Counts can be made by surveys or by assessing theoretically the required inputs for the installation of defined amounts of solar capacity – for example, the first part of a JEDI model which estimates the number of jobs created in the solar sector in a linear fashion based on the MW capacity of the solar installations. Studies examined in this report that use the counts method are:

- Montana: ETIC, 2016
- Germany: Frondel, Ritter, Schmidt and Vance, 2009
- Ontario: Pollin and Garrett-Peltier, 2009
- Spain: Alvarez, Jara, Julian and Bielsa, 2009

Partial models consider the wider effects of levels of activity in a specific economic sector, and are one of the most common commercial approaches in economic impact modeling. In contrast to counts, which generally assess the direct impacts of a change in the economy, partial models also consider the indirect and induced effects of the direct changes within a particular geography. The one drawback with partial models is that they do not consider the feedback effects of changed levels of an investment or economic activity such as, for example, the effect of large solar projects on wages in the labor market. Studies examined in this report that use the partial model method are:

- California: AECOM 2011
- California: Vote Solar Initiative, 2013
- Illinois: Loomis, Jo & Alderman, 2013
- Massachusetts: Motamedi & Judson, 2012
- Missouri & U.S.: Treyz, Nystrom and Cui,, 2011
- Montana: Comings, Fields, Takahashi and Keith (Synapse Energy Economics), 2014
- New York: NYSERDA, 2012
- Nevada: Vote Solar Initiative and Clean Energy Project Nevada, 2011
- Rhode Island: Berkman, Lagos and Weiss (the Bratton Group), 2014

General models consider the effects of levels of solar activity in an economy-wide context with reference to every economic interconnection and feedback effect. An example is computable general equilibrium (CGE) models. These model the entire economy and attempt to account for all of the impacts associated with a specific level of solar activity. Only one study examined in this report uses a general model to assess impacts, due to the cost prohibitive nature of producing a CGE model for a state or a region. This is Cansino, Cardenete, Gonzalez and Pablo-Romero's (2013) study of Andalusia.

Figure 2 summarizes the studies examined in this report in terms of the method employed, and whether they consider positive impacts alone, or both positive and negative impacts.

Figure 2: Classification of Studies Examined by Method

	Counts	Partial Models	General Models
Gross *Only positive or negative impacts*	• Pollin and Garrett-Peltier, 2009 • ETIC, 2016	• AECOM, 2011 • Loomis, Jo & Alderman ,2013 • Motamedi & Judson, 2012 • VSI and Clean Energy Project Nevada, 2011 • VSI, 2013 • Comings et al. , 2014	• Cansino et al. 2013
Net *Both positive and negative impacts*	• Alvarez et al., 2009 • Frondel et al., 2009	• NYSERDA, 2012 • Treyz et al., 2011 • Berkman et al., 2014	

3.0 Evaluation Framework and Review of Fourteen Economic Impact Analyses

To objectively critique fourteen contemporary analyses of the economic impact of solar PV/renewables, Seidman uses the following questions as an evaluation framework:

(a) What is the context for a study?
(b) What are the study's objectives?
(c) Which geography is being studied?
(d) What is the time-horizon of the study?
(e) Which economic modeling tool is used?
(f) What types of effects are modeled, with reference to Seidman's 3 x 2 classification of economic impact models?
(g) What are the key inputs and assumptions used in the modeling process, including the solar growth projection assumptions?
(h) What are the key findings?

The following tables in this Section provides Seidman's assessment of each of the fourteen contemporary studies.

Reference will also be made, where appropriate, when a particular study method is replicated in multiple geographies by the same authors.

Title	**Economic and Fiscal Impact Analysis of Residential Solar Permitting Reform**
Author(s)	**AECOM, July 2011**
Background	Considers the impact of a 76% reduction in homeowner permitting costs for solar PV when scaled to the regional and state level, taking into account the projected growth in the industry through 2020.
Objective(s)	• Evaluate the economic and fiscal implications of a streamlined local government permitting system for installing residential solar PV.
Geography	California
Time Period	2012-2020
Modeling Tool	IMPLAN
Type of Effects Examined	• This is a ***Partial Gross*** analysis, as it lacks detail on negative impacts considered. • Considers a few more factors than the VSI reports, such as the initial down payment for a solar system which is positioned as a loss to homeowner savings and a gain to the solar industry. • It is at best a weak, borderline example of a net partial study as it does not: ○ Explicitly consider non-solar energy sector losses; ○ Take into account utility obligations from a transmission and distribution grid perspective in terms of savings, upgrades or modifications; ○ Quantify the impact of a reduction in the demand for centralized power generation due to increased distributed generation; ○ Remove the rebate dollars paid to homeowners and installers from the IMPLAN inputs; and ○ Consider the administrative costs associated with changing permitting rules. • Also questionably assumes that increased homeowner savings from reduced electricity bills will be spent in full in-state.
Model Assumptions	• Base case scenario uses California Solar Initiative's 2011 residential installation costs of $6.97 per watt decreasing to $3.63 per watt by 2020. • Streamlined permitting would reduce annual costs by $0.38 per watt in 2020 (i.e. from $6.10 per watt in 2011 to $3.25 per watt in 2020). • Investment Tax Credit of 30% is assumed to continue through 2020. • Average size of residential solar systems was 5.6 kW, 2012-2020. • All solar systems will be purchased in California, albeit region unknown. • Assumes solar in both cases will appeal to homeowners whose annual electricity bills would be reduced by at least 5% post-installation. • Value of residential solar only impacts property taxes when the home is sold. • Buyers will pay on average 3.6% more for solar PV homes.
Solar Growth Projection Assumptions	• Projects 1,006,500 installations at 5 utilities' service areas for current permitting, 2012-2020; or an additional 131,500 installations for streamlined permitting. • 332 MW installed 2007-2011; 2,668 MW installed 2012-2020 without streamlined permitting (BAU case).
Effects Scaled per Year (2015 $)	• Current permitting scenario assumes: ○ 73.5 job years created per total MW installed, amounting to 196,020 job years in total for the entire 2012-2020 period; ○ $1.24 million GSP per MW per year (2015 $); and ○ $69.70 per MW per year increase in additional sales tax, property tax, and payroll tax (2015 $).

Title	**Economic and Job Creation Benefits of SB 43/AB 1014**
Author(s)	**The Vote Solar Initiative, April 2013**
Background	SB43 and AB 1014 are two shared renewable pilot programs to enable residential renters and commercial customers to subscribe via PG&E, SCE, and SDGE to an offsite renewable energy project and receive a utility bill credit in return.
Similar Studies	• VSI (2010) Colorado; • VSI (2011) Nevada; • VSI (2011) Iowa; and • The Solar Foundation (2013) Colorado.
Objective(s)	• Estimate the number of jobs created under SB 43/AB 1014, and the increased dollars that will subsequently circulate throughout the California economy.
Geography	California
Time Period	2014-2016 construction; 25 year lifetime O&M
Modeling Tool	JEDI (based on IMPLAN I-O) version January 3, 2013
Type of Effects Examined	• This is a ***Partial Gross*** analysis of two shared renewable programs. • Study does not consider net job creation. It simply details the cumulative employment benefits of both proposed shared renewable programs, without taking into account the potential loss of jobs in other energy sectors. • State sales tax revenue and instate economic activity results are also exclusively considered from a shared renewable program perspective. • Authors ignore the net changes that will in reality occur due to changes in other sectors of the state economy prompted by both programs, including the potential for higher energy bills.
Model Assumptions	• Crystalline Silicon – fixed mount commercial; single axis tracking utility scale. • For both pilots, study assumes the following local purchases: ○ 100% of components for solar installations < 100 kW; ○ 50% of components for 100 kW to 1 MW installations; and ○ 30% of components for installations > 1 MW. • For both pilots, it also assumes the following local manufacturing: ○ 10%-20% of components for installations < 1 MW; and ○ 5-10% of components for installations > 1 MW. • This amounts to 546 MW local total purchases for the implementation of both pilot schemes, and 91.5 MW to 183 MW local manufacturing. • 2014-2016 construction period. • 25 year operational phase.
Solar Growth Projection Assumptions	• For SB 43, 53 MW installed in 2014, 161 MW installed in 2015, and 286 MW installed in 2016, resulting in a 500 MW pilot. • For AB 1014, 65 MW installed in 2014, 285 MW installed in 2015, and 650 MW installed in 2016, resulting in a 1,000 MW pilot.
Effects Scaled per Year (2015 $)	• SB 43 is estimated to have a gross jobs impact of 26.7 job years/MW, $179,000 GSP per MW per year, and $5,291 sales tax revenue per MW per year (2015 $). • AB 1014 is estimated to have a gross jobs impact of 24.0 job years/MW, $175,000 GSP per MW per year, and $5,331 sales tax revenue per MW per year (2015 $).

