Southwest Virginia Solar Manufacturing Target Market Analysis

Prepared for the Solar Workgroup of Southwest Virginia

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SOLAR WORKGROUP of Southwest Virginia

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EXECUTIVE SUMMARY

The *Southwest Virginia Solar Manufacturing Target Market Analysis* is the first report to take a deep dive to examine the potential for solar manufacturing in Southwest Virginia's coalfield region. This report takes a quantitative and qualitative approach to understand the market potential of solar manufacturing in the region. The report covers the full solar manufacturing value chain; including solar modules, solar inverters, solar mounting technology, and energy storage technology. The analysis considers the unique characteristics of Southwest Virginia – geography, transportation, incentives, demographics, workforce, educational resources, existing manufacturing activity in the region, research and development opportunities, and entrepreneurial opportunities – and how these may contribute to a successful solar manufacturing industry in Southwest Virginia.

The U.S. solar industry is booming. Solar capacity in the U.S. is expected to grow 23% year-over-year in 2019 alone. Over the last six years, solar has been one of the top two electric capacity additions in the U.S., reaching over 2.5% of total electricity generation.[1] Further, in the fall of 2019 Governor Northam of Virginia announced aggressive clean energy goals for the state. 100% of the Commonwealth's electricity will be powered by carbon-free sources by 2050 and 30% of Virginia's electricity will be powered by renewable energy by 2030. The Governor included language ensuring that 3,000 MW of solar and onshore wind be under development by 2022. Given the current strength of the solar industry in the U.S. and Virginia's aggressive renewable energy goals, communities in Virginia should consider their unique position to enter the solar industry, to foster economic growth, and position themselves as a clean energy leader. Southwest Virginia has historically been a leader in the energy industry, but as coal is phased out, the region can maintain its energy leadership by shifting to clean energy.

Key Trends in the National Solar Manufacturing Industry:

- Polysilicon, Ingot, and Wafer manufacturing in the U.S. has been declining over the past several years due to trade conditions and the inability to be cost competitive with overseas production.
- Cell manufacturing has historically been slow in the U.S., but may be on the rise due to the opening of the Tesla Gigafactory.
- Module manufacturing has been ripe with opportunity given the Section 201 tariffs, which place duties on foreign modules. Multiple recent openings, mostly driven by tariff conditions, have increased the capacity of module manufacturing in the U.S. Though it is unclear whether U.S. production facilities will continue to be economically viable as the tariffs decrease over four years.
- Inverter manufacturing supplies the majority (71%) of domestic inverter applications, therefore as the solar industry continues to grow there will be increased demand for solar inverters.
- Racking, mounting, and tracking manufacturing will most likely continue to grow as demand for solar increases.
- Battery storage deployment is expected to increase over 100 times by 2040 due to decreasing system costs. There is room for growth in battery manufacturing to meet this demand.

Southwest Virginia's Coalfield Counties have a unique set of characteristics and attributes to support the future potential for solar manufacturing in the region. Geographically, Southwest Virginia is strategically located on the East Coast between major city hubs on the East Coast and Midwest such as Louisville, KY; Charlotte, NC; and the Hampton Roads area in VA. The region has a robust integrated highway system, Port of VA access, and access to a foreign trade zone near Christiansburg, providing access to markets

1 https://www.seia.org/solar-industry-research-data

throughout the South, mid-Atlantic and Midwest. In addition, the region has over 30 industrial buildings and sites suitable for industrial manufacturing activity. Coupled with existing industrial buildings and sites, there are many incentive opportunities for new and existing businesses that aim to expand economic development in the region, including tax incentives, low-interest loans, and technical assistance resources to aid firms in business development.

Attributes of the region's population and workforce may support a solar manufacturing firm. Common across rural America, Southwest Virginia has a lower labor force participation rate compared to Virginia and the U.S. The region has a higher-than average location quotient of mining employment as the mining industry's share of total local employment is much greater than that of the U.S., though as coal becomes less economically viable, these workers will seek new employment. Coal miners have a set of skills such as operation monitoring and equipment maintenance that are easily transferable to manufacturing positions. Further, the region has a lower-than-average location quotient of manufacturing employment, pointing to potential opportunities for expansion or attraction in this industry.

New facilities and programs support expanding and new businesses in the area. The Oxbow Center is an innovative space that offers resources and programs to foster entrepreneurial development in the region. Recently, the Virginia legislature passed a bill establishing the Southwest Virginia Energy Research and Development Authority to support energy development in the region to create jobs and economic activity. Additionally, existing manufacturing in the region has potential to pivot their technology to support the solar value chain. Alternatively, these firms can support new solar manufacturing firms in the region or surrounding regions.

The key recommendations are summarized below.

1. Gain the interest of high school and college students and demonstrate manufacturing as a viable career path to train the next generation of Southwest Virginia workers through hands-on training opportunities.

2. Work to pivot current manufacturing companies to serve the PV industry and attract new solar manufacturing companies. Firms in the region that can transform their technology include Lawrence Brothers Inc., VFP Inc., and Pemco - AMR. Further, surrounding manufacturing technology could aid in the attraction of a new module, OEM, or solar tracking company.

3. Market the abundance of resources available in Southwest Virginia that foster the growth of manufacturing in the region, including the available financial incentives and the available industrial buildings and sites to companies looking to site new manufacturing facilities.

4. Continue to foster entrepreneurial development through programming at the Oxbow Center to support and high growth entrepreneurs.

These recommendations should be utilized by leaders in the Southwest Virginia Coalfield Counties to best position the region as an innovator in solar manufacturing while spurring economic growth through an industry that supports the clean energy revolution.

INTRODUCTION

The Solar Workgroup of Southwest Virginia was convened in 2016 to advance the goal of leveraging solar development as an economic catalyst in the seven-county region. As part of this goal, the group sought to understand the market potential of solar manufacturing in the region as an economic driver. In June of 2019, the Workgroup was awarded a GO Virginia Region One Grant to develop the Solar Jobs, Manufacturing and Utility-Scale Investment Playbook for the region. As part of this effort, the Workgroup contracted The Solar Foundation to conduct an analysis regarding the feasibility of solar manufacturing in the region.

The purpose of the target market analysis is to understand Southwest Virginia's economic position in the solar manufacturing value chain and highlight its advantages, disadvantages, and potential steps for improvement. The Southwest Virginia Solar Manufacturing Target Market Analysis takes a combined quantitative and qualitative approach to understand the market potential of solar manufacturing in the region. The findings from the report stem from an assessment of the solar industry and the region regarding demographics, workforce, and regional assets. As part of the assessment, The Solar Foundation also conducted focus groups and 1:1 interviews with a multitude of stakeholders and employers in the region, listed in Appendix A. Below is a summary of the report:

1. Analysis of the solar manufacturing value chain, including the battery storage value chain, and the market trends across the United States.
2. Analysis of the characteristics of Southwest Virginia, including geographic assets, transportation infrastructure, and the regional and statewide incentive options.
3. Demographic analysis of the population and workforce in the region.
4. Analysis of the transferability of mining skills to solar manufacturing skills and the educational resources available to the region.
5. Discussion of strengths, challenges, opportunities, and threats for solar manufacturing in the region and next steps to attract solar manufacturing in the region to create long-term high-quality clean energy jobs

SOLAR MANUFACTURING TRENDS ACROSS THE UNITED STATES

The U.S. solar market installed 10.6 GW of solar in 2018 and is projected to install a total of 12.6 GW in 2019. 2020 is expected to be the biggest year ever for solar with 19 GW coming online, a 46% increase over 2019. Within the region of Virginia and the states that border SW Virginia, North Carolina has traditionally experienced the greatest solar deployment. With just over 6,600 solar jobs, North Carolina ranks 11th in the nation in total jobs and 20th in solar jobs per capita.[2] By comparison Virginia's 4,500 solar jobs ranks 28th in solar jobs per capita and Tennessee, Kentucky, and West Virginia rank 23rd, 40th, and 49th respectively. Recent legislation in Virginia and West Virginia should spur solar jobs in those states and solar corporate procurement is adding to solar deployment and related jobs in Virginia and surrounding states.

Therefore, manufacturing in the U.S. is ripe with opportunity as demand for solar continues to increase. Further, since 2010, the number of solar manufacturing jobs has increased 36%. Though the past two years show a decline in solar manufacturing jobs, this trend will not likely continue as demand for solar increases. In 2018 employers projected a 3.6% growth in manufacturing jobs.[3] This section presents the different technologies that make up the solar value chain and are essential to a solar installation. Further, this section dives into the state of the solar manufacturing market in the U.S. and potential market trends as the solar market continues to grow and mature.

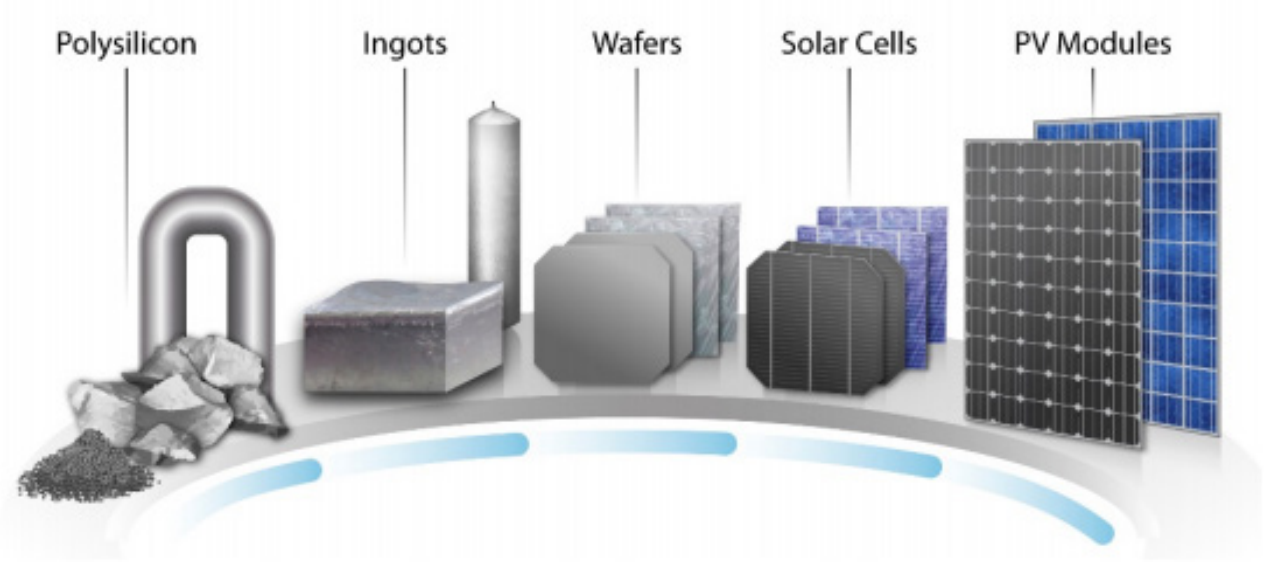
The Solar Manufacturing Value Chain

The solar industry value chain encompasses a broad range of professions and technologies. Each segment can be generally divided into an upstream activity and a downstream activity. Upstream activities cover the manufacturing process, which includes research and development, product manufacturing, and distribution. Downstream activities cover the installation process, which includes solar installation, development of solar projects (finance, sales, permitting, etc.), and the operations and maintenance of solar installations. The report will focus on upstream activities, specifically product manufacturing of solar modules and supportive technologies.

