Paul A. Coomes, Ph.D.
Consulting Economist
3604 Trail Ridge Road Louisville KY 40241 502.608.4797 coomes.economics@gmail.com
Emeritus Professor of Economics, University of Louisville

Revised August 20, 2023

TO: Megan Stahl
Development Manager
106 Isabella Street, Suite 400
Pittsburgh, PA 15212
m: 689-666-8536
Megan.Stahl@OridenPower.com

FROM: Paul Coomes

RE: Estimated economic and fiscal impacts of Christian County solar project

Oriden is developing a solar farm with 125 MW generating capacity on about 1,600 acres of rolling farmland northeast of Hopkinsville, in Christian County KY. The company plans to invest approximately $192 million to develop the site, named Dogwood Corners. This note provides estimates of the new local economic and fiscal activity expected from the development.

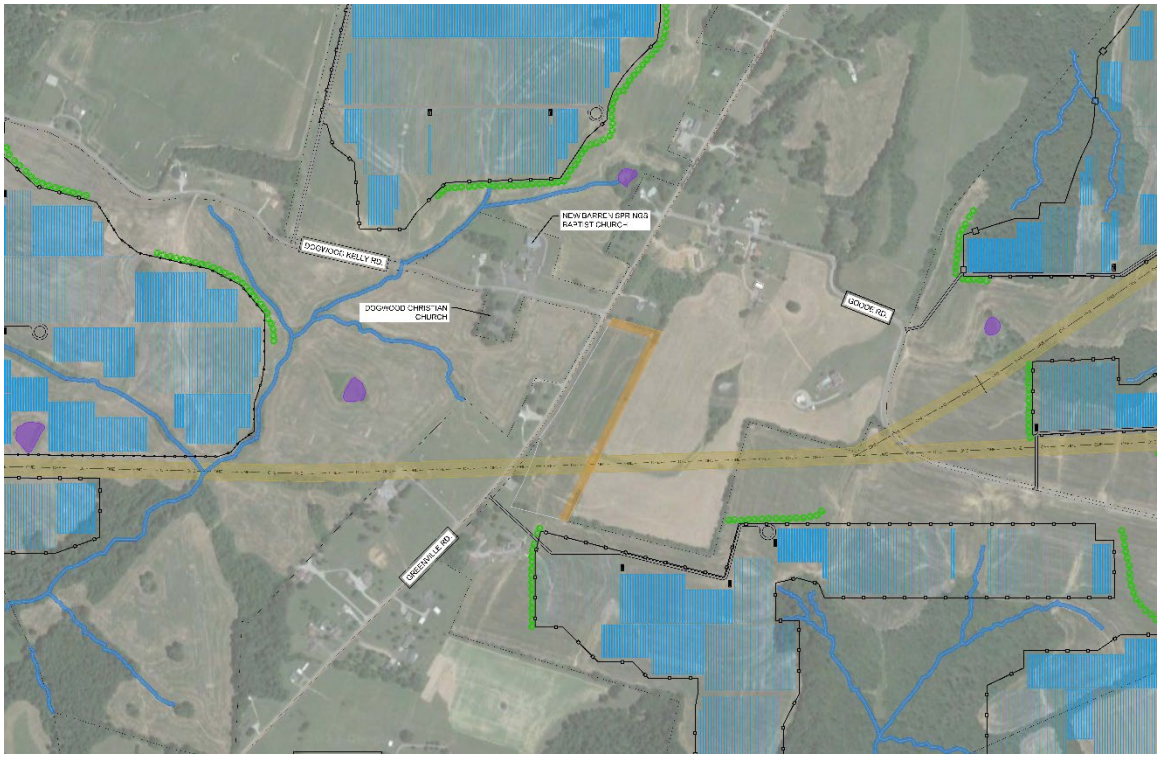
There are two primary impacts expected from the project. First, there will be a spike in construction and linked jobs as the site is built out over approximately one year. Using estimates of the construction payroll, I estimate that there will be a total (direct and spinoff) of 371 new jobs in the County in year one, with new labor compensation of $22.1 million.