Title	**Economic Impact Potential of Solar Photovoltaics in Illinois**
Author(s)	**Loomis, Jo and Alderman, December 2013**
Background	Center for Renewable Energy (Illinois State University) study, supported by an Illinois Department of Commerce and Economic grant.
Objective(s)	Considers employment and output impacts for the construction and operations phases of 3 solar deployment scenarios, with 3 levels of in-state manufacturing.
Geography	Illinois
Time Period	2014-2030
Modeling Tool	JEDI PV Model (PVS4.5.13)
Type of Effects Examined	• This is a ***Partial Gross*** analysis. • It exclusively considers renewable (solar) sector impacts, including supply chain. • It does not consider corresponding impacts in other parts of the energy sector, or other economic sectors.
Model Assumptions	• Installations profile: ○ 10% residential (80% retrofits, 20% new construction); ○ 10% small commercial; ○ 20% large commercial; ○ 60% utility-scale. • 100% local purchases: ○ Labor and soft costs (permitting and business overhead); and ○ Residential and small commercial materials and equipment. • All materials and equipment for large commercial and utility-scale installations are purchased 100% out-of-state. • Three levels of instate manufacturing per scenario – 0%, 5%, and 10%.
Solar Growth Projection Assumptions	• 2,292 MW, 2714 MW, or 11,265 MW by 2030.
Effects Scaled per Year (2015 $)	• For all 3 scenarios at 10% in-state manufacture: ○ 12.2 gross job years per MW installed; ○ Approximately $107,000 GSP per MW per year (2015 $); and ○ Approximately $45,600 labor income per MW per year (2015 $).

Title	**Modeling the Economic Impacts of Solar PV Development in Massachusetts**
Author(s)	**Motamedi and Judson, March 28, 2012 (Unpublished PowerPoint)**
Background	REMI. commission for the New England Energy and Commerce Association Renewables and Distributed Generation Committee.
Objective(s)	• Assess the economic impact of the ○ Construction of 305 MW of solar PV, 2012-2018; and ○ Operation of solar PV installations, 2012-2025.
Geography	Massachusetts
Time Period	• 2012-2018 construction; and • 2012-2025 operations.
Modeling Tool	REMI
Type of Effects Examined	• ***Partial Gross*** study, which generically describes, but does not state, the value of inputs used.[13] • Energy cost savings are only considered from a solar savings perspective.
Model Assumptions	• Combination of residential, commercial, and utility-scale solar installations, with regional purchase coefficients of 0.629, 0.564, and 0.580 respectively. • Construction phase uses total investment after federal and state tax credit cost reduction, including some consumer consumption reallocation and production costs, along with consumer electricity price, and business electricity fuel cost changes. • Models locally supplied inputs as total construction spending. • Consumer price of electricity, electricity fuel costs for businesses, and production cost to utilities are used to represent the energy cost savings; and analysis assumes no change to SREC market.
Solar Growth Projection Assumptions	• Additional 305 MW of PV, 2012-2018, taking total installation to 400 MW. • Does not state the split between residential, commercial and utility-scale solar.
Effects Scaled per Year (2015 $)	• 20.1 job years created per MW installed. • Approximately $122,000 GSP per MW per year (2015 $). • Approximately $155,000 personal income per MW per year (2015 $).

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[13] Motamedi and Judson mention energy cost savings, implying some consideration of the negative economic impacts of solar deployment. However, their PowerPoint presentation does not include any obvious assessment of negative impacts, and the REMI output is not suggestive of their inclusion. As a result, Seidman has classified their approach as ***Partial Gross***.

Title	**A Multiregional Macroeconomic Framework for Analyzing Energy Policies**
Author(s)	**Treyz, Nystrom and Cui, October 2011**
Background	REMI-authored study considering the local, regional and national economic impacts of Missouri's RPS, excluding environmental and social impacts.
Objective(s)	Compares effects of electricity price-cap mandate (Scenarios 1 and 2) and an alternative bond-funded cost-recovery strategy (Scenarios 3 and 4) to finance the subbing of wind and solar for coal.
Geography	Missouri and the U.S.
Time Period	• Construction impacts (RPS implementation), 2011-2021. • Operational impacts, 2011-2035.
Modeling Tool	REMI
Type of Effects Examined	• ***Partial Net*** study.
Model Assumptions	• Baseline: No RPS implemented in Missouri. • Scenario 1 = IOUs raise prices to statutory cap of 1% to recover low cost of subbing wind and solar for coal (cost fully recovered by 2023). • Scenario 2 = IOUs raise prices to statutory cap of 1% to recover high cost of subbing wind and solar for coal (cost fully recovered by 2025). • Scenario 3 = IOUs issue bonds with maturity of 15 years at 3.25% interest rates to raise funding needed for low cost infrastructure. • Scenario 4 = IOUs issue bonds with maturity of 15 years at 3.25% interest rates to raise funding needed for high-cost infrastructure. • In Scenarios 1 and 2: ○ 1% compound increase in commercial and industrial electricity prices; ○ 1% compound increase in residential electricity prices, with lower disposable income corresponding consumption reallocation. • In Scenarios 3 and 4: ○ Utilities issue bonds at bank prime rate of 3.25% per year for 15 years; ○ Impacts greater in the 2020s when consumers have to pay higher prices to pay off bonds, compared to 2010s when consumers pay the costs up front in Scenarios 1 and 2. • In Scenarios 1-4: ○ Solar panel purchase and O&M are treated as semiconductor manufacture exogenous final demand with corresponding consumption reallocation ○ IOU rebates accounted for in production cost and transfer payments; ○ Partial substitution of conventional electricity for solar electricity allows households to reduce conventional electricity consumption and expense, captured in consumption reallocation; and ○ Creation of a custom industry for commercial wind generation, to account for different intermediate demands.
Solar Growth Projection Assumptions	• RPS: Coal = 66%, Wind 14.7%, Solar 0.3% and Other 20% from 2021 onwards. • Coal declines from 81% of electric production in 2010 to 66% by 2021; wind and solar from 0% to 15%.
Effects Scaled per Year (2015 $)	• Graphs rather than data tables are provided, creating difficulties for interpretation. • A state RPS is assumed to cause a short-term decrease in local employment, real GDP and personal real disposable income per capita. • Raising electricity prices is estimated to result in the loss of 4,000 to 5,000 job years by 2021 or 2025, before recovering to the same level as the 2010 baseline in 2031. • A bond scheme is estimated to create an initial short term annual employment increase of up to 1,000 jobs, but the trend reverses upon completion of the RPS in 2021,

	decreasing by 2,000 to 3,000 jobs per year up until 2027, before recovering to a net decrease of 600-800 jobs by 2035. • Real GDP would steadily decrease under the price-cap scenario, hitting a low of \$350-\$458 million loss in 2021 and 2025, before regaining some ground to a \$102 million loss in 2035 (2015 \$). • The utility bond approach would have expand real GDP until 2021, peaking at \$153-\$204 million in 2019, fading to a decrease of \$306-\$408 million in 2027, before picking up to a loss of \$153-244 million by 2035 (2015 \$).

Title	**Employment Effects of Clean Energy Investment in Montana**
Author(s)	**Comings, Fields, Takahashi and Keith (Synapse Energy Economics), 2014**
Background	Examines the employment impacts of hypothetical additions to Montana's renewable energy portfolio.
Objective(s)	• Estimate employment impacts of construction and O&M activities associated: ○ Large-scale wind; ○ Large-scale solar PV; ○ Small-scale solar PV (rooftop), and ○ Energy efficiency.
Geography	Montana
Time Period	• Installation of systems is assumed to take place in 2016-2017. • Assumes 20 years of system operation.
Modeling Tool	IMPLAN in conjunction with capacity data from NREL's JEDI model.
Type of Effects Examined	• ***Partial Gross*** study of direct, indirect and induced employment impacts. • Makes no attempt to consider net effects. Focused entirely on job impacts of solar installation and O&M spending and considers no other benefits of solar deployment.
Model Assumptions	• Develops solar spending patterns associated with rooftop and utility-scale installations using NREL's JEDI model with adjustments for local conditions. • Estimates construction jobs in short-run and allocates them over 20 years together with O&M to obtain a 20 year cumulative job impact per average MW deployed.
Solar Growth Projection Assumptions	• No actual projections. • Uses NREL's (2012) maximum hypothetical potential of 4,409 GW utility-scale and 2 GW rooftop solar PV for Montana.
Effects Scaled per Year	• Small PV – 9.2 job years per MW. • Large PV – 5.0 job years per MW.

Title	**Quantifying the Economic Impacts of Net Metering in Montana**
Author(s)	**Energy and Telecommunications Interim Committee (ETIC), January 2016**
Background	Examines the historical economic development impact of net metering installations in 2014 and 2000-14 in Montana.
Objective(s)	• Evaluate economic development impacts of the installation of net metering systems in terms of the following benefits and costs: ○ Bill savings of net metering customers; ○ Residential property value increases; ○ Revenue generated by installations; ○ Employment from installations; ○ Value of avoided carbon emissions; ○ Costs of income tax credits; and ○ Universal System Benefits (USB) renewable energy and Research & Development (R&D) allocations.
Geography	Montana
Time Period	2000-2014
Modeling Tool	Counts based on survey/modeling estimates from other states.
Type of Effects Examined	• This is in fact not an economic impact study or a normal assessment of economic development impacts. • It's a partial ***Count Gross*** analysis that considers a limited set of costs and benefits associated with net metering system deployments. • The tax revenue estimates are unclear, incomplete and based on very general assumptions.
Model Assumptions	• Based mostly on Montana Renewable Energy Association (MREA) survey data. • Uses NREL models to assess installation sales revenue based total installations each year but no specifics of the nature of the system(s) installed are given. • Employment outcomes are also based on survey work done by the Montana Environmental Information Center, Synapse Energy and the Sierra Club. • It is lacking in a number of aspects. It needs to: ○ Consider *full* indirect and the induced impacts of net metering; ○ Use appropriate bespoke models for Montana reflective of local economic circumstances; and ○ Not rely on very general rule of thumb estimates for jobs, revenues and taxes generated as base data. • It double-counts historical property value and homeowner energy savings as separate benefits.
Solar Growth Projection Assumptions	• The extent of net metering systems installed in 2014 is stated as $4M (2014 $) but there is no statement of the extent of system additions or their capacity between 2010 and 2014.
Effects Scaled per Year	• There is no statement of installed capacity during the study period. There is also no statement of GSP, employment or tax revenue. It is thus impossible to calculate a jobs impact per MW, GSP per MW per year, or sales tax revenue per MW.