Manufacturing is the vital step between technology development and its deployment in the marketplace. The most vital product in a solar installation is the solar module itself. Figure 1 presents the supply chain necessary to manufacture a solar module.

2 U.S. Solar Jobs Census 2019, The Solar Foundation
3 U.S. Solar Jobs Census 2018, The Solar Foundation

Figure 1: Supply chain of Crystalline Silicon (c-Si) PV Module Manufacturing.



Source: National Renewable Energy Laboratory

Solar installations require additional components such as the technology to mount the solar modules to a roof or the ground as well as the technology necessary to transform the electrons produced from the solar module into usable energy. Further, battery technology that stores the usable energy produced from solar modules has become more feasible as prices continue to drop. Table 1 outlines the components that are part of the solar value chain.

Table 1: Technologies present in the solar value chain.

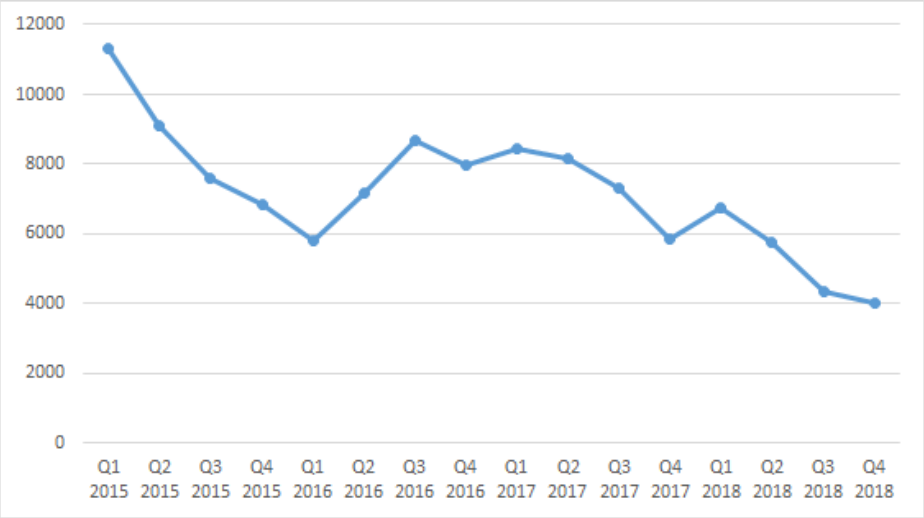
Technology	Description
Modules/Panels	Silica is transformed into wafers, cells, frames, and encapsulants to make the end solar panel
Inverters	Intake the DC power generated by a solar panel and convert it to AC power
Balance of System	Work to combine the electrical products within a solar system – DC/AC disconnects, junction boxes, combiner boxes, etc.
Racking/Mounting/Tracking	Ensures an array is connected properly to the ground or roof – Mounting brackets, rails, flashing, steel piping, aluminum piping, caps, attachments, etc. Further, tracker technology allows a system to track the sun throughout the day.
Monitoring Equipment	Technology that collects real-time data regarding system energy information and analytics to maximize system productivity.
Wiring	Ensures components are interconnected and can pass electricity safely from the module to the inverter.
Storage	Enable the ability to store solar power for later use. Nationwide, battery storage is most common for new growth. For SW VA, pumped hydro is also a possibilty

Polysilicon Manufacturing

Once dominant in the world market, U.S. Polysilicon production continues to drop as Chinese duties and failed trade talks between the U.S. and China impose challenges to U.S. polysilicon manufacturing.[4] Polysilicon is a high purity form of Silicon, which is used as a raw material during PV wafer and eventual PV module production. U.S. Polysilicon imported to China face duties between 55 and 57%, making it difficult for U.S. manufacturers to stay competitive.[5] As shown in Figure 2, U.S. polysilicon production has steadily decreased since Quarter 1 of 2015 as shown in Figure 2.[6]

4 https://www.latimes.com/nation/la-fi-solar-trade-trump-tariff-20190530-story.html
5 https://www.pv-magazine.com/2018/07/02/norways-rec-silicon-lays-off-40-of-us-workforce-reduces-production/
6 U.S. SMI Q3 2019

Figure 2: Quarterly U.S. Polysilicon Production (Metric Tons)



Note: Polysilicon Production was not available for 2019. Source: Wood Mackenzie Power & Renewables

There are three major polysilicon manufacturers in the U.S. market which make up 98% of the total polysilicon production in the U.S.[7] These include Hemlock, REC Silicon, and Wacker Chemie. Just in May of 2019, REC Silicon shut down production in its Washington state facility and permanently closed the facility in July 2019. REC Silicon's workforce reached a peak of 500 jobs in 2011 and has announced frequent layoffs in the proceeding years. In July 2019 alone, as a result of the Washington plant closure, the company laid off 100 workers.[8] Hemlock closed their Tennessee factory as pressure from Chinese tariffs made it uneconomical to continue production. Between 2010 and 2017 alone, the global share of U.S. polysilicon production went from 29.1% to 11.3% and continues to decrease.[9] There are currently no U.S. manufacturers that produce silicon ingots or wafers for solar applications, which are the crucial production steps prior to PV cell production (Figure 1), therefore the polysilicon being produced in the U.S. is being exported.[10]

Ingots and Wafer Manufacturing

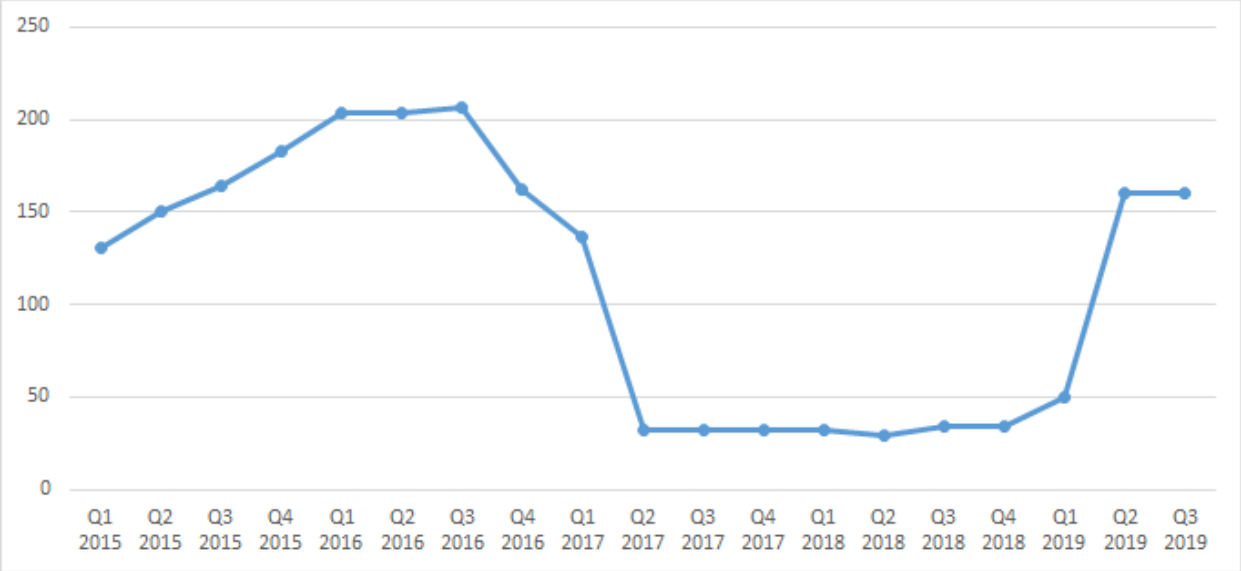
Polysilicon ingot and wafer production is nonexistent in the U.S. Panasonic, SolarWorld, and SunEdison halted production of ingots and wafers in 2017, 2016, and 2013, respectively. The silicon wafers being produced in the U.S. do not serve the solar industry, rather are used in production of electronics. In fact, Virginia Semiconducter in Fredericksburg, Virginia is one of the major wafer production facilities in the U.S., though it does not serve the PV industry.

7 U.S. SMI Q3 2019
8 https://www.pv-magazine.com/2018/07/02/norways-rec-silicon-lays-off-40-of-us-workforce-reduces-production/
9 https://www.greentechmedia.com/articles/read/rec-silicon-may-sell-montana-facility
10 https://www.nrel.gov/docs/fy19osti/73363.pdf

Cell Manufacturing

Cell manufacturing recently experienced a growth spurt with the opening of the Panasonic and Tesla Gigafactory in Buffalo, New York as shown in Figure 3. The Tesla Gigafactory manufactures solar cells in Buffalo, New York after its purchase of SolarCity. The company was awarded $750 million in state subsidies with promises of new jobs for the state. The factory now employs 800 workers and is expected to continue to increase its workforce, or otherwise pay millions to the state in penalties.[11]

Figure 3: Quarterly U.S. Cell Production (MWp)



Source: Wood Mackenzie Power & Renewables

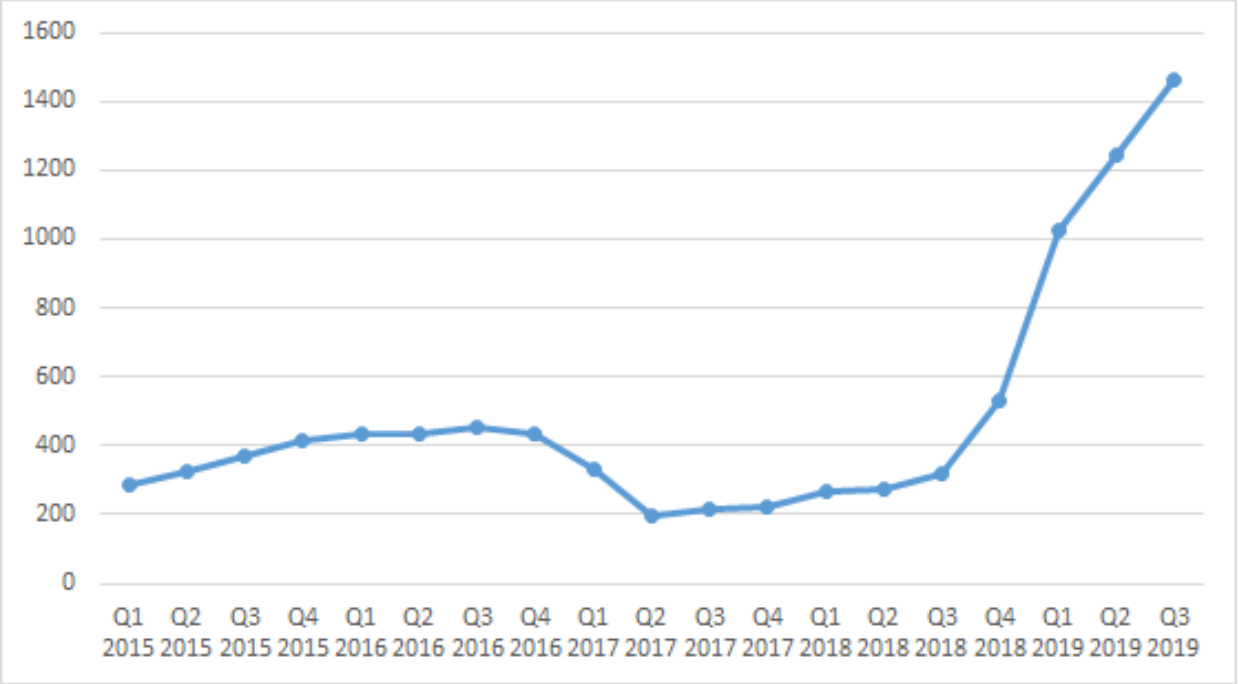
Module Manufacturing

Module manufacturing is ripe with opportunity to meet the growing U.S. demand for solar modules. Current tariff conditions are pushing companies to begin or expand production in the U.S. The Section 201 tariffs that were enacted in February 2018 mandate 30% duties on cells and modules imported to the U.S., making it more cost effective to produce modules in the U.S. to serve the U.S. market.[12] The tariffs will step down 5% each year for 4 years. As shown in Figure 4, module production began to increase in 2018 and will likely continue on this trajectory as new production facilities that are currently under construction open. Given the lack of cell production in the U.S., module manufacturers must import cells from other countries.

