

**PV Solar Net Economic Impact Estimation Model**

Steven R. Miller, Ph.D.

Michigan State University  
Center for Economic Analysis

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## Introduction

When initiating this research, there were varied examples of economic impacts of utility scale PV solar projects with little comparability. This project set out to establish a standard for estimating the economic considerations of utility scale PV projects. The simulation philosophy follows that adopted by the National Renewable Energy Labs (NREL) and their Jobs and Economic Development Impact (JEDI) models of the economics around energy generation projects. The JEDI models have become the standard for measuring economic effect of energy installation projects. However, when this project initiated, NREL did not have a PV JEDI model for PV installation. The simulation model developed here went further than the JEDI models to net out the economic value of lost economic activity on the acres of PV panels that would have been placed in the next most likely use of the acres to be transitioned to PV solar. In other regards, this estimation model was developed with simplifying assumptions over those in comparable JEDI models with the intent to improve non-expert use of the model.

This model is not designed to provide the final definitive estimate of the economic contribution of an intended project, but rather establish expected baselines. It is designed for non-expert use in generating expected net economic benefits of citing commercial PV systems of various sizes. Alternatively, a comprehensive site-specific estimate of the expected economic impact of a PV solar project requires the skillful analysis of a qualified analyst using specifications specific to the planned PV solar development, property proposed under that development and the local economy for which the installation is to be installed and operated. This report documents the use and methods of development of the SETO Economic Simulation Model.

## SETO Economic Simulation Model

There were two goals in developing the economic simulation model. The first was to make a representative, turnkey spreadsheet simulation model that will find wide use by policy makers. The second was to provide an economic simulation platform for geographically profiling socio-optimal citing of PV solar projects. Accordingly, the development of the SETO Economic Simulation Model was guided by a few overriding objectives:

- To encourage wide use, the model should minimize the number of parameters required of the user;
- To facilitate more advanced users, the model should be flexible in assumptions to allow the user to modify the simulation;
- The model should be all encompassing, not requiring the user to populate the spreadsheet with expensive third-party software or data.

## Methods

The economic simulation of utility scale PV solar must account for at least two phases of the project: 1) the installation phase and 2) the ongoing operational phase. A third phase is also reasonable, and that is the teardown phase to be completed at the end of the expected life. Each phase exhibits different expenditure and employment profiles and has different considerations around the timing and sequence of economic activities. In addition, as such projects have a 25-to-30-year life, the models must account for social time value of money preferences and inflation. Social time value of money preferences recognizes the human nature to value benefits today more than the same benefits in the future. Similarly, time value preferences also reveal that we prefer to put off costs rather than experience them now. Economists discount the value of distant benefits and costs according to well established theory of the *time value of money*, as applied in this analysis.

An unrelated concept, which has the potential to impact future measures of value is the presence of price inflation. The U.S. tends to experience persistent and positive inflation over time. Positive inflation indicates that dollars command less spending power over time. Over most of the prior 20 years, inflation was not a significant consideration in economic planning, but the higher rates of inflation since 2019 have put prices progression in the forefront of economic policy. Despite the uncertainties associated with inflation, the modeling approach employed is to abstract from price questions by setting all current and future prices in real dollar terms.

## Project Specification

The user must set some minimal specifications for the project. The minimum specifications include the state and county of the installation and the name plate capacity of the planned project. These minimal specifications will determine the projected soil productivity, the tax treatment and parameters, and the economic multipliers to apply to project expenditures along all phases of the project. The nameplate capacity determines the number of acres required under current technology, where the model power generation per acre of solar panels follows a single axle tracking mounts.

Other parameters have default values that do not depend on the size of the installation. These parameter values can be overridden by the user. For instance, the inverter load ratio is the current technology's market capacity for converting between direct current (DC) power and alternating current (AC). PV solar cells generate DC power, which requires conversion to AC to be connected to the utility grid. The default ratio is set to 1.25 which is a conservative baseline based on current technologies (Anderson, *et. al*, 2022). Similarly, the expected capacity factor and annual downtime are measures of efficiency in converting sunlight to DC power. Capacity factor may be influenced by the expected annual solar radiation at the installation site while the downtime is the expected percent of possible operating time expected to be offline. The default capacity factor is set to 20.1%, indicating that 20.1% of the nameplate capacity is expected to be reached annually (U.S. Energy Information Administration, 2019). The default annual downtime is set to 10% of the

potential operating time.<sup>1</sup> The user can also set the projected life of the solar panel installation to 25 years or 30 years, where 30 years is the default. The life of the project may alter the timing of depreciation and net flows of earnings and tax revenues.