Title	**Economic and Job Creation Benefits of the Nevada Solar Jobs Now Proposal of 2011**
Author(s)	**Vote Solar Initiative and Clean Energy Project Nevada**
Background	Considers the economic impact of expanding Nevada's DG solar market from 35 MW to 400 MW between 2011 and 2020.
Similar Studies	• VSI (2010) Colorado; • VSI (2011) Iowa; • VSI (2013) California; and • The Solar Foundation (2013) Colorado.
Objective(s)	• Evaluate the economic, job benefits and tax impacts of expansion of and changes to the incentive structure of Nevada's Solar Jobs Now proposal of 2011.
Geography	Nevada
Time Period	2011-2020
Modeling Tool	NREL's Jobs and Economic Impacts (JEDI) model.
Type of Effects Examined	• This is a very simplistic and rather opaque ***Partial Gross*** analysis since it lacks *any* consideration of the negative impacts of expansion. • It is biased in terms of its assessment of economic impacts since it does not: ○ Consider any non-solar energy sector losses; ○ Take into account utility obligations from a transmission and distribution grid perspective in terms of savings, upgrades or modifications; ○ Quantify the impact of a reduction in the demand for centralized power generation due to increased distributed generation; ○ Consider the economic impacts of rebate dollars paid to DG homeowners and installers; ○ Examine the economic impacts of reduced spending on other categories of expenditure throughout the expansion phase from capital expenditures on DG solar systems; and ○ Consider the administrative costs associated with changing permitting rules.
Model Assumptions	• Base assumptions are drawn from a JEDI model specific to Nevada. • Basic premise is a growth of 365 MW in residential and commercial DG solar. • No specifics about system characteristics used in the JEDI model are outlined in the paper.
Solar Growth Projection Assumptions	• 365 MW installed 2011-2020.
Effects Scaled per Year (2015 $)	• Over the period 2011-2020, The Solar Jobs Now Proposal is estimated to have: ○ A gross jobs impact of 28.5 job years/MW; ○ $443,400 GSP per MW per year (2015 $); and ○ $22,500 sales tax revenue per MW (2015 $).

Title	**New York Solar Study**
Author(s)	**New York State Energy Research & Development Authority (NYSERDA), January 2012**
Background	Study required by The Power New York Act of 2011.
Objective(s)	Evaluate the cost-benefits of increasing solar PV in NY to 5,000 MW by 2025.
Geography	New York State
Time Period	2013-2049
Modeling Tool	REMI
Type of Effects Examined	• ***Partial Net*** study. • Quantifies direct PV job impacts of each scenario, economy-wide net impacts, gross state product, retail rate impacts, and environmental impacts. • Economy-wide net job analysis includes: ○ Positive impacts such as the creation of new PV jobs, and ratepayer savings when electricity prices are suppressed by PV output; and ○ Negative impacts, such as the cancellation of new power plants that are made unnecessary by the added PV capacity, or the additional costs of PV incentives, which reduce personal disposable income. • Net retail impact of PV deployment includes: ○ The above-market costs of PV; ○ Net metering costs; and ○ Savings generated by the suppression of wholesale electricity prices. • Net environmental impacts include: ○ Lower emissions via a reduction in the need for fossil fuel plants; and ○ Land use changes from rooftop to ground-mounted over time.
Model Assumptions	• Three scenarios: ○ Low Cost Scenario, using DOE SunShot goal for PV cost reduction, assuming extension of the federal tax credit (FTC) through 2025; ○ Base Case Scenario, using a DOE survey and moderate reduction of FTC beyond 2016, plus costs of \$2.5 million/MW for large-scale and \$3.1 million/MW for small-scale installations; and ○ High Case Scenario, based on the national average annual PV system price decline over the past decade, with FTC reverting to a pre-federal stimulus level in 2016. • 5% of solar components are manufactured in NY; the rest are imported. • Incentive costs are recovered from ratepayers through their electricity bills. • Quantified benefits of the 5000 MW by 2025 goal include a wholesale price suppression assumption, a reduction in energy lost to transmission and distribution inefficiencies, a reduction or deferral of the need to upgrade the utility distribution system, avoided RPS compliance costs, and a monetized carbon value of \$15 per ton.
Solar Growth Projection Assumptions	• Achieve 5,000 MW solar PV deployment by 2025. • Four policy options are analyzed to stimulate demand: ○ Utilities obliged to purchase tradable solar renewable energy credits (SRECs) from spot market, supported by a price floor mechanism to provide greater degree of revenue certainty; ○ Utilities manage a competitive procurement similar to CA in which they award long-term contracts to purchase renewable energy; ○ Residential and commercial small PV system rebates, and larger systems incentives, provided centrally via competitive bidding; and ○ Utilities incentives for larger projects through competitive long-term contracts, and a cents per kWh produced for smaller projects.

Effects Scaled per Year (2015 $)	• 4.7-6.3 gross job years created per MW installed, dependent on scenario, 2013-2025. • 700 economy-wide jobs net gain (low) or 750 to 2,500 economy-wide jobs net loss (base and high), 2013-2049. • $15,760 GSP per MW per year gain (low), or $16,930 to $58,386 GSP per MW per year loss (base and high), 2013-2049 (2015 $).

Title	**Distributed Generation Standard Contracts Program and Renewables Energy Fund: Jobs, Economic and Environmental Impact Study**
Author(s)	**Berkman, Lagos and Weiss (The Brattle Group), 2014**
Background	• Prepared for the Rhode Island Office of Energy Resources and Commerce as stipulated by the July 2013 Distributed Generation Standard Contracts (DGSC) Law.
Objective(s)	• Examine the potential economic, fiscal and environmental impacts of the Distributed generation Standard Contract (DGSC) and Renewable Energy Fund (REF) 20134-2038.
Geography	Rhode Island
Time Period	2014-2038
Modeling Tool	IMPLAN in conjunction with energy capacity planning and energy dispatch models
Type of Effects Examined	• A ***Partial Net*** study in terms of its economic impact assessment. • Includes spending on installations as a gross addition to final demand. • Does not net out the associated purchase/leasing costs which would likely swamp installation spending. • Includes payments to DGSC/REF participants but no allows no countervailing reduction in non-DGC ratepayers' spending. • Costs to ratepayers are assessed but not included in the economic impact assessment. • Assess central generation capacity and operating costs with a capacity planning and economic dispatch model.
Model Assumptions	• Includes both wind and solar renewable energy. • Operational life span of renewable resources assumed to be 25 years. • Source metrics for with and without DGC and REF scenarios obtained from past studies. • Use secondary sources to assess central generation and capacity costs using approximations rather than primary modeling. • It is unclear how DGSC/REF capacity deletions/additions are assessed to affect central generation costs.
Solar Growth Projection Assumptions	• Three (assumed not forecast) scenarios above 2013 40 MW are assessed: ○ 160 MW (by 2019) with REF of $800,000 in solar installations; ○ 200 MW (by 2019) with REF of $800,000 in solar installations; and ○ 1,000 MW (by 2024) with REF of $1,600,000 in solar installations.
Effects Scaled per Year (2015 $)	• Average annual GSP per MW: ○ 160 MW DGC:$191,790 GSP per MW (2015 $); ○ 200 MW DGC: $182,216 GSP per MW (2015 $); and ○ 1,000 MW DGC: $135,290 GSP per MW (2015 $). • Average annual job years per MW: ○ 160 MW DGC: 1.53 jobs; ○ 200 MW DGC: 1.465 jobs; and ○ 1,000 MW DGC: 1.095 jobs.