Second, there will be three to four decades of new property-related tax payments to state and local jurisdictions in Christian County due to the increased value of real estate, machinery and tangible property installed at the site. Over 36 years, this would lead to $5.2 million in property tax revenues for local government jurisdictions in Christian County. The eleven land parcels involved generated $9,600 in property taxes in 2021,

almost all going to local jurisdictions. This can be compared to an average of $144,000 likely to be generated per year by the solar project over the life of the project.

Location

The site is near the intersection of Dogwood Kelly Road and Greenville Road (Highway 107), 6.5 miles northeast of Hopkinsville. The next exhibit shows the site plan produced by Oriden. The yellow shading indicates the TVA high voltage lines passing through the area.

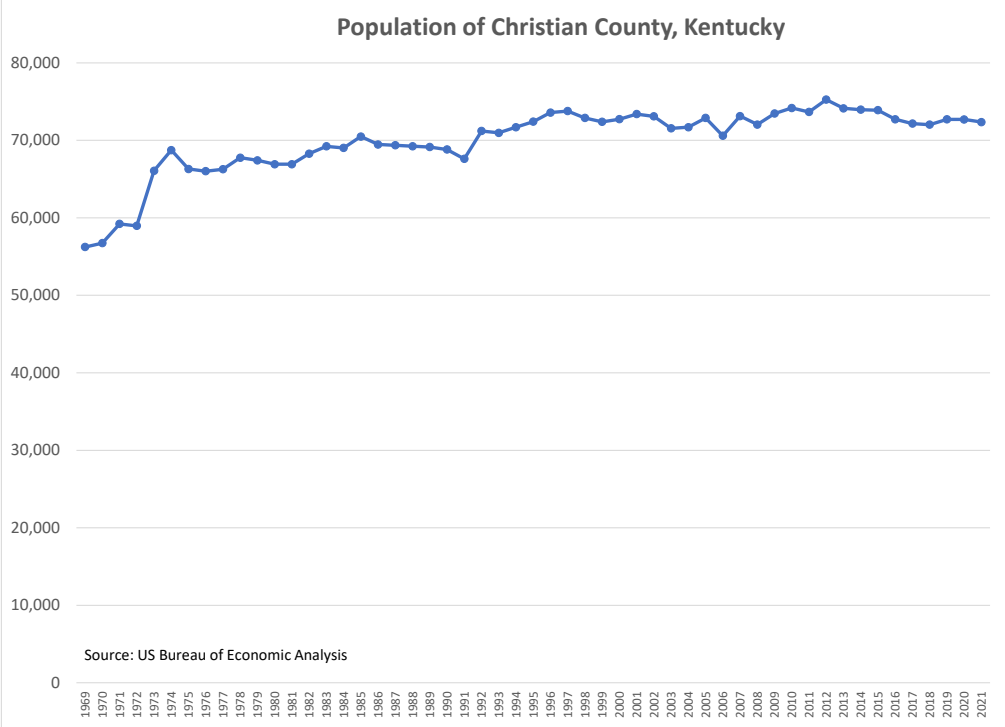


Newly released results from the 2021 American Community Survey provide a nice summary of demographic and economic characteristics of Christian County. Some details are provided in a table at the end of this report. For many of the measures, the County is similar to the State, for example percent native-born, high school attainment, and unemployment rate. However, a few things stand out:

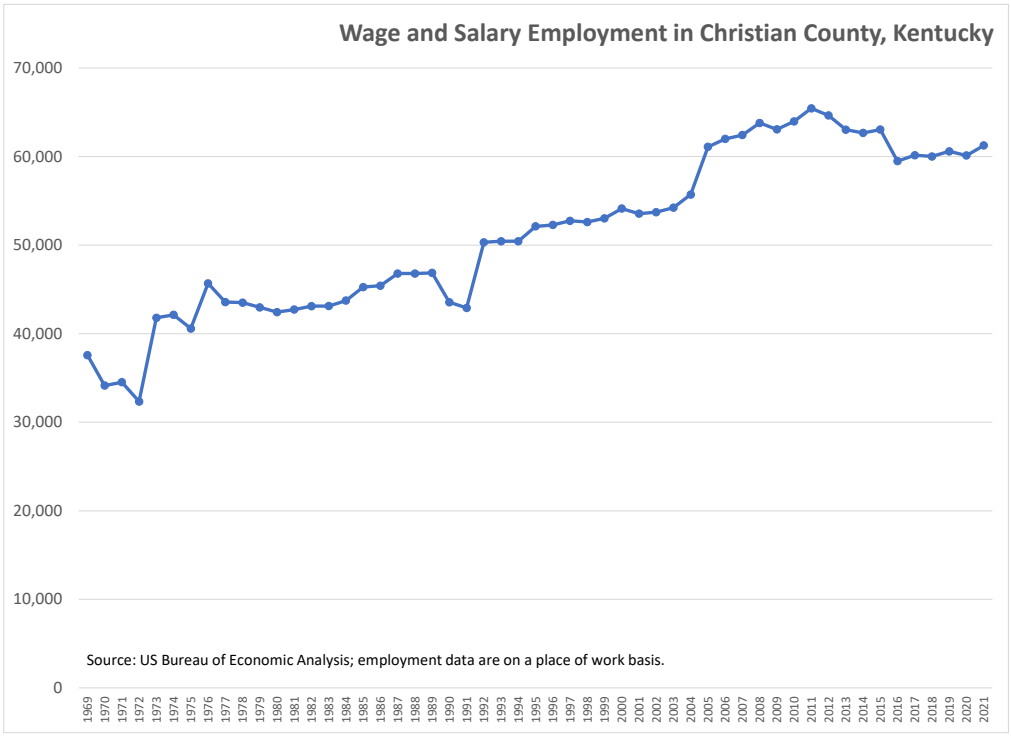
- Compared to the Kentucky state average, the County population is much younger, less white, more mobile, more people per household, and with more veterans.
- Fewer adults have a four-year college degree, and a much larger percentage of adults are in the Armed Forces. The average commute time in Christian County is much shorter, presumably lowered due to soldiers at Fort Campbell.

- Civilian residents tend to work disproportionately in construction and distribution occupations around the region, and in manufacturing industries.
- Median household income was $45,900, compared to a state average of $55,500.

Christian County's population has hovered around 72,000 for several decades. Its last major growth spurt was in the 1970s and early 1980s, when it gained around 14,000 residents. This was also a time of strong job growth in the County. See charts below.



Any economic analysis of Christian County must take account of the presence of Fort Campbell on its southern border with Tennessee. Indeed, the military accounted for 43 percent of all employment in the County in 2021. Because the soldiers and staff are technically located at the Fort Campbell headquarters they are all counted as employed in Christian County, even though a majority live in Tennessee. This is discussed further below in an analysis of commuting patterns, where we find that a large percentage of workers in Christian County live in Montgomery County, Tennessee.


Wage and Salary Employment in Christian County, Kentucky
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Source: US Bureau of Economic Analysis; employment data are on a place of work basis.
1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021


Military Employment in Christian County, Kentucky
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Source: US Bureau of Economic Analysis; employment data are on a place of work basis.
1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021

Modeling the Economic Impacts

I take a conventional approach to modeling the regional economic impacts, using a customized input-output model of Christian County[1]. I have purchased annual economic data for all 120 Kentucky counties, and use these as needed to construct regional models – of a county, a group of counties, or the whole state. The model has detailed information about the linkages among 500 potential industries in each regional economy, as well as the relationship between household spending and demand for local retail goods and services due to the employee compensation or other forms of income. When there is new industrial activity in a region, the model can predict how much of the supply chain can be met by local businesses and how much the new payroll will result in additional sales (and jobs) by local businesses.