11 https://www.reuters.com/article/us-tesla-solar-exclusive/exclusive-teslas-solar-factory-is-exporting-most-of-its-cells-document-idUSKCN1SL1H5

12 Section 201 tariffs place tariffs on imported solar cells and modules for a period of four years. The tariff level was set at 30%, with a 5% declining rate per year over the four-year term of the tariff.

Figure 4: Quarterly U.S. Module Production (MWp)



Source: Wood Mackenzie Power & Renewables

Hanwha Q-Cells, a Korean module company opened the largest solar module factory in the Western Hemisphere in Dalton, Georgia. This production facility, which opened in September 2019, is expected to produce 12,000 PV modules per day and employ 650 full-time workers. This plant will fulfill the majority of Hanwha's solar shipments to the U.S.[13] Hanwha representatives stated that their decision to locate in Georgia was due to their strong presence already in the state and Georgia's skilled workforce.[14] Additionally, in 2019, LG Electronics completed construction of a module production facility in Alabama and has commenced production, boasting 500 MW of annual capacity. LG placed the production facility in an existing building to save costs by only requiring the installation of necessary production equipment. The plant is expected to support 159 full time employees. LG's decision to locate the production facility there relied heavily on state and local incentives available to the company.[15]

In 2018, JinkoSolar opened up a PV module manufacturing plant in Jacksonville, Florida that supports an estimated 200 workers. The company agreed to open the $50 million plant with support of city and state incentives. The company was awarded $3.4 million in incentives from the city and $1 million in incentives from the state. The plant leases half of the space of a 400,000 square foot existing manufacturing plant.[16] Jeff Juger, Director of Business Development at JinkoSolar noted that "proximity to demand and ability to offer local products with local service are strong motivators for moving to the U.S."[17] While these devel-

13 https://www.greentechmedia.com/articles/read/hanwha-q-cells-set-to-open-georgia-factory#gs.aygppe
14 https://businessfacilities.com/2018/05/hanwha-q-cells-korea-investing-150m-dalton-georgia/
15 https://www.solarpowerworldonline.com/2018/06/lg-will-build-a-500-mw-solar-panel-assembly-plant-in-alabama/
16 https://news.wjct.org/post/jinkosolar-launches-pilot-production-jacksonville-plant
17 https://www.solarpowerworldonline.com/2018/09/how-to-start-a-solar-panel-manufacturing-facility-in-the-united-states/

opments infer that there might be opportunity to expand or locate solar module manufacturing in the U.S., the market outlook is uncertain. The tariffs on cells and modules are dropping although the administration is reviewing them and could extend them. Global prices for modules have declined considerably since the above firms decided to invest in U.S. module production. Given the tariffs and global price trends, future investment is likely on hold.

While these plant openings and increased module production trends continue, it will be difficult to keep costs low when the Section 201 tariffs are no longer in place. Analysts state that it is still more expensive to make modules in the U.S. and with the impending step-down of the tariffs, U.S. module manufacturers may find it difficult to stay economically viable given lower production prices overseas.[18]

Inverter Manufacturing

Solar inverters convert the direct current (DC) energy produced from the solar modules into alternating current (AC) before it can be fed into a utility grid. The various technologies that make up an inverter include an AC and DC disconnect switch, transformer, cooling system, various circuits, LED indicators/display, and overall packaging to withstand environmental extremes.[19] The materials to produce such technology include aluminum, copper, adhesives, and electrical insulation.

According to GlobalData's recent report on the global PV inverter market, the U.S. holds the second largest market share of PV inverter production in the world.[20] GlobalData estimates the U.S. inverter market will grow at an estimated 2.8% to reach 12.8 GW of capacity of inverter production in 2023. Further, Wood Mackenzie Power & Renewables found that in 2018, the U.S. and Canada had a 21% increase in PV inverter exports, compared to a global average growth of 8%.[21] In 2017, the majority (71%) of all inverters (including for electrical applications other than PV) that were installed in the U.S. were from domestic inverter manufacturers. Though just 40% of PV inverters that were installed in the U.S. for PV installations were from domestic inverter manufacturers. There may be greater demand for domestically produced inverters in the coming years due to concerns over grid cybersecurity from foreign-made technology.[22] Solar Power World lists eight companies that have solar inverter manufacturing locations in the U.S., including Chilicon Power in Los Angeles, CA; Ingeteam in Milwaukee, WI; and Yaskawa Solectria Solar in Lawrence, MA.[23]

Racking/Mounting/Tracking Manufacturing

Solar racking, mounting, and tracking provide structural support to the solar modules. There are various processes in this manufacturing process including piping and tubing, castings and coatings, stamped components, roll forming for racking and mounting, and utilization of corrosion resistant steel.[24]

The tracker market has been dominated by the United States. Wood Mackenzie reports the tracker market grew 62% in 2019 and will continue to grow by an average 11% annually through 2024.[25] San Francisco based NexTracker alone claimed one-third of the global market share by shipments in 2018.

Though there is no research regarding the state of the racking manufacturing industry in the U.S., many companies exhibit growing demand for their products which are vital to solar installations. Quick Mount

18 https://pv-magazine-usa.com/2018/12/20/2018-solar-power-year-in-review-part-1/
19 http://www.fabrico.com/sites/default/files/Import_0/Import/Fabrico_SolarInverters_ApplicationSheet.pdf
20 https://www.globaldata.com/store/report/gdpe1059emr--solar-pv-inverters-update-2019-global-market-size-competitive-landscape-key-country-analysis-and-forecast-to-2023/
21 https://www.greentechmedia.com/articles/read/top-five-inverter-players-lose-market-share#gs.ayko3h
22 https://www.nrel.gov/docs/fy19osti/73363.pdf
23 https://www.solarpowerworldonline.com/global-inverter-manufacturing-locations/
24 https://bci-engineering.com/renewable-energy-solutions/solar-racking-tracking-technology/
25 https://www.woodmac.com/our-expertise/focus/Power--Renewables/the-global-pv-tracker-landscape-2019/?utm_source=gtm&utm_medium=article&utm_campaign=wmpr_trackermarket19

PV, a leading American manufacturer of watertight solar roof mounting and racking systems recently announced they will double their manufacturing production. Further, they are hiring hundreds of workers as they add a second shift to their California manufacturing facility.[26] Additional leading manufacturers of mounting equipment include Unirac in Albuquerque, NM, which produces racking and mounting for PV installation; IronRidge in Hayward, CA, which produces racking and mounting; PV Racking in Southampton, PA, which produces racking and mounting; and RBI Solar in Cincinnati, OH, which produces racking, mounting, and tracking technology.[27] Startup firms include Falls Church, VA based Powerfield that provides ballasted based racking making it easier to relocate systems should there become a higher value use for the property. The growing number of solar installations is expected to continue to grow demand for the solar PV mounting systems market.

Battery Manufacturing

Historically, battery technology has been costly and market uptake has been slow, though recent technology trends have changed this. BloombergNEF recently published its ninth annual Battery Price Survey that evaluates battery prices since 2010. The most recent report found that the price of Lithium-ion batteries has dropped 85% from 2010-2018, from an average price of $1,160/kWh to $176/kWh (Figure 5). The cost of Lithium-ion batteries is projected to continue to decrease to reach an average price of $94/kWh by 2024 and $62/kWh by 2030.[28] This drop in battery prices is expected to increase deployment of energy storage installations from 9 GW in 2018 to over 1,000 GW by 2040.[29]

Figure 5: Volume weighted average lithium-ion pack price from 2010-2018

Source: BloombergNEF

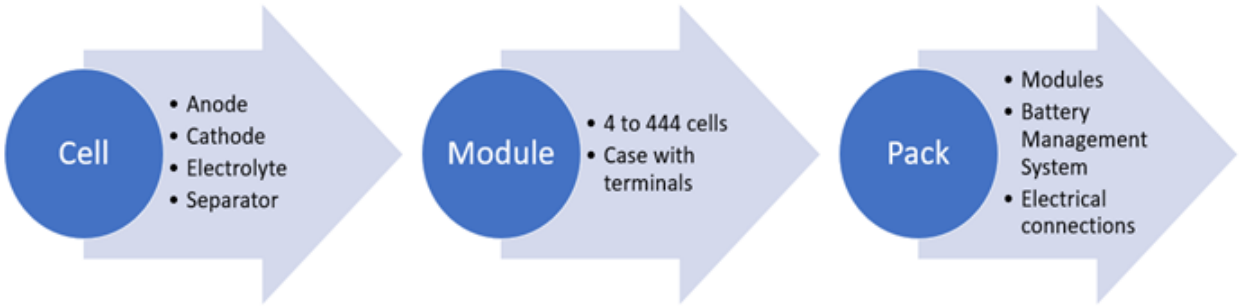
Lithium-ion batteries were first commercialized in 1991 and since then the market has seen rapid progression and dropping prices, leading lithium-ion batteries to be the dominant technology in the renewable energy storage and electric vehicle markets. In Q4 2018, lithium-ion batteries made up 99% of all battery

26 https://www.prnewswire.com/news-releases/quick-mount-pv-doubles-manufacturing-production-to-1-2-gigawatts-300871481.html
27 https://news.energysage.com/solar-panel-mounts-unirac-ironridge-quick-mount-pv/
28 https://about.bnef.com/electric-vehicle-outlook/#toc-viewreport
29 https://about.bnef.com/blog/energy-storage-investments-boom-battery-costs-halve-next-decade/#_ftn1

deployments according to Wood Mackenzie.[30] The demand for lithium-ion batteries will continue to grow as costs continue to drop. According to Rocky Mountain Institute, the cumulative worldwide demand for lithium-ion batteries, starting at less than 500 GWh in 2019 will increase to over 8,000 GWh by 2030.[31]

The production of lithium-ion batteries is split into three stages as shown in Figure 6, which include cell manufacturing, module manufacturing, and pack assembly.[32] Different manufacturing firms can perform just one or multiple stages of the production process. For example, Tesla's plant in Nevada originally imported cells to assemble into modules and packs, but now produces all three components, while a plant in England produces all three components for the Nissan Leaf electric vehicle.