In determining the number acres required for the project, the model asserts 10 acres are required per MW<sub>ac</sub>. Scale economies assert this is likely larger for smaller installations and the acres per MW of capacity will decrease with large projects. Total acres include right of way and infrastructure in excess of the required installed PV solar panels. By assumption, about 60 percent of the committed project acres will be under solar panels. Displaced agricultural acres make up all of the acres under solar panels plus an extra two acres per MW<sub>ac</sub> for access and mandated offsets.

## Installation Phase

The installation phase is a limited duration phase of the project comprising of land preparation, construction, connection and initial deployment. While the required time has some dependence on the size of the PV installation, the developer has a great deal of control over how many months to allocate to the site development. The model defaults on the number of months for installation to 18 months (Bertsch, 2022), though the user can easily adjust this to meet their expectations. Generally, the number of months required for installation has less impact on the estimated economic impact than the size of the installation and the total expected installation expense. However, an elongated installation phase may prolong the lost agricultural output, as the agriculture disruption is calculated on a 12-month year basis. The number of growing seasons disrupted from production is by assumption rounded up to the next year. For example, an installation phase that requires up to 12 months to complete would disrupt a single season of agricultural production, but 13 to 24 months of installation will disrupt two years of agricultural production by assumption. The total number of agricultural acres displaced by the project is determined by the user but defaults to 2/3rds of the project's committed acres.

The model will gather all relevant PV installation expenditures and model how those expenditures are first captured by the local economy and second, how those expenditures spur secondary transactions in the local economy. Expenditure considerations are limited to on-site development expenditures. This omits from consideration soft site development expenditures for lobbying local and state government for development permits and other siting costs incurred in identifying target sites for development. It also excludes offsite engineering and legal expenses.

Initial onsite expenditures by category (Table 1) are estimated as a proportion of total installation cost per MW<sub>dc</sub> nameplate capacity, currently set at \$1.262 per W<sub>dc</sub> or \$1,262 per MW<sub>dc</sub>. The share of costs by component is provided by NREL studies of PV solar development projects (Ramasamy, *et al*, 2021), with minimal modification. The value of \$1.262 per W<sub>dc</sub> of nameplate capacity is measured in 2022 dollars and can be changed by the user and all the distributed category expenditures will adjust proportionately. Additionally, the user can alter the category distribution of

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<sup>1</sup> Potential operating time is the number of hours in a year, or approximately 8,768 hours.

cost shares by changing the share values, but the share values must sum to 100 for the model estimates to be valid.

<b>Installation Expenditures by Category</b>			
<b>Installation costs per <math>W_{dc}</math></b>	<b><math>\\$/W_{dc}</math></b>	<b>Share of Total</b>	
Engineering, Procurement and Construction Margins	\$0.057	4.5%	
Contingency	\$0.035	2.8%	
Developer Overhead	\$0.028	2.2%	
Transmission Line	\$0.014	1.1%	
Interconnection Fee	\$0.035	2.8%	
Permitting Fee	\$0.014	1.1%	
Sales Tax	\$0.057	4.5%	
Engineering, Procurement and Construction Overhead	\$0.071	5.6%	
Install Labor & Equipment	\$0.156	12.4%	
Electrical Balance of System	\$0.099	7.9%	
Structural Balance of System	\$0.170	13.5%	
Inverter	\$0.057	4.5%	
PV Modules	\$0.468	37.1%	
<b>Total</b>	<b>\$1.262</b>	<b>100%</b>	

**Table 1: Installation Expenditures by Category**

While on-sight expenditures measure the relevant costs of installing the PV project, not all of those expenditures will be expected to benefit the local economy. Table 2 shows heuristic capture rates, in percentage of total expenditures that are captured by the local economy. The expenditure categories are mapped into those categories in Table 2 and the user can modify the local share of expenditures captured to meet expectations. The share values are bound to lie between and included zero and one. However, this set of parameters may be a primary source of critique by reviewers as there are no restrictions on values the percentage takes. Two notable zero values deserve attention. The contingency cost projection capture is set to zero, not necessarily because the expectation is that such expenditures will go to outside vendors, but more so because allocations to unanticipated expenditures should not be part of an a priori economic impact assessment. By setting the local capture share to zero, the model assures the projections of unanticipated costs are not part of the economic impact assessment. The second zero is PV Modules. Under very rare conditions should this not be zero. Such may exist if the projected solar installation is in a county where PV modules are manufactured.