The ratio of the total regional economic activity to a change in activity by a local industry is call a multiplier. For example, if a new manufacturing company adds 100 jobs and the County were to ultimately see another 80 jobs due to related spinoff activity, the employment multiplier would be 1.8 (180 total jobs divided by 100 direct jobs). Similar multiplier effects are generated for business output, employee compensation, and value-added[2].

The relevant sector for the construction phase is number 52, "Construction of new power and communication structures", and I use this to model the initial investment. The employment multiplier for that sector in Christian County is 1.237. This is a very modest multiplier, due to the fact that almost all the materials used to assemble a solar farm are made outside the County; thus, there are few inter-industry impacts locally..

There will also be some modest spin-off impacts from ongoing operations. Unfortunately, for the operations phase, the relevant IMPLAN sector, number 42, "Electric Power Generation – Solar", is empty of data and results for Christian County. This is because there is no history of solar electricity generation and therefore no basic economic data to construct industry relationships. The sector is also empty of data for the statewide model.

[1] For documentation of IMPLAN modeling, see www.implan.com/history/ . For this project I use economic data for 2019. While data for 2020 and 2021 are available now, they reflect abnormal pandemic conditions, and I do not believe they are representative of typical economic linkages.

[2] Value-added is a measure of how much economic activity actually sticks to a region. For example, if one purchases a new vehicle for $40,000 from a local dealership, only a few thousand dollars actually is captured in the county. Business revenues rise by $40,000, but most of it flows right out to the place where the vehicle was made. Local value-added measures the fraction of the sale that ends up paying workers and owners at the dealership, as well as any local taxes captured as a result of the sale.

Construction Payroll and Local Economic Impacts

From an economic perspective, the solar project has two phases, construction and operations. The construction phase is expected to last about one year, while the operations phase will last several decades. Almost all the employment occurs in the construction phase. The regional economic impacts consist of the direct effects of spending by the developer, and any spinoff impacts due to local purchases of supplies and new spending by households as a result of the increased incomes.

Direct effects

The company expects to invest approximately $192 million in the solar project. The investment involves land acquisition, site preparation, solar panel and electrical equipment installation, plus landscaping and security fencing. Oriden will hire construction companies for this project, so it is not possible to know precisely how many workers will be employed nor their total compensation. For modeling purposes, I am using an estimate of average employment over a one-year construction phase. Using the results of a recent California study of six large photovoltaic projects suggests that there will be an average of 300 direct jobs over a twelve-month construction period for this project[3].

Construction wages and benefits from 2014 Berkeley study

	Average annual wage	Average annual benefits	Total compensation
CA Valley & Topaz Combined, Low Wage	$52,736	$24,104	$76,840
Average Across Six Solar Projects	$78,002	$36,880	$114,882

Source: https://laborcenter.berkeley.edu/pdf/2014/building-solar-ca14.pdf

The California study also provides a range of results for construction wages and benefits. The lowest average annual construction wage reported was $52,736, and the average wage across the six projects was $78,002, as shown in the table. California is, of course, a high wage state, with a much higher cost of living than Kentucky. On the other hand, the wage results are from projects developed a decade ago, and there have been large increases in average wages across the US since then.[4]

[3] A University of California-Berkeley study looked at six large PV projects in California, and summarized the economics. The author finds a ratio of 2.4 FTE construction jobs per MW. Applied to Dogwood Corner's 125 MW you get 300 direct construction jobs. He shows the permanent operations jobs per MW, and applied to this project you get about 4 FTEs. See page 28 of *Economic and Environmental Benefits of Building Solar in California*, by Peter Philips, November 10, 2014, https://laborcenter.berkeley.edu/pdf/2014/building-solar-ca14.pdf

[4] By contrast, a recent union-oriented report on Ohio solar projects claims temp workers there are only making $18 to $20 per hour, implying average annual pay of around $40,000; See

Occupations include construction managers, earth grader operators, panel installers, electricians, and fencers. I searched the federal database on hundreds of occupations to learn how much these workers are likely to earn on the project. The US Bureau of Labor Statistics publishes estimates of employment and wages by occupations for states and metropolitan statistical areas, but not for counties. Christian County is in the Clarksville TN-KY MSA, and some relevant estimates are shown in the next table.