Figure 6: Lithium-ion Battery Production Stages



Source: U.S. International Trade Commission

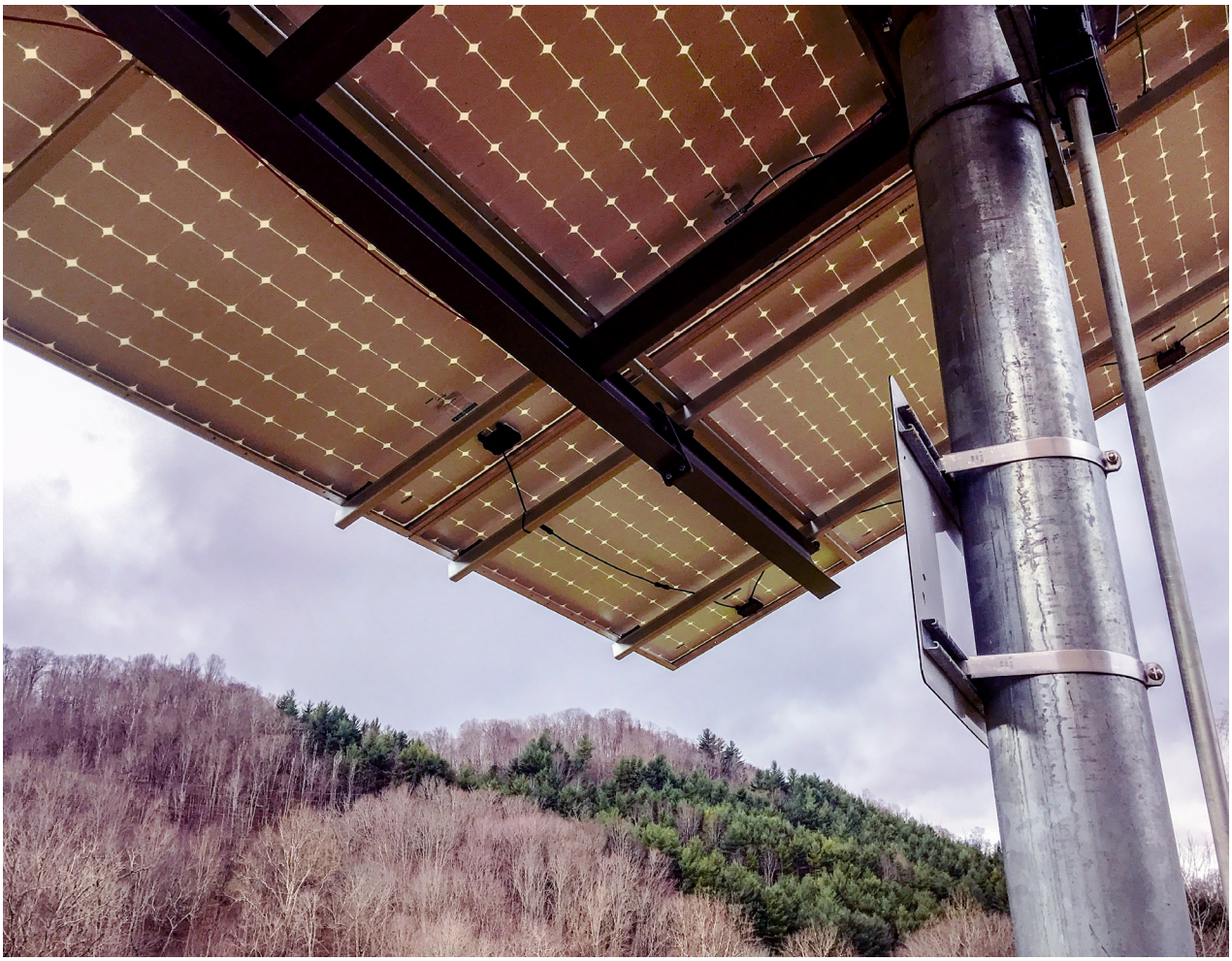
Most cells for lithium-ion batteries are imported into the U.S. from China.[33] One estimate states that about 40% of lithium-ion batteries for grid storage projects are imported from China.[34]Further, according to the U.S. International Trade Commission, about half of lithium-ion batteries were imported in 2017.[35] Battery modules are made up of cells and a case to attach the cells; modules and packs are typically made in the same facility and are assembled with cells that have been imported or produced on site.

The U.S. controls just 13% of the global capacity of lithium cell production, second to China, which is home to 73% of global capacity.[36] Capacity in the U.S. is expected to grow at a slower pace than global capacity. Leading manufacturers in the U.S. include Tesla, located in Nevada, XALT Energy, located in Michigan, LG Chem, located in Michigan, Power-Sonic, located in California and EnerDel, located in Indianapolis, IN. As prices continue to drop and expected battery storage deployment increases 100 times

30 https://www.renewableenergyworld.com/2019/10/22/which-new-energy-storage-technologies-might-outcompete-lithiumion-in-the-2020s/#gref
31 https://rmi.org/wp-content/uploads/2019/10/rmi_breakthrough_batteries.pdf
32 https://www.usitc.gov/publications/332/journals/the_supply_chain_for_electric_vehicle_batteries.pdf
33 https://www.usitc.gov/publications/332/journals/the_supply_chain_for_electric_vehicle_batteries.pdf
34 https://www.greentechmedia.com/articles/read/trump-administration-lowers-import-tariffs-on-chinese-batteries
35 https://www.usitc.gov/publications/332/journals/the_supply_chain_for_electric_vehicle_batteries.pdf
36https://www.forbes.com/sites/rrapier/2019/08/04/why-china-is-dominating-lithium-ion-battery-production/#6cb8db773786

through 2040, there is room for growth in the battery manufacturing industry. One report estimates the North American lithium-ion battery market will grow 12% from 2019-2024.[37]

Several battery storage companies are headquartered in Virginia. Arlington based Fluence is a joint venture of Siemens and AES. It focuses on the integration of storage with energy sources including solar. Fermata is a Charlottesville based startup that is tapping into bidirectional benefits for electric vehicles (EVs) that are part of commercial and government fleets. The EVs not only charge their batteries from the grid but also provide energy storage services to the grid. They have a demonstration project in Danville, VA.[38]



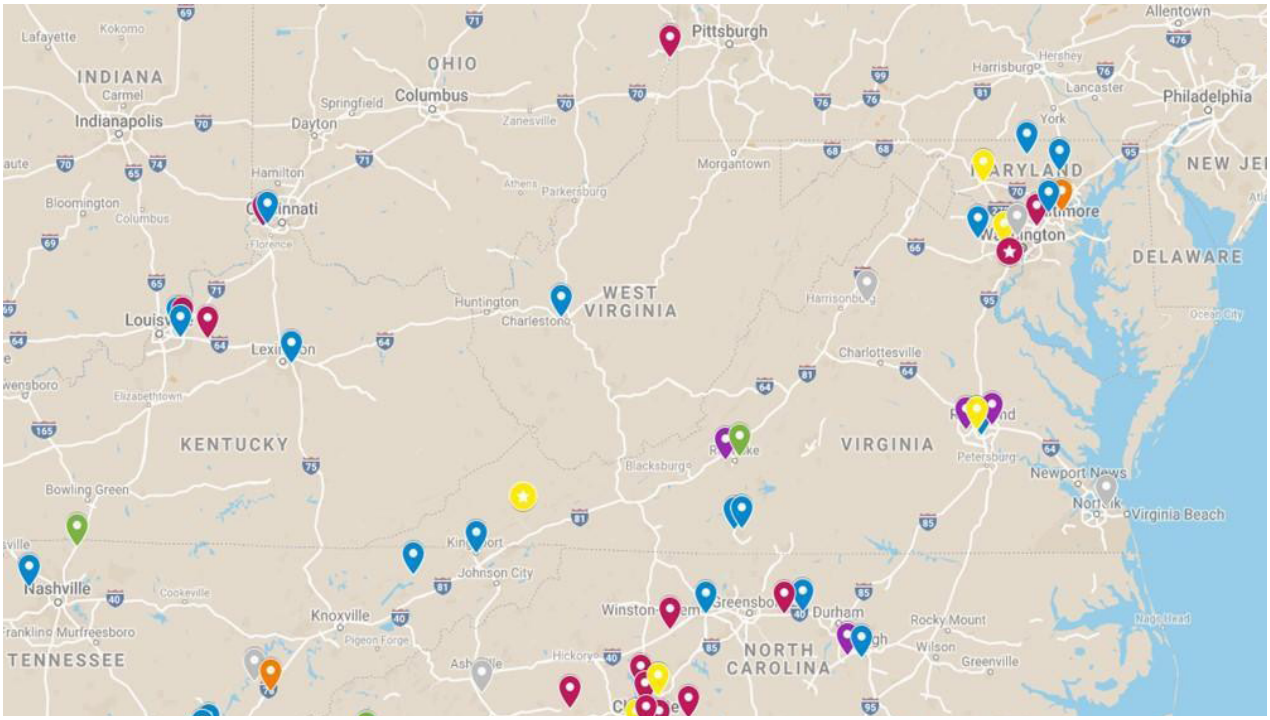
37 https://www.researchandmarkets.com/reports/4893990/north-america-lithium-ion-battery-market?utm_source=dynamic&utm_medium=BW&utm_code=dwm7lb&utm_campaign=1337856+-+North+America+Lithium-ion+Battery+Market+Estimated+to+Grow+with+a+CAGR+of+11.8%25+During+the+Forecast+Period%2c+2019-2024&utm_exec=anwr281bwd

38 Commonwealth of Virginia Energy Storage Study, August 2019, https://www.dmme.virginia.gov/de/LinkDocuments/Virginia%20Energy%20Storage%20Study%20-%20Final%20Report%20%202019.pdf

GEOGRAPHY OF MANUFACTURING COMPANIES

The states surrounding Virginia display a multitude of solar manufacturing activities. Figure 7 is a map which shows the different solar manufacturing companies in Virginia and the surrounding states. The majority of companies are categorized as mounting, racking, or tracking, or categorized as other solar manufacturing activity such as aluminum welding for mounting, chemical manufacturing, and film technology. North Carolina and the D.C. – Maryland – Virginia metropolitan area hold clusters of solar manufacturing activity.

Figure 7: Solar Manufacturing Activity Surrounding Virginia



Source: Solar Energy Industry Association National Solar Database

Solar Electric America, an Original Equipment Manufacturer (OEM) is located in Richmond, Virginia.[39] This 16,000 square foot module plant was a former die plant that only cost $1.2 million to transform into a module assembly plant. The advantage of an OEM facility, compared to operating a large production facility and selling under onebrand, is that resources are not needed for branding or inside sales.[40] The workers assemble solar modules that are sold by other companies. OEMs are ideal for companies that are looking to produce 150 MW of annual capacity or less. Another example of a successful OEM of solar modules is Auxin Solar, located in San Jose, CA, which provides consistently steady work for 60 employees on two shifts.[41]

39 An OEM is a firm that manufactures a product that is then sold to another firm, which resells the product under its own brand name.