In the example below, installation is set to 100 percent local research, as installation mostly entails construction activities by which skills are generally readily available. All of these categories can be adjusted, depending on the developer's intentions. The PV developer will often indicate the extent to which they plan to hire services and workers from the local economy but may be limited by availability. As the developer will often contract with local firms for excavation and construction services, as well as for heavy equipment leasing, they may only have indirect control of the local capture despite their intentions.

The parameters provided in Table 2 are based on three sources of information. First, the representative county data was used to determine the extent to which commodities that make up the category are provided in the county. Each of the categories in Table 2 can be made up of multiple commodities and the more of those commodities/services exist, the more assured of local availability. The second source was a general heuristic of the generality of the skills required under

each category. Construction is largely a general skill that can be undertaken by a relatively larger share of the population than engineering. Accordingly, finding local sources for engineering may be more difficult than that of construction. Finally, local capture estimates from previous economic simulation projects for Michigan PV solar developments and applied to other studies were combined. Collectively, these inputs went into the development of the local share coefficients in Table 2. Of course, the developer may intend to purchase from local suppliers and not find sufficient sources to meet their needs. They can also plan not to employ local suppliers. Table 2 largely reflects local availability, and the developer's stated intention should be taken into account when specifying the final local share capture.

<b>Local Capture of Install Expenditures by Expenditure Category</b>	<b>Percent</b>
Engineering, Procurement and Construction	25.0%
Contingency	0.0%
Transmission/Interconnection	65.0%
State Taxes and Fees	80.0%
Installation (non-residential construction)	100.0%
Electrical components (less transmission)	15.0%
Structures	25.0%
PV Modules	0.0%

**Table 2: Local Capture of Installation Expenditures**

The economic impact simulation model will compile the expenditures by category captured in the local economy and estimate the economic effects measured in annual employment equivalence, earnings and wages, contributions to gross regional product and value of sales/output. Note that only employment requires a modifier in interpreting the outcome. This is because the model will estimate the total number of jobs that would accomplish that level of expenditure if it were completed in 12 months' time. Given the potential for the construction phase to span more or less than 12 months, the analysis must recognize that estimated installation job counts represent the number of jobs supported by the expenditure, regardless of how long it takes to spend down that level of expenditure. For example, if it requires one construction worker to complete a \$100,000 construction project, then the project should require one such worker whether that was spent in six months, 12 months or 24 months. If completed in six months, it is likely two ½-year workers completed the task, making up one annual equivalent job. If over 24 months, it is likely that one worker working half time over two years would complete the task – once again accounting for single year equivalence job. To be further nuanced, the actual job counts may be less informative than the actual earnings for the installation phase. This is because the employment may be spread over many contractors and workers engaged in temporary work at different times of the year, rather than a limited set of workers, working consistently on this project over the course of a year. That is, one year-equivalent job may be spread out over more than one worker, working part-time or temporarily employed on this project.

More detail on the methods of estimating economic impact can be found below in the Economic Simulation Model section of this report.

## Operations and Maintenance Phase

Operations and maintenance of the project is an ongoing concern with recurring expenditures year-over-year. As is the case with most electrical and mechanical equipment, reliability decreases over time. The NREL provides an estimate of the typical standard operational expenditures of PV solar projects, but this schedule is subject to change over time (Walker, et al., 2020). Because operational costs are variable over time, the strategy for modeling the annual costs was to establish a benchmark year as the average annual costs over the life of the project and then apply a formula-driven schedule of total annual O&M costs over the 25- or 30-year life of the project that averages to the benchmark year. To minimize the required calculations in accomplishing this, a linear approximation to the NREL-derived schedule (Walker, et al., 2020) was adopted that asserts a five percent annual increase in operating costs at the baseline values at year 15 of the life of the project. Accordingly, each year before year 15, the annual operating costs are expected to be about five percent lower than the next year, while each subsequent year beyond year 15, it is expected to increase by about five percent. Since the growth rate is linearized, the actual year over year change in percentage terms will approximate five percent annual growth.