Title	**Economic Impacts of Solar Thermal Electricity Technology Deployment on Andalusian Productive Activities: A CGE Approach**
Author(s)	**Cansino, Cardenete, Gonzalez and Pablo-Romero, 2013**
Background	Annals of Regional Science published paper estimating the impact on productive activities of increasing the production capacity of two types of solar thermal plant in Andalusia.
Objective(s)	• To quantify the gross direct and induced productivity impacts of a single parabolic trough solar collector power plant and a single solar tower plant for the Andalusian economy. • To also quantify the gross direct and induced productivity impacts of both types of solar thermal technology based on the addition of 789 MW installed capacity by 2013 to comply with the Sustainable Energy Plan for Andalusia (PASENER).
Geography	Andalusia (Spain)
Time Period	• 2008-2013 installation; and 30 year estimated lifetime for each plant.
Modeling Tool	Static computable general equilibrium (CGE) model, consisting of 27 productive activities in the Andalusian economy.
Type of Effects Examined	• ***General Gross*** study.[14] • Describes gross economic impacts by sector, based on an enlarged electricity sector which combines renewables and non-renewables and prevents any substitution.
Model Assumptions	• Walrasian notion of competitive equilibrium, extended to include producers, households, government, and foreign sectors. • The single representative consumer maximizes a Cobb-Douglas utility function. • Government maximizes a Leontief utility function. • Foreign sector is modeled as a single sector that includes the rest of Spain, the European Union, and the rest of the world. • Benchmark equilibrium scenario includes a perfect inelastic supply of capital and positive unemployment rate, and a fixed level of government and foreign sector activities which allows relative prices, activity levels, public deficit and foreign trade deficit to work as exogenous variables. • Equilibrium is defined as an economic state in which the representative consumer maximizes his utility, the 27-sector productive activities maximize their profits after taxes, and public revenue is equal to the payments to the different economic agents. • Does not consider if Andalusia's gross output gains are at the expense of other states' output – e.g. from the crowding-out effect of power generation.
Solar Growth Projection Assumptions	• For the single plant analysis: ○ 50 MW parabolic trough plant with 624 collectors; and ○ 17 MW solar tower plant with 2,750 heliostats. • Estimated lifetime of each plant is 30 years. • For the PASANER scenario, to meet the 800 MW target by 2013 (789 MW additions), the model assumes 80% parabolic trough and 20% solar tower.
Effects Scaled per Year	• Scenario 1 (single plant additions) is estimated to result in an economy-wide gross productivity increase of 0.75% for the parabolic trough plant, or a 0.68% economy-wide gross productivity increase for the solar tower plant. • Scenario 2 (PASANER) is estimated to result in an economy-wide gross productivity increase of 35.37% over the 30-year lifetime of the parabolic trough and solar tower plant additions (30.81% parabolic trough; 4.57% solar tower).

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[14] Cansino et al. use a 27-sector CGE model that is a general modeling representation of the Spanish economy, allowing for both positive and negative feedback effects of increased levels of solar penetration in Andalusia. However, they model renewables and non-renewables as a single sector that does not allow for substitution between forms of generation, which means that they are effectively only allowing for positive direct demand shocks in their modeling. This is why Seidman classifies their approach as a *General Gross* model.

Title	**Economic Impacts from the Promotion of Renewable Energy Technologies – The German Experience**
Author(s)	**Frondel, Ritter, Schmidt and Vance, 2009**
Background	Critically reviews cost and job implications of the Renewable Energy Sources Act (EEG) – the centerpiece of the German promotion of renewable energy. This guaranteed stable feed-in-tariffs (FITs) for up to 20 years, and also favorable conditions for investments in green electricity production for the long-term.
Objective(s)	To demonstrate the impact of government-backed renewable incentives for stimulating the economy
Geography	Germany
Time Period	2000-2020
Modeling Tool	Non-Applicable
Type of Effects Examined	• ***Count Net*** study which balances gross renewable sector gains with: ○ The losses that result from the crowding out of cheaper forms of conventional energy generation; and ○ The drain on economic activity precipitated by higher electricity prices, including a loss of consumer spending power, and lower total investments of industrial energy consumers. • Also notes that: ○ New green jobs are often filled by workers who were previously employed, leading to a further overestimate of gross jobs effects; ○ Energy security benefits of solar PV are undermined by reliance of imported fossil fuel sources to meet technological demand; and ○ Technological innovation is stifled via a subsidy that compensates an energy technology for its lack of competitiveness. • Assesses real net present cost of solar subsidies, based on the volume of solar generation, the FIT, and conventional electricity prices. • Specific net cost per kWh = difference between solar FIT and market prices at the power exchange.
Model Assumptions	• Utility central station generation costs of 2-7 cents/kWh • Utilities obliged to accept delivery of power into their own grids from independent renewable producers • Solar-specific FIT of 50.62 cents/kWh paid by utilities in 2000 falling to 43.01 cents/kWh in 2009. • If solar subsidization ended in 2009, electricity consumers would still face charges until 2029. • Assumes 2% annual inflation. • Cost estimates for PV modules installed 2000-2008 are based on an overall solar electricity production of 96 billion kWh during 20 years of subsidization.
Solar Growth Projection Assumptions	• Germany had 5,311 MW installed PV capacity in 2008.
Effects Scaled per Year (2015 $)	• Net cost promoting Solar PV per MW installed: $3.18 million, 2000-2008 (2015 $).[15]

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[15] €2.2 million (2007 €) converted to US$ at a rate of US$1: €0.7687.

Title	**Building the Green Economy: Employment Effects of Green Energy Investments for Ontario**
Author(s)	**Pollin & Garrett-Peltier, 2009**
Background	University of Massachusetts-Amherst study sponsored by the Green Energy Act Alliance, Blue Green Canada, and World Wildlife Fund (Canada).
Objective(s)	• Considers the employment benefits of two Ontario green investment agendas: ○ Baseline Integrated Power System Plan (IPSP): $18.6 BN investment over 10 years in conservation and demand management, hydroelectric, on-shore wind, bioenergy, waste energy recycling and solar power; and ○ Expanded Green Energy Act Alliance (GEAA): $47.1 BN investment over 10 years in IPSP's 6 areas plus off-shore wind and smart grid electrical transmission system.
Geography	Ontario, Canada
Time Period	10 years
Modeling Tool	• Author-modified provincial I-O tables for Ontario, combined with national I-O tables for Canada to construct wind, solar, biomass and building retrofitting as industries in their own right. • Also uses U.S. data (BLS 2007 Occupational Employment Survey) to determine which occupations are likely to be in high demand for each of the 8 renewable energy areas considered.
Type of Effects Examined	• ***Count Gross*** study, addressing employment. • No comparison is made with alternative, non-green investments. • Neither do they consider if a green investment program is the most effective way to generate jobs in the region.
Model Assumptions	• Uses three factors to establish relative employment effects of alternative green investments: ○ Labor intensity of spending – that is amount spent on workers rather than land, energy, or materials; ○ Local content of spending; and ○ Wage rates. • 3% of baseline IPSP spending is allocated on an annual basis to solar. • 16% of expanded GEAA spending is allocated on an annual basis to solar.
Solar Growth Projection Assumptions	• 88 MW of solar energy supplied over 10 years for baseline IPSP. • 1,738 MW of solar energy supplied over 10 years for expanded GEAA.
Effects Scaled per Year	• IPSP: 89.7 gross job years per MW installed. • GEAA: 68.7 gross job years per MW installed.

Title	**Study of the Effects on Employment of Public Aid to Renewable Energy Sources**
Author(s)	**Alvarez, Jara, Julian and Bielsa, March 2009**
Background	Universidad Rey Juan Carlos study part-funded by DG TREN (Energy & Transport) of the European Commission.
Objective(s)	To demonstrate the extent to which government support for green jobs in Europe has been economically counterproductive.
Geography	Spain
Time Period	2000-2008
Modeling Tool	Non-Applicable
Type of Effects Examined	• ***Count Net*** study. • Compares average amount of subsidized investment needed to create a solar job with the average amount of capital needed for a job in the private sector. • Also compares the average annual productivity that the solar job subsidy would have contributed to the economy had it not been consumed in public financing, with the average productivity of labor in the private sector that allows them to keep their job.
Model Assumptions	• The total subsidy to PV, wind, and hydro since 2000 is $36 billion. • No additional solar plants have been constructed since December 2008. • $12.1 billion has been committed for PV generation, 2000-2008.
Solar Growth Projection Assumptions	• Assumes that Spain has installed 2,934 MW solar PV by 2008.
Effects Scaled per Year	• For every renewable energy job financed by government, on average 2.2 jobs will be lost in the private sector. • However, for every solar MW installed, 8.99 private jobs are destroyed as a result of “green jobs” mandates, subsidies and related regimes.

4.0 Economic Impact Analyses – Magnitudes & Preferred Modeling Methods

Gross (positive impact only) studies clearly produce higher estimates of the economic impacts of solar enhancements than net studies, as demonstrated by the studies reviewed in Section 3. It is also important to note that gross studies are uniformly positive, while net studies are generally negative in terms of divined economic impact.

The principal effect of using a partial model approach rather than a count approach, or using a general (macroeconomic) modeling approach rather than a partial approach, is to reinforce the magnitude of the divined economic impacts. Thus, using a general (macroeconomic) model approach yields the most significant gross and negative studies.

Figure 3 summarizes the magnitude of impacts by type of economic impact study, based on the studies critiqued in Section 3.

Counts usually quantify the number of jobs. The Ontario ***Count Gross*** analysis reviewed in Section 3 estimated 68.7 to 89.7 gross (direct) job years are generated for every MW of wind and solar energy installed, which averages out at 69.74 for both renewable programs.

The Spanish ***Count Net*** analysis reviewed in Section 3 estimates that 8.99 private jobs are lost through "green jobs" mandates, subsidies and related regimes, for every 1 MW of solar installed.