40 https://www.solarpowerworldonline.com/2018/09/how-to-start-a-solar-panel-manufacturing-facility-in-the-united-states/

41 https://www.solarpowerworldonline.com/2018/09/how-to-start-a-solar-panel-manufacturing-facility-in-the-united-states/

SolSunTech, a firm that recently developed a breakthrough technology in solar modules, announced it was looking to locate its manufacturing facility in Russell County, Virginia. The firm was looking to develop manufacturing operations in a 300,000 square foot former furniture assembly warehouse.[42] The company has been offered $5.5 million in financial incentives from the state to create 132 highly skilled jobs for Russell County in the first year.[43] There have been no updates on the completion of this facility since December 2018.

CPFilms and Suntek, two manufacturing facilities that are subsidiaries of Eastman Chemical Company, are located in Fieldale, Virginia, (near Martinsville, Virginia). These facilities produce custom coating and lamination for high value films. These films are used in a number of applications including solar modules. This coating is necessary to provide heat-seal and scratch-resistance coatings for the module.

Also located near Southwest Virginia in Roanoke, VA are TMEIC and Virginia Transformer Corporation. Virginia Transformer Corporation produces transformers that step up the voltage from solar modules to feed into a transformer at the substation. The technology has been used in over 14,000 custom designs for solar projects.[44] TMEIC manufactures a variety of technologies for solar including utility-scale solar inverters, a power plant controller for operator controlling and monitoring, as well as energy storage.[45] Power Distribution Inc. and Lumberg, both located in Richmond, VA, produce inverters for PV applications.

BMZ in Virginia Beach, VA manufactures lithium-ion battery packs. The company expanded its manufacturing operations in Virginia in 2018 due to increased demand and growth.[46] This facility handles the assembly of lithium-ion battery units to be used in a variety of industries including wind and solar energy. Further, BMZ imports lithium-ion battery cells from its facilities in Asia and Europe and partners with local companies to manufacture supporting materials.

Storm Power Components in Decatur, Tennessee is a manufacturer of custom copper and aluminum electrical components. Their manufacturing expertise can be applied to back-up power systems and solar and wind energy systems to store energy. They manufacture copper and aluminum electrical components as well as provide engineering services to help other manufacturers and/or OEM's to improve their products performance.[47]

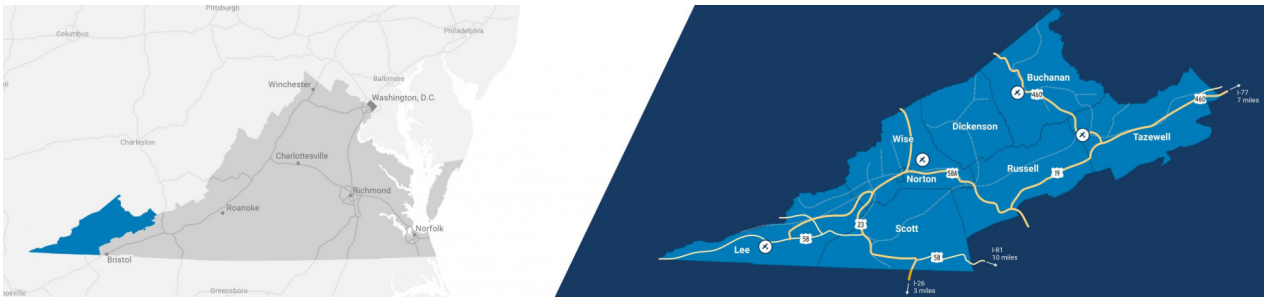
VFP Incorporated, located in Scott County, VA is a manufacturer of concrete shelters for substations. VFP advertises that this technology can be applied to renewable energy installations. The concrete shelters protect the critical components that are part of utility-scale wind and solar installations.[48] Further, as identified in stakeholder interviews, VFP will receive a request about once a year to produce inverters for utility-scale solar installations.

42 https://www.solarpowerworldonline.com/2018/11/two-brand-new-manufacturing-names-want-a-piece-of-the-made-in-usa-solar-panel-market/
43 https://www.accesswire.com/525594/The-US-Registered-SolSuntech-is-Creating-a-Revolution-in-the-Solar-Industry-by-Introducing-the-Most-Efficient-Solar-Panel-on-the-Global-Market
44 https://www.vatransformer.com/renewables/solar/
45 http://www.tmeic.com/industry/renewable-energy
46 http://www.yesvirginiabeach.com/media/pages/article.aspx?release=325
47 https://stormpowercomponents.com/engineering-answers/
48 https://www.vfpinc.com/markets/renewable-energy/

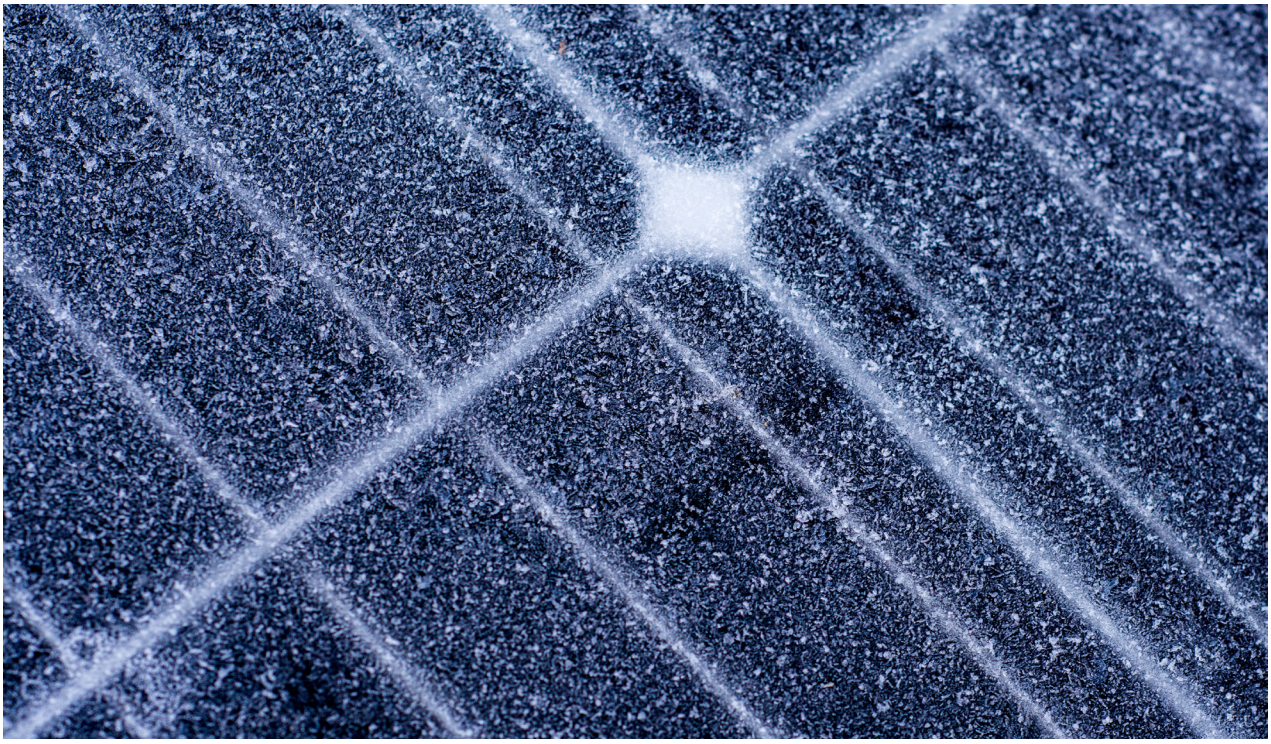
CHARACTERISTICS OF SOUTHWEST VIRGINIA'S COALFIELD COUNTIES

Southwest Virginia's Coalfield Region is made up of seven counties and one city including: Buchanan County, Dickenson County, Lee County, Russell County, Scott County, Tazewell County, Wise County, and the City of Norton. These municipalities make up the southwestern most part of Virginia and have the region's vast coal deposits and historical coal industry. The region offers a multitude of resources and infrastructure that make it an ideal place for business expansion or relocation. This section covers the assets available to support economic development in Southwest Virginia, including its geographic location, the transportation and infrastructure network, the robust workforce and education/training network, and support for research and development and entrepreneurial development.

Figure 8: Southwest Virginia.



Source: Virginia Economic Development Partnership



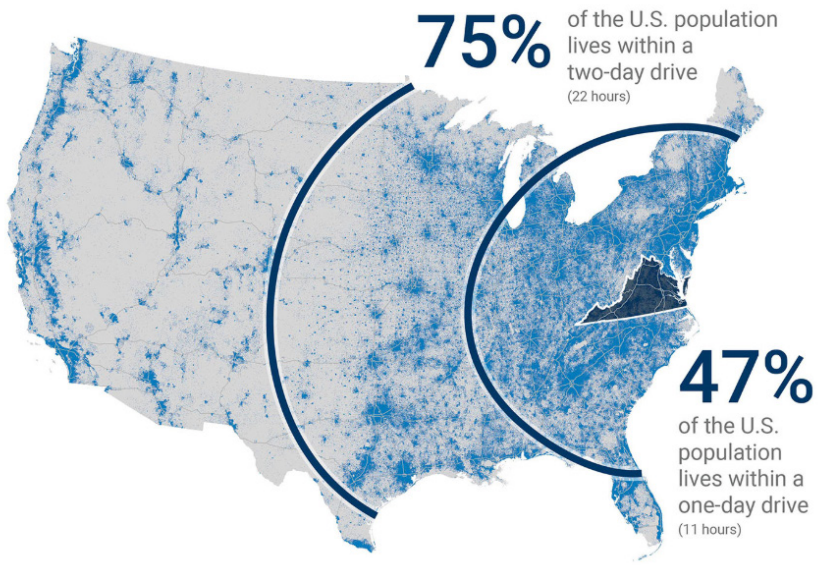
GEOGRAPHIC CHARACTERISTICS AND INFRASTRUCTURE OF THE REGION

Southwest Virginia is ideally located on the East Coast and offers access to robust interstate networks, proximity to a multitude of transportation hubs, including rail, ports, a state-of-the-art broadband connection, over 30 industrial buildings and sites suitable for development, and a variety of incentives at the local, regional, and state level.

Transportation Network

Southwest Virginia is located strategically between major city hubs including Atlanta-Pittsburgh, Charlotte-Cincinnati and Richmond-Louisville, allowing for accessibility to interstate networks. 47% of the U.S. population lives within a one-day drive of Southwest Virginia.

Figure 9: Percent of population within a one or two-day drive from Southwest Virginia.



Source: Virginia Economic Development Partnership.

The region has a robust integrated transportation system enabling access to a greater network of markets. The region is home to high quality four-lane highways that provide connections to the seven interstates in close proximity to the region including: I-81, I-26, I-381, I-77, I-75, I-64, and I-40. The region is also home to a robust freight rail service provided by CSX Transportation and Norfolk Southern, offering reliable shipping options.