While the NREL report that provides installation cost estimates provides some baseline O&M cost estimates (Ramasamy, et al., 2021), the O&M cost breakouts are less precise than desired for modeling economic effects. Accordingly, base year O&M costs start with NREL estimates for a single axle tracking system of project size of 100 MW<sub>ac</sub> or higher, as reported in an alternative NREL report (NREL, 2018). These estimates are dated. Hence baseline estimates were adjusted for technological advances (NREL, 2022, SunSpec Alliance, 2016).

The resulting annual cost profile establishes the baseline aggregate operating costs per MW<sub>DC</sub> of output per year and breakouts of costs by category. The cost breakouts include payment to lease holders, taxes and other operating costs which may be related to other project characteristics, like the number of acres leased versus purchased, the planned lease rate, the planned inverter ratio and others. Such may have material impacts on the expenditure components and the aggregate costs per MW of generated electricity. Additionally, under other objectives in this USDoE grant, a survey established how leaseholders have used the PV lease payments, including if they save, reinvest, or retire and move away from the community. All of these have implications on how dollars are captured and circulate in the local economy and affect the expected local economic impact of the project.

Table 3 shows the baseline assumptions of the O&M costs and are specified relative to operating output, indicating that tax (in this particular example for Iowa) makes up the largest single cost component to O&M. The land lease costs are the second largest expense, under this example followed distantly by technical inspections and technicians. As not all expenditures are expected to be captured by contractors and businesses in the local economies, expenditures must be assigned a value of local capture. The model has underlying assumptions of the local capture that can be over-ridden by the user.

Annual Operating Expenditures by Category	\$/kW <sub>DC</sub> /year	Share of Total
<b>Total O&amp;M Costs per kW<sub>DC</sub>/year</b>	<b>\$21.690</b>	
<b>Annual Operating Expenditures by Category</b>		
Administrator	\$2.254	10.4%
Cleaner	\$2.015	9.3%
Inverter specialist	\$0.004	0.0%
Inspector	\$2.443	11.3%
Journeyman electrician	\$1.016	4.7%
PV module/array Specialist	\$2.585	11.9%
Network/IT	\$0.001	0.0%
Master electrician	\$0.475	2.2%
Mechanic	\$0.239	1.1%
Pest control	\$0.044	0.2%
Structural engineer	\$0.000	0.0%
Mower/Trimmer	\$1.623	7.5%
Utilities locator	\$0.005	0.0%
Land Lease	\$4.406	20.3%
Taxes	\$4.580	21.1%
<b>Total</b>	<b>\$21.690</b>	<b>100.0%</b>

**Table 3: Components of O&M Costs**

Table 4 uses heuristics to assign the share of expenditures captured in the local economy. As pest control and mowing is largely available in even the smallest of counties, the model conjectures that the local economy captures 100 percent of these expenditures. Alternatively, the specialized technical services or centralized operational functions are expected to be provided remotely, such that the local economy will capture none of these expenditures. Other expenditures fall in between, as shown in Table 4.

By assumption in the model, the breakout and local shares do not change over time in the simulation model and there is currently no option for changing these parameters at different stages of the project's life. However, as mentioned above, the total O&M costs will vary from less spent per year to more per year, such that the average annual O&M expenditures will match that shown on the Parameter spreadsheet of the spreadsheet model (Table 3).

Local Capture of O&M Expenditures by Expenditure Category	Percent
Administrator	0.0%
Cleaner	75.0%
Inverter specialist	25.0%
Inspector	0.0%
Journeyman electrician	50.0%
PV module/array Specialist	20.0%
Network/IT	0.0%
Master electrician	25.0%
Mechanic	25.0%
Pest control	100.0%
Structural engineer	0.0%
Mower/Trimmer	100.0%
Utilities locator	0.0%
land lease	75.0%
Taxes	80.0%

**Table 4: Local Capture of O&M Expenditures**

The economic simulation model will take these inputs, along with the project specifications to derive a typical annual economic impact estimate of the O&M phase. It will also generate a time series of annual estimated economic impacts to create a schedule of expected annual economic effects, where all values are measured in constant dollars for the year of the analysis. This implies that inflation is not factored into the estimates, making for easier interpretation.<sup>2</sup>

## Teardown Phase

The final economic impact component for estimation is the cost of deconstructing, or decommissioning, the project. Decommissioning generally anticipates restoring the property to pre-project conditions. If in agriculture, that would mean removing all above and below ground structures and restoring drainage tiles and soils to agricultural-use conditions. Most townships and municipalities go so far as to require a performance bond be issued for the decommissioning of the project. Such a bond exists beyond the life of the development or developer to assure funds will be available to restore the property, even if the venture goes bankrupt.