Frondel et al. do not provide actual job counts for their German ***Count Net*** analysis. They simply conclude that "…any result other than a negative net balance of the German PV promotion would be surprising" (p. 17), based on a per capita subsidy of $257,400 in 2008, the EEG's crowding out effects, negative income effects and the unprecedented competition from cheaper Asian imports.[16]

Partial model estimates extend beyond a count to additionally estimate Gross State Product (GSP). The ***Partial Gross*** models reviewed in Section 3 estimated 5 to 73.5 gross job year gains per MW installed, and

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[16] Frondel et al. report that in 2006 and 2007, almost half of Germany's PV demand was covered by imports, most notably from Japan and China.

a GSP gain of $106,800 to $1.24 million per MW installed per year (2015 $). The AECOM study appears to be something of an outlier, as the gross job year estimate for the three other studies ranges from 5 to 24.9 job years per solar MW installed. Four of the studies in this section estimate GSP contributions of $106,800 to $176,354 GSP per MW per year (all 2015 $). The two exceptions, estimating significantly higher GSP contributions per MW per year are VSI (2011) in Nevada, and the AECOM study.

NYSERDA's ***Partial Net*** model estimates a 700 economy-wide net gain in job years for their low case scenario, but a 750-2,500 economy-wide net loss for job years for their base and high case scenarios. Similarly NYSERDA estimate a $15,760 GSP net gain per MW installed per year for their low case scenarios, compared to net losses of $16,930 to $58,386 per MW installed per year for their base and high case scenarios (all 2015 $). Treyz et al. only present graphs, rather than actual data, which appear to show a net negative loss in both job years and GDP, 2011-2035.

Figure 3: Magnitude of Economic Impacts

	Counts	Partial Models	General Models
Gross ***Only positive or negative impacts***	• 70 gross job years per MW	• Range of 5 to 73.5 gross job years per MW. • Range of $106,830 to $1.24 million GSP per MW per year.	• $7,198 total production per MW installed per year for parabolic trough installations.[17] • $4,265 total production per MW installed per year for solar tower installations.[18]
Net ***Both positive and negative impacts***	• -8.99 private jobs per MW per year	• Range of +750 to -2,500 net job years per MW, dependent on the scenario. • Range of +$15,862 to -$58,386 GSP per MW installed per year, dependent on the scenario.	

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[17] This is based on the PASENER target, 80% of which would be met by parabolic trough.

[18] This is based on the PASENER target, 20% of which would be met by solar tower.

The ***General Gross*** model reviewed in Section 3 offers two solar-technology dependent estimates. These are a total gross productive increase of $7,075 per MW installed per year for parabolic trough; and $4,192 per MW installed per year for solar tower.[19]

Based on the 6-way matrix of economic impact studies initially presented in Section 2, the implementation of a ***General Net*** analysis of solar deployment in the APS service territory, 2016-2035 is the best methodological approach for the current study. However, to the research team's knowledge, a CGE model of this nature currently does not exist for the State of Arizona; and it would be cost prohibitive to test and develop a CGE model for the State of Arizona in a short time frame. As a result, the current study implements a ***Partial Net*** analysis of solar deployment in the APS service territory, 2016-2035, presented in Sections 5 - 8. Seidman expects the results presented in the subsequent Sections to be directionally correct, but possibly understated, compared to a ***General Net*** (CGE) approach.

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[19] This uses an IRS 2013 dollar-euro annual currency exchange rate of US$1: €0.783. Source: IRS (2014), downloaded at www.irs.gov/Individuals/International-Taxpayers/Yearly-Average-Currency-Exchange-Rates. Value is then converted into 2015 $ using the Bureau of Labor Statistics CPI Inflation Calculator.

5.0 Economic Impact of Net Metering – Scenarios, Assumptions and Method

5.1. Scenarios and Assumptions

Three distributed (rooftop) solar deployment scenarios in the APS service territory are assessed for the study period 2016-2035, including the legacy effects of each scenario throughout the (assumed) 30 year economic life of the solar systems.[20] The solar deployment scenarios assessed for APS are:

- A low case scenario, which assumes 1,300 MW_{dc} of nameplate distributed solar PV installations by 2035 in the APS service territory, which will increase APS' total number of distributed solar customers to approximately 150,000 accounts;
- An expected or medium case scenario, which assumes 5,000 MW_{dc} of nameplate distributed solar PV installations by 2035 in the APS service territory, which will increase APS' total number of distributed solar customers to approximately 690,000 accounts; and
- A high case scenario, which assumes 7,600 MW_{dc} of nameplate distributed solar PV installations by 2035 in the APS service territory, which will increase APS' total number of distributed solar customers to approximately 1,050,000 accounts.

Distributed solar deployment is assumed to take place throughout the period of study in each scenario – that is, up to and including 2035.

Approximately 86% of the solar installations are assumed to occur in Maricopa County, 5% in Pinal County, and 9% in Yuma County in each scenario.

The capital costs and financing implications of each solar deployment scenario is determined by examining the level of distributed generation as forecast by APS using generic assumptions about the costs of standard DG solar systems and financing parameters. NREL's JEDI model for solar installations is used to

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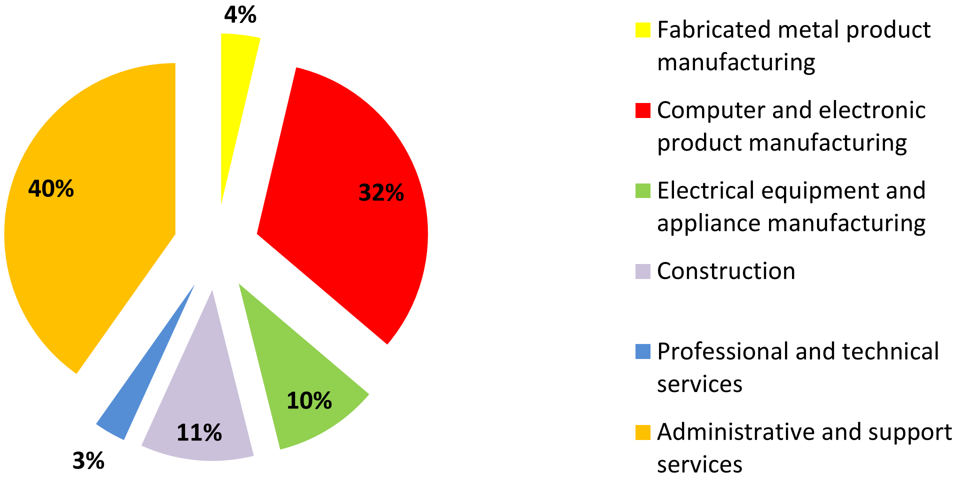
[20] Based on the assumed 30 year economic life of the distributed system, the customer financing costs of solar installations, 2016-2035, will not be completed until 2065. The REMI model used currently only provides economic impact estimates up to and including 2060, but Seidman does not believe that this will materially affect the conclusions in the analysis. If the economic life of an installation is less than 30 years, the negative economic consequences are in all probability greater than the estimates presented in this study.

distribute the capital costs of the solar installations throughout the supply chain in the State of Arizona.[21] Figure 4 summarizes the breakdown of the JEDI model's solar system costs used in this analysis. This is based on national industry averages, and may not match Arizona's experience exactly, but is nevertheless widely accepted as a reasonable approximation. Administrative and support services account for an estimated 40% of solar system costs. This probably includes general administrative costs associated with state government permitting and federal rebates, and also local administrative costs in the solar industry.

Figure 4: JEDI Model Exogenous Final Demand Categories



Source: Authors' Calculations

APS has also supplied Seidman with an estimate of the financial impact of each solar deployment scenario on the utility's operating cash flow, future central station generation investments, and electricity retail rates. Approximately 70% of the deferred or cancelled central station generation investments occurring under the three distributed solar scenarios are assumed to occur in Maricopa County, with the balance in Pinal County.

The investment changes included in the economic impact model are:

- The annual installed costs of distributed solar capacity, 2016-2035; and

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[21] NREL's JEDI models are an open-source, Excel-based, user-friendly tools that estimate the economic impacts of constructing and operating power generation and biofuel plants at the local and state levels. To find out more about the JEDI models, see http://www.nrel.gov/analysis/jedi/about_jedi.html

- APS' deferred or avoided central station generation investments, 2016-2035.

The long-term legacy costs included in the economic impact model are:

- The customer leasing costs of distributed solar installations, 2016-2060;[22] and
- Consumer electricity rate savings, 2016-2060, from the study period's deferred or avoided central station generation.

The timeframe of three of these elements extends beyond the last year of deployment (2035). This is because there are legacy effects associated with the deployment of distributed solar. For example, any customer installing a distributed solar PV system will have to meet the financial costs of that system for up to 30 years after the system has been installed on their roof. A utility is also required to recoup any investment in central station generation investments via retail electricity rates over the lifetime of that investment – again, usually 30 years. The legacy effects are therefore accounted for in the analysis.

The modelling elements are discussed in more detail in Section 5.2.

5.2. Study Method

Given the absence of a CGE model for the State of Arizona, Section 4 recommended the implementation of a ***Partial Net*** analysis of solar deployment in the APS service territory, 2016-2035. As a result, this study makes use of an Arizona-specific version of the REMI regional forecasting model, updated at the Seidman Research Institute, to produce partial net estimates of the impact on the Arizona economy of changes in the economic environment in the state.