Clarksville TN-KY MSA Wages for Related Occupations, 2021

SOC code	Occupation	Employment	Hourly mean wage	Annual mean wage
11-9021	Construction Managers	140	$36.67	$76,280
47-2073	Operating Engineers and Other Constr Equip Operators	270	$20.41	$42,450
47-2111	Electricians	320	$23.14	$48,130
17-2112	Industrial Engineers	190	$39.13	$81,390
17-2141	Mechanical Engineers	90	$41.38	$86,080
49-9021	Heating, AC, and Refrig Mechanics and Installers	310	$21.79	$45,310
49-9051	Electrical Power-Line Installers and Repairers	140	$33.55	$69,780
49-9052	Telecommunications Line Installers and Repairers	70	$25.34	$52,700
	Source: US Bureau of Labor Statistics, Occupational Employment Survey, www.bls.gov/oes/current/oes_ky.htm			

More occupations are covered in the estimates for the state of Kentucky, and these are shown next. The state-level data include estimates for materials engineers and fence installers. For occupations where data are available for both the MSA and the state, we see that mean annual wages are five to twenty percent lower in the Clarksville MSA. This is likely due to the inclusion of workers in higher-wage urban areas, such as Louisville, in the state totals.

There is no listing in the Kentucky or MSA data for "Solar Photovoltaic Installer", but the national average annual wage in 2021 was $50,710[5]. Based on these published wages, the construction managers are likely to earn over $70,000, heavy equipment operators and installers over $40,000, electricians around $53,000, and fencers $35,000.

https://columbusfreepress.com/article/ohio-solar-panel-farms-are-booming-construction-workers-are-being-exploited-make-it-happen

[5] Source: US Bureau of Labor Statistics, Occupational Employment Survey. For national data on solar photovoltaic installer, see www.bls.gov/oes/current/oes_nat.htm#47-2231 . For Kentucky and MSA data, see www.bls.gov/oes/current/oes_ky.htm County-level data are not available.

Assuming an average of $50,000 per construction job over a year leads to a direct payroll of $15 million in the County The average annual pay for all jobs in Christian County in 2020 was $55,200[6]. Multiplying the expected number of jobs times the assumed average pay per job yields a direct construction payroll of $15.0 million. The average fringe benefits, such as employer payments for health insurance, in Kentucky for the construction industry is 21 percent[7]; so, total labor compensation for these jobs is $18.2 million, or $60,700 per job.

	Kentucky Wages for Related Occupations, 2021			
SOC code	Occupation	Employment	Hourly mean wage	Annual mean wage
11-9021	Construction Managers	980	$46.54	$96,800
47-2073	Operating Engineers and Other Construction Equipment Operators	5,930	$24.80	$51,580
47-2111	Electricians	9,260	$25.66	$53,370
47-4031	Fence Erectors	60	$16.77	$34,880
17-2112	Industrial Engineers	320	$41.01	$85,300
17-2131	Materials Engineers	2,370	$45.47	$94,570
17-2141	Mechanical Engineers	1,210	$39.23	$81,600
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	5,790	$24.27	$50,470
49-9051	Electrical Power-Line Installers and Repairers	2,930	$32.41	$67,410
49-9052	Telecommunications Line Installers and Repairers	1,170	$23.25	$48,350
	Source: US Bureau of Labor Statistics, Occupational Employment Survey, www.bls.gov/oes/current/oes_ky.htm			

Spin-off impacts in Christian County

The construction phase will have some spin-off effects in Christian County. I model this using a custom IMPLAN model of the County. The relevant sector for the construction phase is number 52, “Construction of new power and communication structures”, and this can be used to model the initial investment. The direct effect in the County is 300 jobs over one year, with labor compensation of $18.2 million.