The expected life of these projects is between 25 and 30 years, suggesting that much can happen with energy technology during this time. It is conceivable that technological advances may supplant PV solar, rendering the project obsolete before the planned end of life. However, the most likely outcome is that the project will persist through the planned end of life for the particular project. At that point, the developer may have two options. One is to remove the installation and restore the land to its original condition. The second is to repurpose the installation with a next generation solar energy project – by which we can hardly conceive of how that may look. In this model, we assume the property will be restored to its original condition at the end of the project's life.

Because PV solar projects are relatively new and because such projects have significant lifespans, few examples of the costs of decommissioning exist. However, four recent PV installation proposals included the expected costs of decommissioning the site (Dupuis, 2021; Stantec Consulting Services, 2021; Sandifer, 2021; Terracon, 2021). Many of these studies refer to a 2020 New York study on the required tasks for decommissioning PV sites (NYSERDA, 2020). The estimated costs of decommissioning activities are derived from average decommissioning expenditures per- MW<sub>dc</sub> nameplate capacity at \$41,969 per MW<sub>dc</sub>. The NYSERDA (2020) study provides a breakout of expenditures by category. Collectively these provide a scalable expenditure profile for estimating the economic impacts of decommissioning activities.

Decommissioning generally requires less time than installation. The default number of months required to decommission a site is set to nine months. While the user can change this value, the length of time necessary to decommission a site only impacts our economic impact interpretation if the total number of months exceed a year. Whether the decommissioning requires one month or

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<sup>2</sup> For an example of the implication, \$10 an hour for a grounds service worker in 2023 may be equivalent to \$15 per hour for the same worker in 2030. In this analysis, the price of workers remains constant at the 2023 prices of 10\$ per worker and the audience of the model does not have to conjecture what the value of the dollar in the future will be, as it is set fixed at 2023 prices.

12, we assume one growing season is disrupted. Hence, economic net effects of no agricultural output on affected agricultural acres applies.

<b>Decommissioning Expenditure Category</b>	<b>Percent</b>
Remove Rack Wiring	4.1%
Remove Panels	4.1%
Dismantle Racks	20.5%
Remove Electrical Equipment	3.1%
Breakup and Remove Concrete Pads or Ballasts	2.5%
Remove Racks	13.0%
Remove Cable	10.8%
Remove Ground Screws and Power Poles	23.0%
Remove Fence	8.2%
Grading	6.6%
Seed Disturbed Areas	0.4%
Truck to Recycling Center	3.7%
<b>Total Decommissioning</b>	<b>100.0%</b>

**Table 5: Decommissioning Cost Breakouts**

## Economic Simulation Model

The standard model for measuring macroeconomic-level effects is a representative input-output model for the region in question. There are a few options for creating the representative input-output model. Commercial providers like IMPLAN (2024) and Lightcast (2024), can provide county-specific input-output models. However, county-specific models for the seven-state area encompassing this model, these commercial options would be cost prohibited. Rather, this project selects counties in each of the seven states to be representative of all counties of the same size. Hence, all small counties in the state will then be represented by the randomly selected county chosen in that state.