REMI is especially useful when examining the economic impact associated with the launch or expansion of a new program, such as NEM, in a particular region, state or country. Through its dynamic modeling, REMI takes account of variations in the economic impact of a program as it moves from the establishment

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[22] Based on the assumed 30 year economic life of the distributed system, the customer financing costs of solar installations, 2016-2035, will not be completed until 2065. The REMI model used currently only provides economic impact estimates up to and including 2060, but Seidman does not believe that this will materially affect the conclusions in the analysis. If the economic life of an installation is less than 30 years, the negative economic consequences are in all probability greater than the estimates presented in this study.

to operations phase, and also shows how estimates can vary through time. These estimated impacts are the difference between the baseline economy and the baseline economy augmented with the level of solar deployment assumed under each scenario. As a result, the analysis measures the Arizona economy up to 2035 *with* and *without* the existence of the new solar rooftop program.

The use of a county level model also enables a more detailed disaggregation of results to occur, estimating the "leakage" of economic impacts into other counties in Arizona.

Due to its overall flexibility, REMI allows for the examination of a whole host of different scenarios – different businesses and/or different construction and operations phases – while simultaneously providing estimates that are consistent across projects.

The method for estimating the economic impact involves four fundamental steps:

1. **Prepare a baseline forecast for the state and county economies:** This Business As Usual (BAU) case forecasts the future path of state and county economies based on a combination of an extrapolation of historic economic conditions and an exogenous forecast of relevant national economic variables.
2. **Develop a program or policy scenario:** This scenario describes the *direct* impacts that each distributed solar deployment scenario could generate in APS' service territory.
3. **Compare the baseline and policy scenario forecasts.**
4. **Produce the "delta" results**: Differences between the future values of each variable in the forecast results estimate the magnitude that each distributed solar deployment scenario could have on the state or county economies, relative to the baseline.

The baseline or counterfactual scenario employed in this study assumes that there are no additions to the current stock of distributed solar installations over the period 2016-2035 in APS' service territory. One consequence of this counterfactual scenario is that APS would need to add to both its central generation and transmission capacity, to cope with the increased load within its territory over the period. To cover the capital costs of the enhanced capacity and all subsequent operations and maintenance costs, APS would typically need to increase utility revenues over a 30-year period from the date of each investment. In isolation, this would manifest as a reduction in consumer spending, because utility customers would collectively need to pay more for these new investments, and is also accounted for in the current study, up to and including 2060. In reality, some of this increased revenue will be provided by population growth which is creating the additional demand for new generation, and some will be offset by lower revenues for depreciating existing investments over time.

5.3. Solar Deployment Scenarios

Three distributed solar deployment scenarios are analyzed in this study. To represent the effects of increased penetrations of distributed solar, three key changes are included in the current study for the 2016-2035 time horizon. These are:

- The capital costs expended on rooftop solar systems purchased or leased by distributed generation customers, which are assumed to yield 20 years of construction-based benefits on the Arizona economy;
- The financial payments made by utility customers for leased solar systems for the economic life of their assets. This represents a reduction in spending on other goods and services and, as such, a likely reduction in economic activity in Arizona; and
- The reduction in revenue requirement for APS as a result of decreased net investment in centrally generated power. This represents a loss to the Arizona economy due to the reduction in central station generation construction and employment, offset by savings on fuel, O&M and financing costs over time.

Each scenario is modeled over a 20-year timeframe, starting in 2016 and ending in 2035, to estimate the employment, gross state product (GSP), and real disposable personal income (RDPI) for the State of Arizona and Maricopa County. However, there are also legacy effects associated with solar deployment and the deferral or cancellation of central station generation investments, which occur in the years immediately following an installation and last for the economic life of the solar installations. These legacy effects are therefore also included in the cumulative 2016-2035 estimate provided for each assessed economic measure, expressed in 2015 dollars (2015 \$).[23]

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[23] The legacy effects for any 2035 distributed solar installations should last until 2065, to reflect the economic life of the system. The current REMI model is unable to provide estimates after 2060, but Seidman does not believe that this will materially affect the conclusions in the analysis. If the economic life of an installation is less than 30 years, the negative economic consequences are in all probability greater than the estimates presented in this study.

6.0 Simulation Results: Low Distributed Solar Deployment Scenario

The low case scenario assumes that over $1.5 billion is invested in new distributed solar installations by 112,000 customers between 2016 and 2035, and the net deferral or cancellation of $85.5 million central station generation investments up to and including 2065 (all nominal $).[24]

Table 2 estimates the total employment impacts of the low case distributed solar scenario for the period 2016-2035. These are full-time (or equivalent) annual employment changes, applicable to all sectors and industries apart from government and farm workers. They include employees, sole proprietors and active partners, but exclude unpaid family workers and volunteers. The data is expressed in job years. The label "job year" is important and should not be simplified or abbreviated to "job". A "job year" is defined as one person having a full-time job for exactly one year. This means, for example, that one employee holding the same position at the same organization throughout 2016-2035 will account for 20 job years, but also only represent 1 job.

Table 2: Total Private Non-Farm Employment Impacts 2016-2035 (including Legacy Effects to 2060)

Geography	Job Years[25]
State of Arizona	-16,595
Maricopa County	*-15,685*

Source: Authors' Calculations

Table 2 suggests that the low case distributed solar scenario could have a negative employment impact of 16,595 full-time (or equivalent) job years in the State of Arizona throughout the 2016-2035 period of study, including any legacy impacts up to 2060. This legacy effect accounts for the fact that the true effects of the distributed solar deployment are only experienced in full after the period of study (2016-2035), consistent with the economic life of each solar installation.[26]

In Maricopa County, there is a negative employment impact of 15,685 job years for the study period as a whole (including subsequent legacy effects).

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[24] This simply reflects a deferral from the base case.

[25] A job year is equivalent to one person having a full-time job for exactly one year.

[26] The legacy effect should continue up to and including 2065. However, REMI currently does not allow for any analysis beyond 2060. If the economic life of an installation is less than 30 years, the negative economic consequences are in all probability greater than the estimates presented in this study.

Table 3 summarizes the industry sectors impacted the most by the low case distributed solar scenario.

Table 3: Statewide Employment Impacts by Industry Sector (Job Years)[27]

Sector	Total Job Years, 2016-2060[28]
Forestry, Fishing, and Related Activities	-2
Mining	-639
Utilities	-2,025
Construction	-2,549
Manufacturing	-385
Wholesale Trade	-548
Retail Trade	-3,102
Transportation and Warehousing	-514
Information	-203
Finance and Insurance	-845
Real Estate and Rental and Leasing	-998
Professional and Technical Services	-3,505
Management of Companies and Enterprises	-89
Administrative and Support Services	5,447
Educational Services	-440
Health Care and Social Assistance	-3,210
Arts, Entertainment, and Recreation	-406
Accommodation and Food Services	-1,348
Other Services, except Public Administration	-1,237
Total Net Change in Job Years	**-16,595**
Total Number of Job Years Lost in Non-Solar Industry Sectors[29]	**22,042**

Source: Authors' Calculations

The table suggests that administrative and support services could benefit from the low case distributed solar scenario in terms of employment created. However, all other sectors are estimated to experience job losses, resulting in the total net estimate of 16,595 job years lost statewide. The administrative gain probably originates to a large extent from the permitting of solar installations, and also business support functions within the solar industry. The sectors estimated to experience the biggest job losses (expressed

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[27] A job year is equivalent to one person having a full-time job for exactly one year.

[28] Total job years may not tally due to rounding-up.

[29] This is a summation of the job years lost in non-solar industry sectors negatively impacted by the deployment of new distributed solar, 2016-2035.

in cumulative job years) during the study period in rank order are professional; scientific and technical services; health care and social assistance; retail trade; the construction industry; and utilities.

Table 4 estimates the cumulative gross state product (GSP) and real disposable personal income impacts (RDPI) associated with the low case distributed solar scenario for the period 2016-2035.

Table 4: Total Gross State Product (GSP) and Real Disposable Personal Income Impacts (RDPI) 2016-2035 (including Legacy Effects to 2060)

Geography	Gross State Product Millions (2015 $)	Real Disposable Personal Income Millions (2015 $)
State of Arizona	-$4,806.6	-$1,787.3
Maricopa County	*-$4,491.8*	*-$1,862.4*

Source: Authors' Calculations

Table 4 shows that in aggregate terms during the study period 2016-2035, and including legacy effects, total GSP could be cumulatively lower by over $4.8 billion (2015 $) in the State of Arizona. This includes an estimated $4.5 billion GSP lost in Maricopa County (2015 $).

Table 4 also shows that in aggregate terms during the study period 2016-2035, and including legacy effects, RDPI is estimated to be cumulatively lower by almost $1.8 billion (2015 $) in the State of Arizona. This includes an estimated fall in RDPI of over $1.86 billion in Maricopa County (2015 $).[30]

The employment, GSP, and RDPI losses associated with the low distributed solar deployment scenario are valid, because the total amount of money paid by distributed generation and central station generation electricity consumers over the relevant time period (which extends beyond 2035) is greater than the amount which would have been paid had they all instead continued to draw electricity from the utility's central grid. In short, electricity consumers are paying more for the same amount of electricity consumed under the low distributed solar deployment scenario, and therefore have less money to spend in other parts of the economy.

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[30] Some of Maricopa County's estimated losses in RDPI will be offset by minor gains in other counties, thereby resulting in a negligibly smaller loss for the State as a whole.