Additionally, Southwest Virginia has access to both airports and port facilities. The Port of Virginia is less than 400 miles from Southwest Virginia, touting the deepest harbor on the U.S. east coast and the third largest port on the east coast. The Port of Virginia offers businesses access to markets around the globe, with almost 30 international direct shipping routes and connections to over 200 countries around the world.[49]

The Virginia TradePort is another resource that offers benefits to businesses accessing international markets. Located at New River Valley Airport, 67 miles north of Tazewell County in Southwest Virginia,

49 http://www.portofvirginia.com/about/

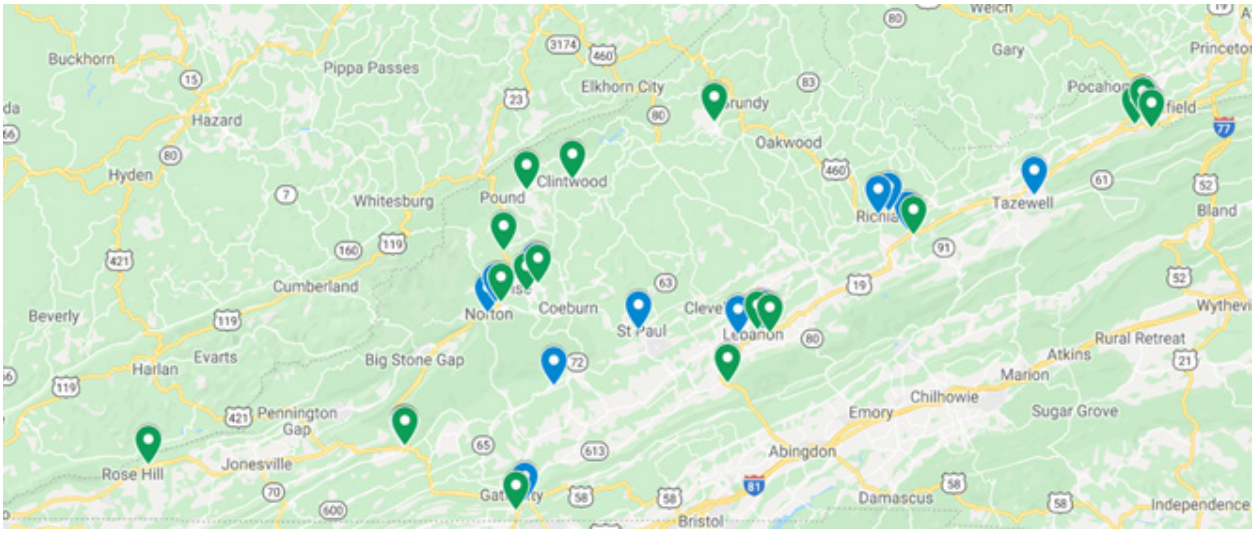
the Trade Port provides multiple trade resources in one location, including a U.S. Customs and Border Protection Port of Entry and a Foreign Trade Zone. These resources allow local companies to more readily conduct business outside of the U.S. The U.S. Customs Port of Entry processes goods entering and exiting the U.S. The goods can be immediately handled at this port and allows local importers to avoid more congested ports that have long waiting periods. The Foreign Trade Zone is a secure and enclosed area under supervision of U.S. Customs and Border Protection but is considered to be outside U.S. customs territory. Therefore, foreign goods stored in this zone are not subject to U.S. customs, remaining duty-free until the goods enter into the U.S. commerce system. Goods can be stored, inspected, manipulated, processed, relabeled, and repackaged in a duty-free environment.

The Virginia Economic Development Partnership (VEDP) refers to Southwest Virginia as the e-Region due to its 4G wireless access and its focus on electronic information technology, energy, education, and emerging technologies.[50] During a focus group held with economic development agencies in the region, the broadband connection was cited as a major asset of the region. This robust broadband network is an exceptional asset for businesses looking to expand or relocate to select locations within the region. As with many rural areas, last mile access for many customers remains a need.

Industrial Sites

In addition to the region's geography and robust transportation and broadband network, Southwest Virginia is home to several industrial shell buildings as well as large tracts of land which are suitable for potential manufacturing activity. The buildings included in the characterization are up to 285,000 square feet and the industrial land available ranges from 2.5 acres to over 800 acres.[51] The sites shown in Figure 10 and described in further detail in Table 2 and 3 include 17 empty industrial buildings and 17 industrial sites. Each site is described in further detail on both VEDP's website and VACEDA's website

Figure 10: Available Industrial Buildings (shown in blue) and Sites (shown in green) in Southwest Virginia



Source: Virginia Economic Development Partnership List of Sites

50 https://www.vedp.org/region/southwest-virginia-e-region
51 http://www.vaceda.org/sites-buildings-overview/

Table 2: List of Industrial Buildings in Southwest Virginia.

Site Name	Location	Square footage
Bush Building Industrial Park	St. Paul, VA	284,406
Former Louisiana Pacific Building	Dungannon, VA	117,000
Cozart Warehouse	Weber City, VA	90,000
Claypool Hill Mall	Cedar Bluff, VA	21,500
Bluestone Shell Building	Bluefield, VA	40,000
Ammar's Inc.	Bluefield, VA	235,793
Russell Place	Lebanon, VA	172,000
Buster Brown Apparel Building Lebanon	Lebanon, VA	92,880
Magic Mart 475	Richlands, VA	49,301
Richlands Mall	Richlands, VA	148,216
Pinnacle Business Center	Wise, VA	45,210
Scott County Virtual Building	Duffield, VA	60,000
The Crooked Road Tech Center	Duffield, VA	70,000
Doyle Rasnick Building	Tazewell, VA	10,000
Former AT&T Relay Center	Norton, VA	16,751
Norton Business Center	Norton, VA	35,000
Ridgeview Professional Offices	Bluefield, VA	12,500

Source: Virginia Economic Development Partnership List of Sites.

Table 3: List of Available Industrial Sites in Southwest Virginia

Site Name	Location	Acres Available
Town of Clintwood Site	Clintwood, VA	0.5
Coalfield Regional Industrial Park	Clintwood, VA	38
Project Intersection	Norton, VA	100
Richwood Properties, Inc	Bluefield, VA	50
Riverside Development	Weber City, VA	70
Bear Creek Business Park	Wise, VA	15
U.S. 23 Site	Wise, VA	50
Hansonville Property	Lebanon, VA	150
Scott County Regional Business and Technology Park	Duffield, VA	40
Southern Gap Business Park	Vansant, VA	3,100
Indian Paint Road Site	Pounding Mill, VA	8
Bluestone Regional Business and Technology Center	Bluefield, VA	250
Russell Regional Business Technology Park	Lebanon, VA	9
Leatherwood Site	Bluefield, VA	850
Constitutional Oaks Industrial Park	Rose Hill, VA	228
Lonesome Pine Business and Technology Park	Wise, VA	388
Cumberland Plateau Regional Industrial Park	Lebanon, VA	8

Source: Virginia Economic Development Partnership List of Sites

State, Regional, and Local Assistance Programs

There are a multitude of incentives and financial aid programs available to economic development projects in Southwest Virginia. Economic development incentives are a vital tool to encourage private sector investment in a community to create jobs and improve the economic well-being of the community.[52] In fact, recent press releases from solar module manufacturing companies opening locations in the U.S., JinkoSolar and Hanwha Q-Cells cite the importance of the state and local incentives provided for relocation/expansion in the region.[53] Further, Tesla was given $750 million from New York State to locate the Gigafactory in Buffalo.[54] These incentives are provided in various forms, including but not limited to, tax incentives, cash grants, and workforce services. The following is a list of incentives available to the region at the state, regional, and local level to encourage economic development in the region:

52 https://www.brookings.edu/wp-content/uploads/2018/02/report_examining-the-local-value-of-economic-development-incentives_brookings-metro_march-2018.pdf

53 https://www.greentechmedia.com/articles/read/hanwha-q-cells-set-to-open-georgia-factory#gs.aygppe; https://news.wjct.org/post/jinkosolar-launches-pilot-production-jacksonville-plant

54 https://buffalonews.com/2018/08/01/for-tesla-the-clock-is-ticking-to-bring-jobs-to-buffalo/

- **Virginia Coalfield Economic Development Authority Financing:** low-interest loans or grants offered to new or expanding businesses in the region
- **Virginia Collaborative Economic Development Performance Grant:** grants to localities that enter into collaborative economic development initiatives across the region to promote new or expanding businesses that meet certain job and capital investment requirements
- **Virginia Enterprise Zone Job Creation Grant:** offers annual tax credits for each new green job that meets a minimum threshold of hours worked beginning before January 1, 2021
- **Major Business Facility Job Tax Credit:** $1,000 income tax credit for each full-time job created over a minimum threshold for companies locating in Virginia
- **New Company Incentive Program:** offers exemption from corporate income tax and up to $2,000 per new job for companies with no employment or property in Virginia prior to January 1, 2018
- **Port Volume Increase Tax Credit:** offers a corporate income tax credit for manufacturing, distribution, agricultural, mineral and gas companies that increase the cargo volume at Virginia's port facilities
- **Cumberland Plateau Regional Opportunity Program:** offers funds for economic development projects available to local governments
- **Commonwealth's Development Opportunity Fund:** a fund that can be used at the Governor's discretion to secure a company expansion or location in Virginia
- **Tobacco Region Opportunity Fund:** performance-based monetary grants and loans to assist in the creation of new jobs and investments through new business attraction or expansion
- **Rail Industrial Access Program:** offers funding to construct railroad tracks for new or substantially expanded industrial and commercial projects having a positive impact on economic development in Virginia
- **Commercial and Industrial Sales and Use Tax Exemption:** tax exemptions for eligible equipment used directly in manufacturing and research and development
- **Major Business Facility Job Tax Credit:** companies locating or expanding in Virginia are eligible to receive $1,000 income tax credit for each new full-time job created over a threshold number of jobs beginning in the first taxable year
- **Virginia Jobs Investment Program:** services and funding provided to companies that create new jobs or experience a technological change which reduces the human resource development costs for new or expanding companies or companies retraining their employees
- **Abandoned Mine Land Pilot Funding:** funding provided to projects which boost the economy and improve the communities of Southwest Virginia's coalfields as well as enhance the environment
- **Opportunity Zone Funding:** federal economic development program which offers tax incentives to spur economic development and revitalization in low-income and rural communities

Further, Genedge, a manufacturing extension partnership, provides extensive resources to manufacturing firms in the region. They provide consulting services to help firms innovate, compete, and grow in the region. Genedge works primarily with small and medium sized manufacturers in the region to help them

grow their business, diversify their markets, aid in quality management system certification, aid in product improvement, product development, and improve manufacturing processes. The Manufacturing Technology Center, located in Wytheville, partners with Genedge to provide additional expertise to manufacturing firms in Southwest Virginia. Genedge has served over 15 clients in Southwest Virginia alone by providing technical assistance and support services to improve firms' bottom line.[55] Through 1:1 technical assistance, Genedge works with firms to identify the challenges they experience, identify potential markets to expand to, and aid in the transition to tap into these markets. Genedge realizes the importance of the diversification of products and markets and is therefore dedicated to supporting manufacturers in the region to continue to diversify in order to continue to be competitive.