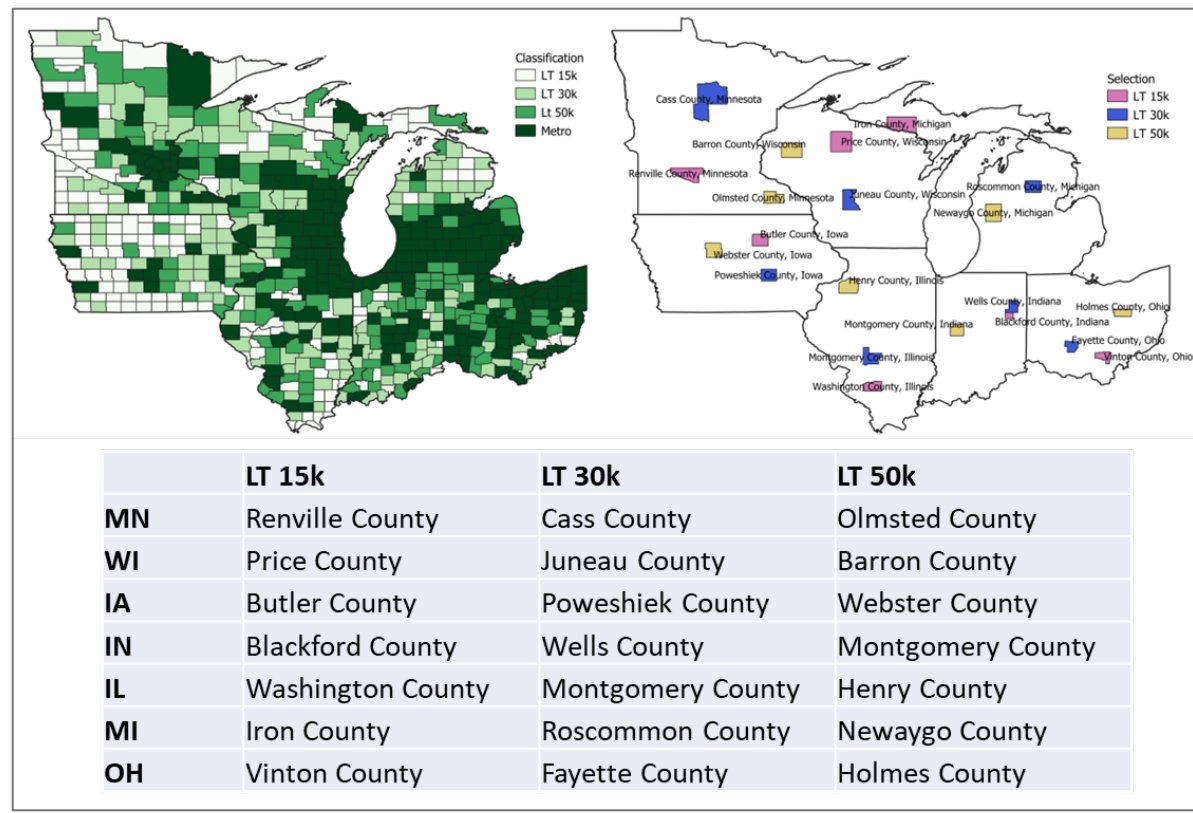
Input output models trace economic linkages through transactions across the economy. The concept underlying the modern rendering of the input-output model dates to the 1940s and has remained a key tool for understanding macroeconomic impacts for over 60 years. They start with a nationally-specified social accounting matrix (SAM) that is derived from surveys of businesses at the national level. The surveys detail what commodities are purchased by industries and what commodities institutions like households purchase over the course of a year. The SAM entries by industry are double-entry ledgers of transactions that recognize that one industry's purchases are other industries' sales revenue. Both purchases and sales can be made with parties outside the US in the form of imports and exports. Each industry has different regional linkages from which inter-industry transactions arise. That is, each industry exhibits unique expenditure patterns with other industries, institutions and the rest of the World and these expenditure patters depend on availability of inputs by other providers in the local economy.

Input-output models are useful for estimating how a potential change in production or economic activity ripples throughout the economy. Multiplier effects are industry- and geographically specific. Industries with deep local supply chains tend to generate larger macroeconomic effects than industries that primarily rely on suppliers from outside the local economy. Similarly, geographies with larger economies, like metropolitan areas, tend to have larger multiplier effects than economically smaller regions, like rural economies. This is because larger economies tend to capture more transactions internally rather than rely on imports. Coughlin and Mandelbaum (1991) provide a gentle introduction to the workings of input-output models, while Richardson (1985) provides a more rigorous presentation.

The impact simulation starts by properly specifying the direct expenditures, or sources of economic impact. Direct effects are all the transactions that can be directly attributed to the installation, operation and decommissioning of the solar project, depending on the phase. They include new transactions that would not have taken place in the local economy without the project, as well as transactions that do not take place because of the project. For example, construction of the solar panel array on agricultural land necessitates direct expenditures to install the panels but also results in lost agricultural activities on that land. Properly specifying these direct effects is imperative for estimating economic impacts accurately and objectively.