7.0 Simulation Results: Expected Distributed Solar Deployment Scenario

The expected or medium case scenario assumes that approximately $8.9 billion in total is invested by 650,000 customers in distributed solar installations between 2016 and 2035, and the deferral or cancellation of $194 million central station generation investments (all nominal $).[31]

Table 5 estimates the total employment impacts of the expected or medium case distributed solar scenario for the period 2016-2035. These are full-time (or equivalent) annual employment changes, applicable to all sectors and industries apart from government and farm workers; and the data is again expressed in job years.

Table 5: Total Private Non-Farm Employment Impacts 2016-2035 (including Legacy Effects to 2060)

Geography	Job Years[32]
State of Arizona	-76,308
Maricopa County	*-71,344*

Source: Authors' Calculations

Table 5 suggests that the expected or medium case distributed solar scenario would have a negative employment impact of 76,308 full-time (or equivalent) job years in the State of Arizona for the 2016-2035 period of study, including any legacy impacts up to 2060. This legacy effect accounts for the fact that the true effects of the distributed solar deployment are only experienced in full after the period of study (2016-2035), consistent with the economic life of each solar installation.[33]

In Maricopa County, there is a negative employment impact of 71,344 job years throughout the study period (including subsequent legacy effects).

Table 6 summarizes the industry sectors impacted the most by the expected or medium case distributed solar scenario.

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[31] This simply reflects a deferral from the base case.

[32] A job year is equivalent to one person having a full-time job for exactly one year.

[33] The legacy effect should continue up to and including 2065. However, REMI currently does not allow for any analysis beyond 2060. If the economic life of an installation is less than 30 years, the negative economic consequences are in all probability greater than the estimates presented in this study.

Table 6: Statewide Employment Impacts by Industry Sector (Job Years)[34]

Sector	Total Job Years, 2016-2060[35]
Forestry, Fishing, and Related Activities	-18
Mining	-2,563
Utilities	-7,709
Construction	-11,098
Manufacturing	-1,504
Wholesale Trade	-2,691
Retail Trade	-15,762
Transportation and Warehousing	-2,472
Information	-943
Finance and Insurance	-4,558
Real Estate and Rental and Leasing	-4,948
Professional and Technical Services	-14,366
Management of Companies and Enterprises	-361
Administrative and Support Services	29,025
Educational Services	-2,336
Health Care and Social Assistance	-18,026
Arts, Entertainment, and Recreation	-2,231
Accommodation and Food Services	-6,886
Other Services, except Public Administration	-6,860
Total Net Change in Job Years	**-76,308**
Total Number of Job Years Lost in Non-Solar Industry Sectors[36]	**105,333**

Source: Authors' Calculations

The table again suggests that administrative and support services alone could benefit from the expected or medium case distributed solar scenario in terms of job years' employment created. However, all other sectors are estimated to experience job losses, resulting in the total net estimate of 76,308 job years lost statewide. The administrative gain again probably originates to a large extent from the permitting of solar installations and business functions within the solar industry. The sectors estimated to experience the biggest job losses (expressed in cumulative job years) during the study period in rank order are health care and social assistance; retail trade; professional; scientific and technical services; the construction industry; and utilities.

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[34] A job year is equivalent to one person having a full-time job for exactly one year.

[35] Total job years may not tally due to rounding-up.

[36] This is a summation of the job years lost in non-solar industry sectors negatively impacted by the deployment of new distributed solar, 2016-2035.

Table 7 estimates the cumulative gross state product (GSP) and real disposable personal income impacts (RDPI) associated with the expected or medium case distributed solar scenario for the period 2016-2035.

Table 7: Total Gross State Product (GSP) and Real Disposable Personal Income Impacts (RDPI) 2016-2035 (including Legacy Effects to 2060)

Geography	Gross State Product Millions (2015 $)	Real Disposable Personal Income Millions (2015 $)
State of Arizona	-$21,613.3	-$7,956.4
Maricopa County	*-$20,149.9*	*-$8,087.9*

Source: Authors' Calculations

Table 7 shows that in aggregate terms during the study period 2016-2035, and including legacy effects, total GSP could be cumulatively lower by over $21.6 billion (2015 $) in the State of Arizona under the expected or medium case scenario. This includes an estimated $20.1 billion GSP lost in Maricopa County (2015 $).

Table 7 also shows that in aggregate terms during the study period 2016-2035, and including legacy effects, RDPI is estimated to be cumulatively lower by approximately $8 billion (2015 $) in the State of Arizona. This includes an estimated fall in RDPI of almost $8.1 billion in Maricopa County (2015 $).[37]

The employment, GSP, and RDPI losses associated with the expected distributed solar deployment scenario are valid, because the total amount of money paid by distributed generation and central station generation electricity consumers over the 2016-2060 time horizon is greater than the amount which would have been paid had they all continued to draw electricity from the utility's central grid. In short, electricity consumers are paying more for the same amount of electricity consumed under the expected distributed solar deployment scenario, and therefore have less money to spend in other parts of the economy.

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[37] Some of Maricopa County's estimated losses in RDPI will be offset by minor gains in other counties, thereby resulting in a negligibly smaller loss for the State as a whole.

8.0 Simulation Results: High Distributed Solar Deployment Scenario

The high case scenario assumes that approximately $13.4 billion is invested by approximately 1 million customers in distributed solar installations between 2016 and 2035, and the deferral or cancellation of $194 million central station generation investments (both nominal $).[38]

Table 8 estimates the total employment impacts of the high case distributed solar scenario for the period 2016-2035. These are full-time (or equivalent) annual employment changes, applicable to all sectors and industries apart from government and farm workers; and the data is again expressed in job years.

Table 8: Total Private Non-Farm Employment Impacts 2016-2035 (including Legacy Effects to 2060)

Geography	Job Years[39]
State of Arizona	-116,558
Maricopa County	*-108,857*

Source: Authors' Calculations

Table8 suggests that the high case distributed solar scenario could have a negative employment impact of 116,558 full-time (or equivalent) job years in the State of Arizona for the 2016-2035 period of study, including any legacy impacts up to 2060. This legacy effect accounts for the fact that the true effects of the distributed solar deployment are only experienced in full after the period of study (2016-2035), consistent with the economic life of each solar installation.[40]

In Maricopa County, there is a negative employment impact of 108,857 job years throughout the study period (including subsequent legacy effects).

Table 9 summarizes the industry sectors impacted the most by the high case distributed solar scenario.

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[38] This simply reflects a deferral from the base case.

[39] A job year is equivalent to one person having a full-time job for exactly one year.

[40] The legacy effect should continue up to and including 2065. However, REMI currently does not allow for any analysis beyond 2060. If the economic life of an installation is less than 30 years, the negative economic consequences are in all probability greater than the estimates presented in this study.

Table 9: Statewide Employment Impacts by Industry Sector (Job Years)[41]

Sector	Total Job Years, 2016-2060[42]
Forestry, Fishing, and Related Activities	-30
Mining	-3,496
Utilities	-10,632
Construction	-14,220
Manufacturing	-2,074
Wholesale Trade	-4,318
Retail Trade	-25,645
Transportation and Warehousing	-3,847
Information	-1,505
Finance and Insurance	-7,489
Real Estate and Rental and Leasing	-7,892
Professional and Technical Services	-20,701
Management of Companies and Enterprises	-538
Administrative and Support Services	45,650
Educational Services	-3,898
Health Care and Social Assistance	-29,486
Arts, Entertainment, and Recreation	-3,668
Accommodation and Food Services	-11,364
Other Services, except Public Administration	-11,405
Total Net Change in Job Years	**-116,558**
Total Number of Job Years Lost in Non-Solar Industry Sectors[43]	**162,208**

Source: Authors' Calculations

Consistent with the previous two scenarios, the table suggests that administrative and support services could benefit alone from the high case distributed solar scenario in terms of job years employment created. The administrative gain again probably originates to a large extent from the permitting of solar installations, and also business support functions within the solar industry. All other sectors are estimated to experience job losses, resulting in the total net estimate of 116,558 job years lost statewide. The sectors estimated to experience the biggest job losses (expressed in cumulative job years) during the study period in rank order are health care and social assistance; retail trade; professional; scientific and technical services; the construction industry; and other services (excluding public administration).

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[41] A job year is equivalent to one person having a full-time job for exactly one year.

[42] Total job years may not tally due to rounding-up.

[43] This is a summation of the job years lost in non-solar industry sectors negatively impacted by the deployment of new distributed solar, 2016-2035.

Table 10 estimates the cumulative gross state product (GSP) and real disposable personal income impacts (RDPI) associated with the high case distributed solar scenario for the period 2016-2035.

Table 10: Total Gross State Product (GSP) Impacts 2016-2035 (including Legacy Effects to 2060)

Geography	Gross State Product Millions (2015 $)	Real Disposable Personal Income Millions (2015 $)
State of Arizona	-$31,454.4	-$11,901.4
Maricopa County	*-$29,346.7*	*-$12,091.2*

Source: Authors' Calculations

Table 10 shows that in aggregate terms during the study period 2016-2035, and including legacy effects, total GSP could be cumulatively lower by $31.5 billion (2015 $) in the State of Arizona under the high case scenario. This includes an estimated $29.3 billion GSP lost in Maricopa County (all 2015 $).