55 https://genedge.org/about-genedge/

SOUTHWEST VIRGINIA'S WORKFORCE AND POPULATION CHARACTERISTICS

Southwest Virginia's coalfield region is home to 190,000 residents, a 7% decline in population since 2013. The population is expected to decline in the region to reach below 170,000 by 2040, a 12% decrease from 2018.[56] Compared to the U.S. and Virginia, Southwest Virginia has a higher proportion of seniors compared to children and youths, as shown in Table 4.

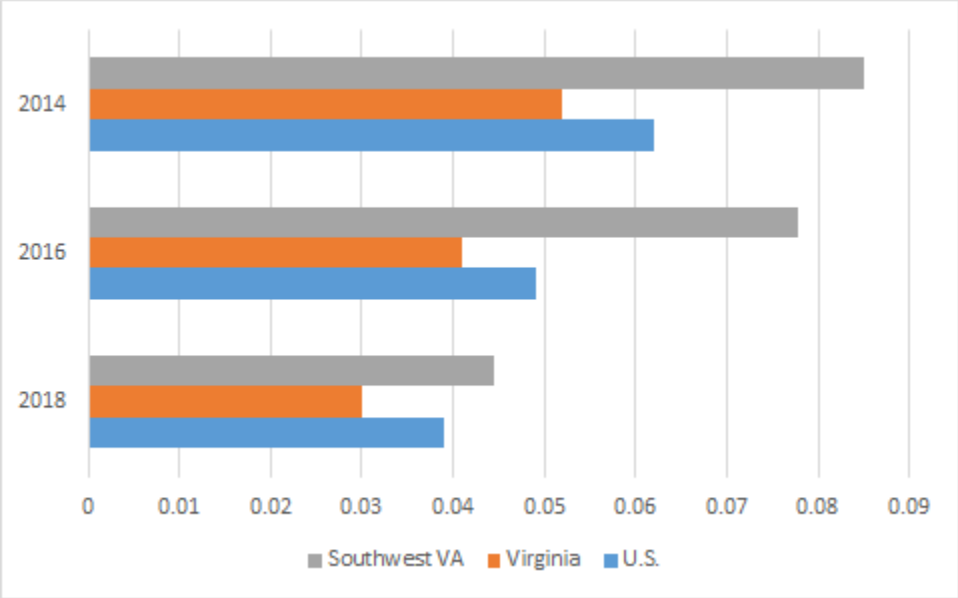
Table 4: Age of Population in Southwest Virginia, Virginia, and the U.S. in 2018

	Children (0-14 years)	Youth (15-24)	Adults (25-64)	Seniors (65+)
Southwest VA	15.5%	10.8%	52.4%	21.4%
VA	18.2%	13.2%	53.2%	15.4%
U.S.	18.6%	13.1%	52.2%	16.0%

Source: U.S. Census Bureau, Population Division 2018 Annual Estimates

Figure 11 shows that in 2014, Southwest Virginia reached an almost 9% unemployment rate, with some counties such as Buchanan and Dickenson reaching over 10% unemployment rates. Since 2014, unemployment rates have declined to reach 4.5% in the region, though unemployment is still higher than Virginia and the U.S. Buchanan County, Dickenson County, and Wise County remain at unemployment rates just over 5%, while the other counties are 4.4% or below.[57]

Figure 11: Unemployment Rates in Southwest Virginia, Virginia, and the U.S.



Source: Bureau of Labor Statistics

56 https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk
57 https://www.bls.gov/lau/#cntyaa

Table 5 shows the labor force participation rate for the U.S., Virginia, and Southwest Virginia for adults age 20-64.[58] This metric represents the number of people available for work as a percentage of the total population, i.e. the number of employed + unemployed persons divided by the population. The labor force participation rate shows the share of those that are working or seeking work in a given area. Therefore, the rate will be lower in areas with an aging population or a greater number of civilians that are not seeking work. The labor force participation rate is lower for all counties in Southwest Virginia than both the U.S. average and the Virginia average. The rate varies widely among counties in the region as Buchanan County has the lowest rate and the City of Norton has the highest labor force participation rate. A common trend among rural populations, the U.S. Department of Agriculture (USDA) found that labor force participation rates tend to be lower in rural areas compared to urban areas.[59]

Table 5: Labor Force Participation Rate of Adults Age 20-64 for Southwest Virginia, Virginia, and the U.S. in 2017.

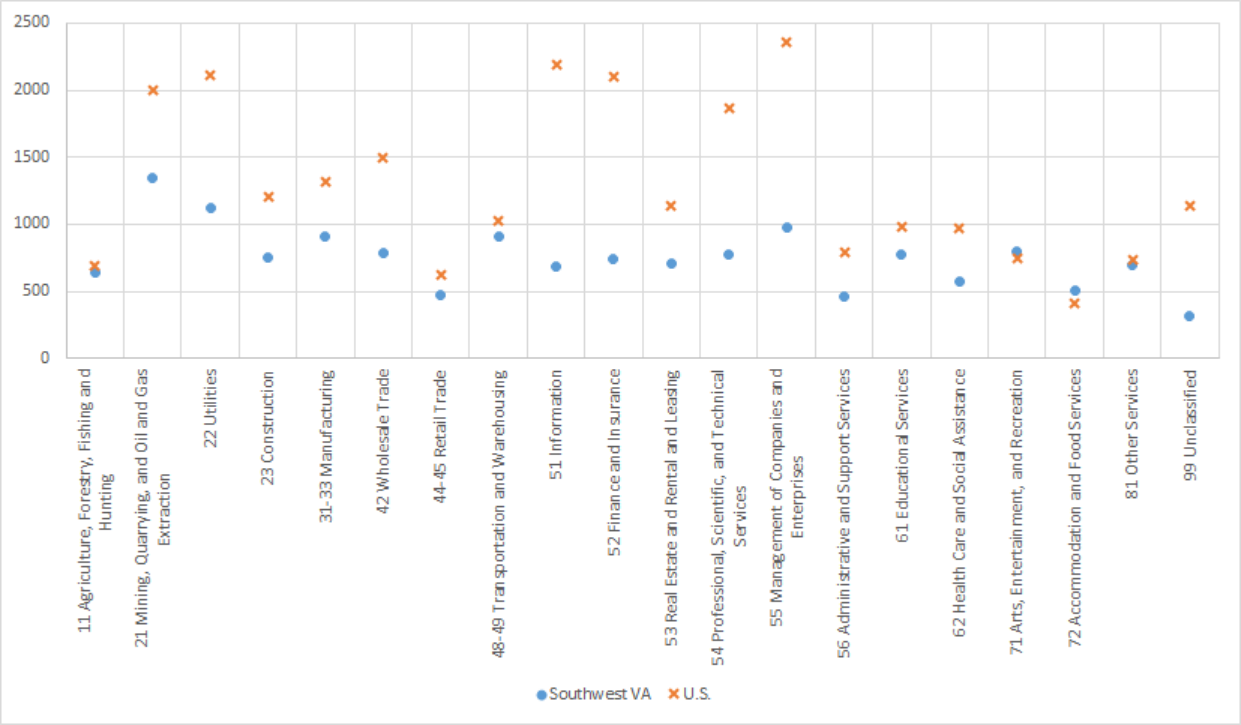
Geography	Rate
U.S.	77.2%
Virginia	79.4%
Buchanan County, Virginia	49.0%
Dickenson County, Virginia	51.2%
Lee County, Virginia	52.1%
Russell County, Virginia	59.3%
Scott County, Virginia	63.4%
Tazewell County, Virginia	63.3%
Wise County, Virginia	55.7%
Norton city, Virginia	70.1%

Source: 2013-2017 American Community Survey 5-Year Estimates

58 https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk
59 https://www.ers.usda.gov/topics/rural-economy-population/employment-education/rural-employment-and-unemployment/

For most industries, Southwest Virginia offers lower wages compared to the overall U.S., including mining and manufacturing, as shown in Figure 12. Some industries in Southwest Virginia provide comparable wages such as retail trade; arts, entertainment, and recreation; and accommodation and food services. This is likely due to minimum wage laws.

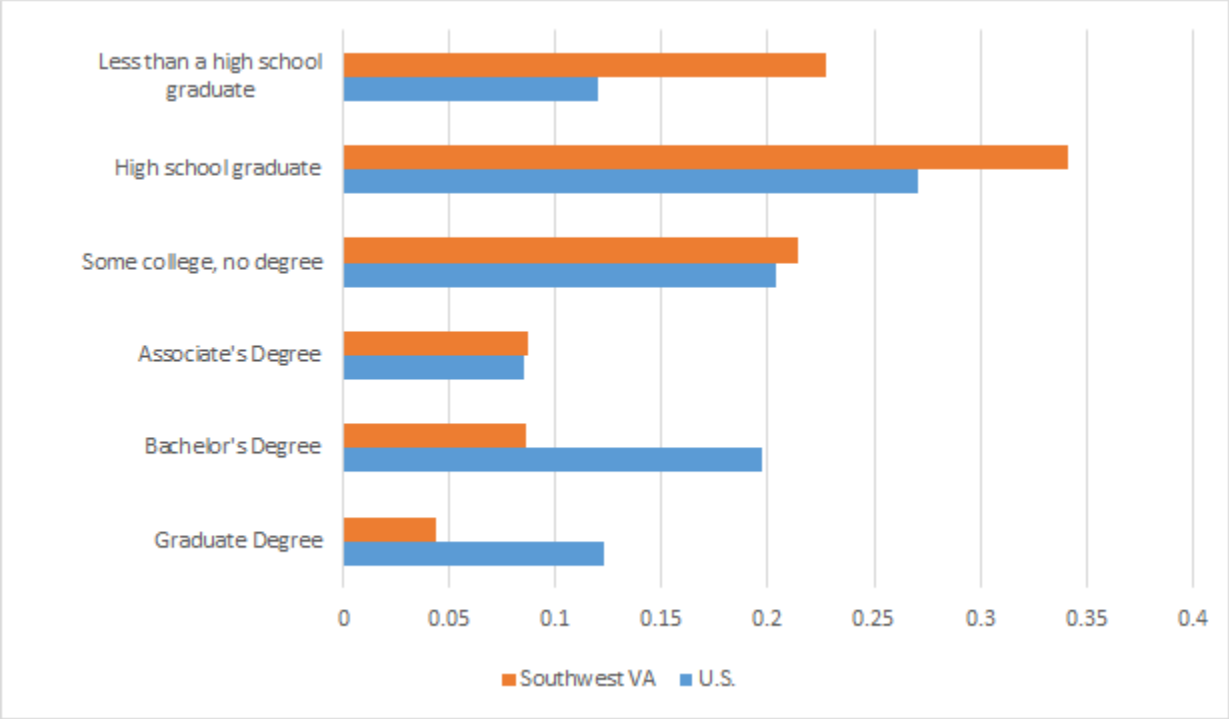
Figure 12: Median Weekly Wages by North American Industry Classification System (NAICS) Two-Digit Industries for Southwest Virginia and the U.S. Two-Digit Industries.