The model has detailed information about the inter-industry linkages in each regional economy, as well as the expected household spending on retail goods and services due to the enhanced employee compensation. When there is new industrial activity in a region, the model can predict how much of the supply chain can be met by local businesses and how much the new payroll will result in additional sales (and jobs) by local businesses. Adding these two effects to the direct effect yields the total effect of a development, and dividing the total effect by the direct effect yields a multiplier. Using

[6] Source: US Bureau of Economic Analysis, https://www.bea.gov/data/by-place-county-metro-local , Table CAINC30, average annual wages and salaries in county.

[7] BEA provides estimates of both total compensation and total wages by industry for the state. Dividing total construction industry compensation by wages in 2021 yields 1.21.

the Christian County multipliers for the relevant construction sector, and the direct construction budget, I project there will be a total of 371 new jobs in the County, and new labor compensation of $22.1 million.

The accompanying table illustrates the various impact components across several standard economic measures. These are stated in terms of 100 direct jobs, but can be scaled up to fit any assumed number of construction jobs[8]. Note that both the indirect and induced effects are quite small. The indirect effect is small due to the lack of local suppliers of solar farm materials. The induced effect is somewhat bigger, though still small due to the lack of retail and service businesses in the County to absorb the new household income linked to the construction jobs

100 Jobs in Sector 52, Construction of new power and communication structures

Impact Type	Employ-ment	Labor Income	Value Added	Output
Direct Effect	100.0	$5,320,565	$8,019,607	$14,997,235
Indirect Effect	11.3	$560,336	$1,038,273	$1,862,131
Induced Effect	12.4	$564,121	$993,464	$1,721,404
Total Effect	123.7	$6,445,021	$10,051,344	$18,580,770
implied multiplier	1.237	1.211	1.253	1.239

Source: IMPLAN model of Christian County, using 2019 economic data.

Regional impacts from construction

Some readers may wonder why I have focused on impacts in Christian County as opposed to more widespread regional impacts. Keep in mind that most federal-state statistical agencies and models measure employment on a place of work basis, as opposed to a place of residence basis. So, all construction workers at the site are counted as Christian County jobs. Nevertheless, clearly there will be some spinoff economic activity in surrounding counties, as supplies are purchased and workers spend their paychecks at retail establishments.

[8] This linear scaling is a feature of IMPLAN and other regional input-output modeling systems. It is reasonable in the case of a solar farm construction project. The feature becomes a problem in cases where an industrial development dramatically changes a local economy, for example, in the case of a large manufacturing plant in rural county. In that case, one could expect complicated and nonlinear effects, such as growth in the local population, much higher wage rates, and growth in support industries.

One can see from the latest data on commuting patterns that 48 percent of workers in Christian County are also residents of Christian County. Montgomery County, Tennessee (Clarksville) supplies most of the remaining workforce, with less significant contributions from Trigg, Todd and Hopkins counties in Kentucky.

County of Residence of Workers in Christian County, KY		
Christian	25,771	48.0%
Montgomery TN	21,301	39.7%
Trigg	1,794	3.3%
Todd	1,110	2.1%
Hopkins	805	1.5%
Stewart TN	413	0.8%
Caldwell	379	0.7%
Logan	213	0.4%
all other	1,849	3.4%
Total	53,635	100.0%

Source: US Census Bureau, American Community Survey, Residence County to Workplace County Commuting Flows, 5-Year ACS, 2011-2015

On the other hand, nearly all (85 percent of) working Christian County residents work in Christian County, with another nine percent commuting to Tennessee. I believe these commuting patterns reflect the strong influence of Fort Campbell, which is headquartered in Christian County on the state border, but draws much of its workforce from the Clarksville TN area. Note the large discrepancy between the total number of people working in Christian County (53,635) and the number of Christian County residents working somewhere (30,384). The difference is largely explained by the large Fort Campbell workforce.