Table 10 also shows that in aggregate terms during the study period 2016-2035, and including legacy effects, RDPI is estimated to be cumulatively lower by $11.9 billion (2015 $) in the State of Arizona. This includes an estimated fall in RDPI of almost $12.1 billion in Maricopa County (2015 $).[44]

The employment, GSP, and RDPI losses associated with the high distributed solar deployment scenario are valid, because the total amount of money paid by distributed generation and central station generation electricity consumers over the 2016-2060 time horizon is greater than the amount which would have been paid had they all continued to draw electricity from the utility's central grid. In short, electricity consumers are paying more for the same amount of electricity consumed under the high distributed solar deployment scenario, and therefore have less money to spend in other parts of the economy.

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[44] Some of Maricopa County's estimated losses in RDPI will be offset by minor gains in other counties, thereby resulting in a negligibly smaller loss for the State as a whole.

9.0 Conclusions

The goal of this study is to assess the impact of three distributed solar deployment scenarios in the APS service territory on economic activity in the State of Arizona and Maricopa County. The results of the analysis are influenced to an extent by the choice of economic impact model implemented.

Economic impact analyses can generally be classified in one of 6 ways, represented in Figure 5.

Figure 5: Seidman's 3 x 2 Classification of Economic Impact Models

COUNT GROSS	PARTIAL GROSS	GENERAL GROSS
COUNT NET	PARTIAL NET	GENERAL NET

Gross studies only consider the direct positive impacts of increased economic activity in a specific sector, whereas ***Net*** studies represent a more thorough form of economic modeling as they also account for the trade-offs in the economy which result from incentivizing one specific sector,

Counts are usually survey-based or theoretical capacity installation quantifications of the number of direct employees within a specific economic sector, which can extend to that sector's entire supply chain.

Partial models consider the wider effects of levels of activity in a specific economic sector, including the indirect and induced effects of the direct sectoral change. Frequently assessed via input-output models such as IMPLAN and REMI, partial models do not consider the feedback effects of changed levels of activity in a specific sector, such as the effect of large solar projects on wages in the labor market.

General models offer the most comprehensive economy-wide analysis, taking into account all of the economic interconnections and feedback effects. Of the fourteen contemporary solar economic impact studies critiqued by Seidman, only one uses a general equilibrium model. This is Cansino, Cardenete, Gonzalez and Pablo-Romero's (2013) study of Andalusia. However, this is a gross, rather than net analysis, because the authors combine renewables and non-renewables as a single sector, thereby preventing any substitution between conventional and renewable forms of generation, and effectively only allowing for positive direct demand shocks in their modeling.

The principal effect of using a ***Partial*** model approach rather than a ***Count*** approach, or using a ***General*** modeling approach rather than a ***Partial*** approach, is *generally* to reinforce the magnitude of the divined economic impacts. Thus, using a ***General*** model approach yields the most significant ***Gross*** and ***Net*** impacts.

However, to the research team's knowledge, a CGE model currently does not exist for the State of Arizona; and it would be cost prohibitive to test and develop a CGE model for the State of Arizona in a short time frame.

Seidman has therefore implemented a ***Partial Net*** REMI analysis of solar deployment in the APS service territory, 2016-2035, for the current study. This is the next best alternative from a methodological standpoint; and it is consistent, for example, with the approach taken by Berkman, Lagos and Weiss (2014), NYSERDA (2012), and Treyz et al. (2011), critiqued in Section 3. Figure 6 positions Seidman's approach relative to the fourteen critiqued studies

Figure 6: Classification of Seidman's 2016 Approach for APS Relative to Fourteen Contemporary Economic Impact of Solar/Renewables Studies

	Counts	**Partial Models**	**General Models**
Gross ***Only positive or negative impacts***	• Pollin and Garrett-Peltier, 2009 • ETIC, 2016	• AECOM, 2011 • Loomis, Jo & Alderman ,2013 • Motamedi & Judson, 2012 • VSI and Clean Energy Project Nevada, 2011 • VSI, 2013 • Comings et al. , 2014	• Cansino et al. 2013
Net ***Both positive and negative impacts***	• Alvarez et al., 2009 • Frondel et al., 2009	• NYSERDA, 2012 • Treyz et al., 2011 • Berkman et al., 2014 • **SEIDMAN 2016**	

The economic impacts of all three distributed solar deployment scenarios are assessed in terms of private non-farm employment, gross state product, and real disposable personal income.

The study clearly demonstrates that increased adoption of distributed solar generation represents a *loss* to the Arizona economy as a whole in all three scenarios. This is because the overall cost of provision of electricity to the State of Arizona will rise when referenced against a base case where electricity continues to be provided by central station generation.

If the low case distributed solar deployment scenario actually transpires, the State of Arizona is cumulatively estimated to lose:

- 16,595 job years private non-farm employment;
- Over $4.8 billion gross state product (2015 $); and
- $1.8 billion real disposable personal income (2015 $).

This takes into account both the solar installation study period (2016-2035) and the legacy effects of those installations to reflect the estimated 30 year economic life of the solar systems and deferred central station generation.[45]

If the expected or medium case distributed solar deployment scenario actually transpires, the State of Arizona is cumulatively estimated to lose:

- 76,308 job years private non-farm employment;
- Over $21.6 billion gross state product (2015 $); and
- Almost $8 billion real disposable personal income (2015 $).

This also takes into account both the solar installation study period (2016-2035) and the legacy effects of those installations, to reflect the estimated 30 year economic life of the solar systems and deferred central station generation.

If the high case distributed solar deployment scenario actually transpires, the State of Arizona is cumulatively estimated to lose:

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[45] The legacy effects of any 2035 distributed solar installation or deferred central station generation will continue until 2065. However, the REMI model used currently only provides economic impact estimates up to and including 2060, but Seidman does not believe that this will materially affect the conclusions in the analysis. If the economic life of an installation is less than 30 years, the negative economic consequences are in all probability greater than the estimates presented in this study.

- 116,558 job years private non-farm employment;
- Approximately $31.5 billion gross state product (2015 $); and
- $11.9 billion real disposable personal income (2015 $).

This again takes into account both the solar installation study period (2016-2035) and the legacy effects of those installations, to reflect the estimated 30 year economic life of the solar systems and deferred central station generation.

The implications of these findings are potentially far-reaching, as they challenge a sometimes expressed claim that an aggressive distributed solar initiative will have a significant positive impact on the state and county economies in the State of Arizona.

In short, and wholly based on the financial implications of solar installations from a customer, utility and supplier perspective, this study estimates that any benefits emanating from the three distributed solar deployment scenarios are at best temporary and only coincident with the timing of those solar installations. This is because the lasting legacy effects of each distributed solar scenario, which reflect the economic life of the installed systems and deferred central station generation, are negative. That is, in all three scenarios, the total amount of money paid by distributed generation and central station generation electricity consumers over the relevant time period (2016-2060) is greater than the amount which would have been paid had they all alternatively continued to draw electricity from the utility’s central grid. In each distributed solar scenario, electricity consumers as a whole are being asked to pay more for the same amount of electricity consumed, and therefore have less money to spend in other parts of the economy.

Thus, when considered in the round from a purely financial perspective, the economic impact of all three potential solar deployed scenarios in the APS service territory are estimated to have a detrimental effect on both the State of Arizona and Maricopa County economies, all other things being equal.

Appendix

A.1. The REMI Model

REMI is an economic-demographic forecasting and simulation model developed by Regional Economic Models, Inc. REMI is designed to forecast the impact of public policies and external events on an economy and its population. The REMI model is recognized by the business and academic community as the leading regional forecast/simulation tool available.

Unlike most other regional economic impact models, REMI is a dynamic model that produces integrated multiyear forecasts and accounts for dynamic feedbacks among its economic and demographic variables. The REMI model is also an "open" model in that it explicitly accounts for trade and migration flows in and out of the state. A complete explanation of the model and discussion of the empirical estimation of the parameters/equations can be found at www.remi.com.

The operation of the REMI model has been developed to facilitate the simulation of policy changes, such as a tax increase for example, or many other types of events – anything from the opening of a new business to closure of a military base to a natural disaster. The model's construction includes a large set of policy variables that are under the control of the model's operators. To simulate the impact of a policy change or other event, a change in one or more of the policy variables is entered into the model and a new forecast is generated. The REMI model then automatically produces a detailed set of simulation results showing the differences in the values of each economic variable between the control and the alternative forecast.

The specific REMI model used for this analysis was Policy Insight Model Version PI$^+$ version 1.7.2 of the Arizona economy (at the county level) leased from Regional Economic Models Inc. by a consortium of State agencies, including Arizona State University, for economic forecasting and policy analysis.

A.2. Effects Not Incorporated into the Analysis

No major financial impacts were left out.

Glossary

Gross State Product (GSP): The dollar value of all goods and services produced in Arizona for final demand/consumption.

Job Year: A job year is equivalent to one person having a full-time job for exactly one year.

Real Disposable Personal Income: The household income that is available to be spent after tax payments. Technically speaking, real disposable personal income is the sum of wage and salary disbursements, supplements to wages and salaries, proprietors' income, rental income of persons, personal dividend income, personal interest income, and personal current transfer receipts, less personal taxes and contributions for government social insurance.

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