This model devises representative economies to represent all economies of size for a given state. Three size categories were created. Small counties are those with population counts of 15,000 or less. Medium counties have more than small counties, up to 30,000 residents. Finally, large counties are designated as having a population no greater than 50,000 residents but larger than that of medium counties. The selected counties are shown in Figure 1, where eligible counties exclude those currently established by the Office of the Management and Budget as being members of a metropolitan statistical area (U.S. Census. 2022).

The results of the input-output model are reported in terms of Output value, Earnings, Employment generated, and total Value Added. Output value represents the total value of production (all Project activities) as measured as the grand total of receipts generated over the course of a year. Employment and earnings represent the number of jobs involved in the Project and the total labor income shared among them all. Jobs in IMPLAN are calculated as total annual job counts. This means that 1 “job” as estimate by the model may in fact be realized across 2 or more individuals in partial-year roles. This is often the case for highly intensive activities over a short-term project like those anticipated at the installation phase. Earnings are combined proprietors’ and wage earnings and includes fringe benefits but excludes taxes and payments to social security. Finally, Value Added is a term that represents total regional income and comprises all labor and proprietors’ income, corporate profits and net earnings by government – generally in the form of tax revenues. All positive economic effects measured represent total additional, or “new” economic activities generated by the project that would not otherwise exist. All negative effects represent reductions in economic activities.



**Figure 1: Representative Geographies**

## Agricultural Offsets

Economic impact assessments account for all changes in economic activity. The installation, O&M and decommissioning phases of the project have the potential to disrupt existing agricultural production on crop acres converted to solar. In assessing the lost agricultural production, the model assumes the targeted number of acres in agriculture disrupted by the PV installation would have been used to grow a standard three-year rotation of corn (conservative till), soybeans (no till) and wheat (conservative till: grain and straw). This posits a typical row crop operation in the Midwest and acts as a representative agricultural placeholder.

Modeling the economic contribution of crop production starts with the number of agricultural acres impacted by the solar project. Crop enterprise budgets then provide a basis for modeling crop transactions and associated economic impacts of crop production activities through the multiplier effect described above.

Crop enterprise budgets are projected statements of expected per-acre revenues and expenditures and are created for specific crops and rotations. Because the assumed rotation is a three-crop in three-year rotation, we will use a simple average over the three crops in deriving the typical annual crop revenues. We use Ohio State University Extension (2021) enterprise crops for the three-crop rotation. These budgets assume \$7.00/bu. corn, \$7.50/bu. wheat, and \$14.25/bu. Soybeans with yields of 147, 57 and 74 bushels to the acre, respectively. Because the level of purchases of inputs,

not the value of crops sold, is the primary driver of economic impacts, changing the agricultural commodity value will not have a material change on outcomes and therefore, is not a built-in option with the model.

While the model assumes that disrupted agricultural acres are otherwise used for common grain production, converting acres that are in higher-value uses could impose a more significant economic loss to the community than that estimated by the model. Particularly acres in specialty crops like asparagus, peppers, cucumbers, tomatoes or other similar specialty crops require substantially more input and labor during the growing season and command higher market prices. Some agricultural commodity production operations are not good candidates to be converted to PV solar production. For example, converting vineyards and orchards would have similar effects but would also disband years of establishment costs required before the vineyard or orchard is productive. Accordingly, it is unlikely to see such acres converted to solar.

There may be some potential to overstate and to understate the expected loss in agricultural production. There exists a potential to overstate the true expected economic losses of reduced agricultural output for several reasons. First, farms with marginal soils will be more willing to lease their property for non-farm uses. That is, there is a self-selection bias that favors placing low productivity acres into PV use. This may be offset by the developer's pursuit of acres that give direct access to utility trunk lines. Second, it is probable that not all the acres converted to PV will offset agricultural production. For the same reason above, unproductive, or fallow land will likely be converted before productive land is. However, because we assume that all the impacted acres would have been in grain production, it is possible that the lost economic value of foregone agricultural production understates the true economic value if those acres would otherwise be used for high-value specialty crops (tomatoes, strawberries, peppers, etc.), or if the acres are part of livestock operations. The analysis undertaken here may therefore overstate OR understate the value of lost agricultural production. We therefore make assumptions based on what we consider is the likely use of the land in Jackson County, Michigan.

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