County of Work for Residents of Christian County		
Christian	25,771	84.8%
Montgomery TN	2,578	8.5%
Hopkins	323	1.1%
Trigg	297	1.0%
Davidson TN	296	1.0%
Todd	263	0.9%
All other	866	2.8%
Total	30,394	100.0%

Source: US Census Bureau, American Community Survey, Residence County to Workplace County Commuting Flows, 5-Year ACS, 2011-2015

It is unlikely that the regional spinoffs of the solar farm construction would mimic the Fort Campbell-induced commuting patterns just presented. To investigate possible broader regional impacts in Kentucky, I built another IMPLAN model, this time of Christian and the three Kentucky counties supplying the most workers – Trigg, Todd, Hopkins. The results are only slightly larger that of the Christian-only simulation.

The job multipliers for the solar farm construction phase are 1.237 for Christian alone, and 1.294 for the four-county region, for a net change of only 17 total predicted jobs. (Other economic multipliers, such as labor income and business output, are also

consistently in that range). I also performed a comparable simulation using a model covering the whole state of Kentucky. The statewide job multiplier for the solar farm is 1.564, larger than that for the four-county region, due to the inclusion of so many more potential suppliers and retail outlets for household spending. Based on our impact analysis tools, there are not significant differences in the predicted regional impacts when zooming out to adjacent counties or statewide[9]. In this case, the economic multipliers are relatively small whether one models one county, four, or 120. This is due to the lack of industrial linkages in the region to the solar industry.

Ongoing operations

There will also be some modest spin-off impacts from ongoing operations. The company expects operations to support one or two jobs. Unfortunately, for the operations phase, the relevant IMPLAN sector, number 42, "Electric Power Generation – Solar", is empty of data and results for Christian County. This is because there is no history of solar electricity generation and therefore no basic economic data to construct industry relationships. (The sector is also empty of data for the statewide model, for the same reason). A reasonable recourse is to tap the literature on solar project impacts, find comparable places, and use other studies to estimate the likely operational impacts on local economies in Kentucky. The California PV study cited above found that a ratio of 31.3 MW per permanent operations job. Applied to the Christian County project, this results in an estimate of 4 permanent operational jobs at the site. Thus, ongoing annual economic impacts are expected to be very small relative to the one-time impacts of construction.

It is beyond the scope of this analysis to try to net out all the other economic impacts from the change in land use. Relevant negative factors include the loss of expected income from farming, and agriculture's linkages to local suppliers of seed, feed, and other supplies. On the positive side are the large lease payments going to the farm owners, the income to the several new operations jobs at the solar farm, plus the linkages of those income streams to the local economy. To measure all these would require some basic information about current farm activity, and the amount of payments to farm owners. The lease payments are confidential and I do not have access to that information.

[9] For other industrial developments around Kentucky it is common for our models to predict job multipliers of 3, 4, or 5, particularly for complicated manufacturing operations such as motor vehicles and parts.

Local tax revenues

Christian County and the Commonwealth of Kentucky levy property taxes on real estate and tangible property (and the Commonwealth taxes the value of manufacturing machinery). The table below provides the latest published tax rates that are applied County-wide. They total less than three-fourths of one percent of the assessed value of property. There are five municipal taxing jurisdictions in Christian County, but the project is outside their city boundaries and thus would not be subject to those property taxes. Unlike the City of Hopkinsville, Christian County does not levy an occupational license fee (payroll tax) or a net profits tax.

Christian County Property Tax Rates, 2021

in cents per $100 valuation

Jurisdiction	Real Estate	Tangible Personal
Extension Service	2.4000	3.2800
General Fiscal Court	18.6000	18.6000
Health	3.2000	3.2000
Soil Conservation	4.0000	0.0000
County Public Schools	42.3000	42.8000
Total, County-wide	70.5000	67.8800

Source: Kentucky Department of https://revenue.ky.gov/News/Publications/Property%20Tax%20Rate%20Books/Property%20Tax%20Rate%20Book%202021.pdf

The company's tax consultant, Altus, has provided estimates of the assessed value of real estate, tangible property, and manufacturer's machinery over the next several decades. Applying current tax rates, they estimate the project would generate about $11.9 million in property tax revenues to state and local governments over 36 years, or $185,000 per year. The local portion of that amounts to $5.2 million, or $144,000 per year, of which $89,000 per year would accrue to the Christian County school system.

The company may negotiate with the County for an Industrial Revenue Bond (IRB). Under an IRB, the County would own much of the property over the life of the bond, and thus the property would not be subject to property taxes. However, the company is expected to make a Payment in Lieu of Taxes (PILOT) to wholly or partially replace the lost property taxes. The school portion is separate and the company would continue to pay the statutory property tax rate to the schools.

The company provided me with the parcel numbers of the land for the site, and I looked up their ownership, taxable value, and current property tax payments through the websites of the Christian County Sheriff's office. The eleven parcels have a combined

assessed value of $1.137 million, and generated $9,600 in property taxes in 2021, almost all going to local jurisdictions. This can be compared to an average of $144,000 generated by the solar project per year over the life of the project, assuming the PILOT just offsets the property tax loss due to the IRB. It should be pointed out that solar projects like this require almost no public services from local government; and because they require so few people to operate do not add students and expenses to the County public school system.

Demographic and Economic Characteristics of Christian County		
	Christian County	**State of Kentucky**
Number of residents	*72,377*	*4,494,141*
Median age	28.3	39.0
Percent white	70.0%	85.5%
Percent of noninstitutionalized population w disability	17.6%	17.4%
Percent foreign-born	3.20%	4.00%
Percent 18 and older veteran	13.0%	7.2%
Percent living in same house as a year ago	79.9%	86.0%
High school attainment rate, population aged 25+	86.2%	87.7%
College attainment rate, population aged 25+	18.3%	25.7%
Number of Households	25,552	1,748,475
Median household income	$45,913	$55,454
Persons per household	2.83	2.57
With broadband internet subscription	78.3%	83.6%
Population 16+	*54,362*	*3,588,209*
In the labor force	60.6%	59.5%
Employed civilian	43.3%	56.0%
Unemployed	3.7%	3.1%
Armed forces	13.7%	0.4%
Not in labor force	39.4%	40.5%
Median travel time to work (minutes)	17.9	23.7
Civilian employed population 16 years and over	*23,515*	*2,009,185*
Management, business, science, and arts occupations	27.7%	35.7%
Service occupations	18.4%	15.8%
Sales and office occupations	21.2%	21.0%
Natural resources, construction, and maintenance occupations	10.9%	8.9%
Production, transportation, and material moving occupations	21.9%	18.5%
Industry		
Agriculture, forestry, fishing and hunting, and mining	3.1%	1.9%
Construction	5.2%	6.1%
Manufacturing	20.5%	14.3%
Wholesale trade	2.3%	2.4%
Retail trade	12.1%	11.9%
Transportation and warehousing, and utilities	4.1%	6.6%
Information	1.4%	1.4%
Finance and insurance, and real estate and rental and leasing	2.9%	5.6%
Professional, scientific, and mgmt, and admin and waste mgmt services	11.5%	8.7%
Educational services, and health care and social assistance	19.0%	24.1%
Arts, entertainment, and recreation, and accommodation and food services	7.4%	8.3%
Other services, except public administration	4.2%	4.5%
Public administration	6.5%	4.3%

Source: US Census Bureau, American Community Survey, 5-year profiles, 2017-21, www.census.gov/acs/www/data/data-tables-and-tools/data-profiles/