Source: 2018 QCEW Annual Employment Estimates

Figure 13 shows educational attainment in Southwest Virginia is lower than that of the U.S. population. 22% of Southwest Virginia residents have achieved an associate degree or higher, compared to 41% of the U.S. population. Further, 23% of residents in the region have not achieved a high school degree compared to 12% of the U.S. population. During focus group interviews, participants noted the low educational attainment in the region, but pointed out that coal industry workers have extensive skills that are not measured by education attainment. Often, coal miners are not required to obtain certificates or technical degrees, but they have extensive experience and skills such as welding, electrical work, and computer skills.

Figure 13: Highest Educational Attainment in Southwest Virginia and the U.S. for residents 25 years and older.

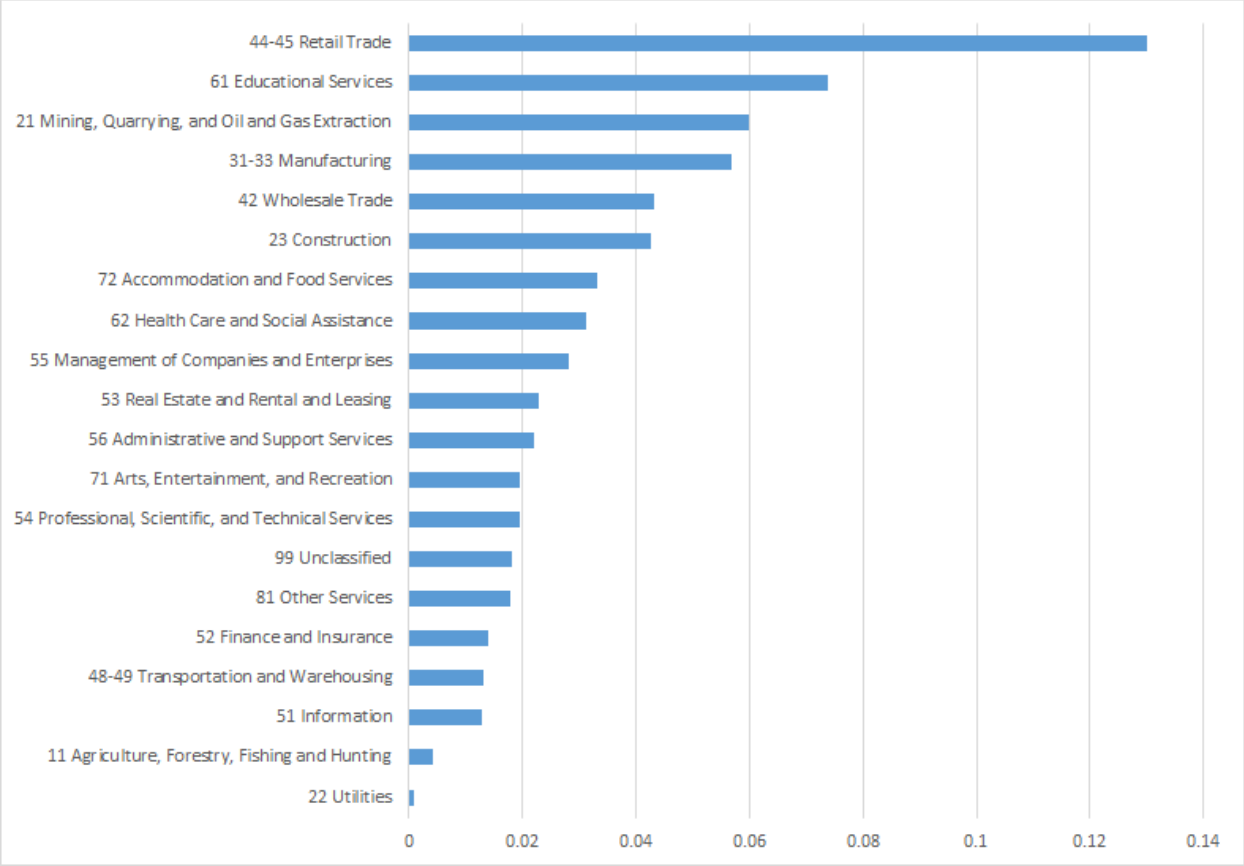


Source: 2017 American Community Survey 1-Year Estimates.

Workforce Characteristics and Educational Offerings

Throughout 2018, Southwest Virginia employed a total of 55,494 workers. As shown in Figure 14, the highest number of workers (13%) were classified as Retail Trade workers. The U.S. Census Bureau defines the retail trade industry as retailing merchandise in small quantities to the public and providing services incidental to the sale of the merchandise.[60] The retail trade industry employment is then followed by educational services (7%); mining, quarrying, and oil and gas extraction (6%); and manufacturing (6%).

Figure 14: Employment in Southwest Virginia by Two-Digit NAICS Code.



Source: 2018 QCEW Annual Employment Estimates

Southwest Virginia has a higher-than-average location quotient (LQ) of employment in mining, especially in Buchanan and Dickenson County (Table 6). LQ is the relative advantage a region may have based on employment base and represents a given industry's share of total local employment divided by the same industry's share of employment at the national level. Therefore, if the local and national industry are proportional, the LQ will be 1.0; if it is greater than 1.0 there is a greater share of that employment in the region than the U.S.; if it is less than 1.0 that may show an area of weakness. Therefore, Buchanan and Dickenson county both have a large competitive advantage over the U.S. in mining, with LQ's greater than 40. This shows that both these counties have a much greater share of workers in the mining industry compared to the U.S. Russell, Tazewell, and Wise Counties also have a greater share of mining workers compared to the U.S.

60 https://www.census.gov/eos/www/naics/2017NAICS/2017_NAICS_Manual.pdf

To analyze the potential competitive advantage Southwest Virginia may have in manufacturing, the LQ for manufacturing employment is included in Table 6. Scott County has a competitive advantage over the U.S. in manufacturing presenting a location quotient of 1.90. While the location quotients for the rest of the counties in Southwest Virginia are below 1.0. While this shows there is little manufacturing employment in these areas currently, this points to potential opportunities for expansion or attraction.

Table 5: Location Quotient of Mining (NAICS 21) and Manufacturing (NAICS 31-33) Industries in Southwest Virginia.

Geography	Mining	Manufacturing
Buchanan County, Virginia	41.62	0.33
Dickenson County, Virginia	45.38	0.08
Lee County, Virginia	1.42	0.31
Russell County, Virginia	8.14	0.83
Scott County, Virginia	0.00	1.90
Tazewell County, Virginia	10.88	0.86
Wise County, Virginia	6.50	0.35
Norton city, Virginia	0.00	0.31

Source: 2018 QCEW Annual Employment Estimates

Workforce Skills

To analyze the skills of Southwest Virginia's workforce that may be relevant to solar manufacturing, the top five occupations for mining and manufacturing are listed in Table 7 and Table 8. The Occupational Information Network (O*NET) provides a comprehensive database of worker attributes and job characteristics defined under each Bureau of Labor Statistics Industry classification.[61] The occupations listed in Table 7 and Table 8 specify the skills and education level required for each occupation as reported by O*NET.[62] For both manufacturing and mining occupations, many of the same skills are listed, including skills in operation and control, monitoring, equipment maintenance, and critical thinking. Further, most occupations only require a high school diploma and a few require a post-secondary certificate.

61 https://www.onetcenter.org/dataCollection.html
62 https://www.onetonline.org/

Table 7: Top Five Occupations Related to Mining under NAICS 21 Mining, Quarrying, and Oil and Gas Extraction

Occupation	Skills	Education
Continuous Mining Machine Operators	Operation and Control Operation Monitoring Equipment Maintenance Critical Thinking Troubleshooting	High School Diploma
Mine Shuttle Car Operators	Operation and Control Operation Monitoring Monitoring Equipment Maintenance	High School Diploma
Mine Cutting and Channeling Machine Operators	Operation Monitoring Critical Thinking Active Listening Operation and Control Monitoring	High School Diploma
Roof Bolters, Mining	Operation and Control Critical Thinking Monitoring Operation Monitoring Troubleshooting	High School Diploma
Service Unit Operators, Oil, Gas, and Mining	Operation Monitoring Critical Thinking Active Listening Operation and Control Monitoring	High School Diploma

*Source: O*NET*

Table 8: Top Five Occupations under NAICS 31-33 Manufacturing

Occupation	Skills	Education
Lathe and Turning Machine Tool Setters, Operators, and Tenders, Metal and Plastic	Operation Monitoring Operation and Control Monitoring Quality Control Analysis Active Listening	High School Diploma Post-secondary certificate
Chemical Equipment Operators and Tenders	Operation and Control Operation Monitoring Monitoring Active Listening Critical Thinking	High School Diploma Some college, no degree
Plating and Coating Machine Setters, Operators, and Tenders, Metal and Plastic	Operation Monitoring Active Listening Monitoring Operation and Control Reading Comprehension	Less than a high school diploma High School Diploma
Computer-Controlled Machine Tool Operators, Metal and Plastic	Operation Monitoring Monitoring Critical Thinking Quality Control Analysis Operation and Control	High School Diploma Post-secondary certificate
Extruding and Drawing Machine Setters, Operators, and Tenders, Metal and Plastic	Operation Monitoring Operation and Control Critical Thinking Judgement and Decision Making Monitoring	High School Diploma

*Source: O*NET*

Table 9 outlines the skills and responsibilities of various solar manufacturing jobs that were posted online from module manufacturers and inverter manufacturers. The skills and education specified match the skills required for both mining and manufacturing occupations from O*NET. Common skills across mining, manufacturing, and solar manufacturing include operation and control, monitoring, troubleshooting, equipment maintenance, and critical thinking. Clearly, the skills of the occupations in Southwest Virginia are easily transferable to skills necessary for a solar manufacturing position. Further, the education requirements for solar manufacturing positions were all high school diploma, similar to the mining and manufacturing industries.

Table 9: Skills and Responsibilities Outlined in Solar Manufacturing Job Postings.

Company	Position	Skills/Responsibilities	Education Requirements
Jinko Solar (Modules)	Machine Operator	Operate and load the machine Monitor smooth production process Ensure quality product	High School Diploma
Ingeteam (Inverters)	Mechanical Assembler	Perform mechanical assembly/coil winding according to SOP Use blueprints, work instruction and schematics to perform assembly operations Ensure each component is tracked properly in the computer system	High School Diploma
LG Electronics (Modules)	Production Operator	Operates various equipment and machinery Assembles various subassemblies (i.e. Cell, Glass, Frame) Performs assembly operations (assembling, soldering) Performs preventative maintenance on equipment and machinery	High School Diploma

Source: Company websites and Indeed

Education and Workforce Training

Southwest Virginia offers education and workforce development opportunities to strengthen the region's workforce.

Community colleges in the region, including Mountain Empire Community College and Southwest Virginia Community College, provide programs to obtain necessary skills to join the workforce. Community colleges work closely with the local private sector to build and personalize training programs. The community colleges in the region can quickly pull in industry experts in the business and set up training to meet workforce needs. These customized training programs provide cost-effective training solutions for employers. Examples of training opportunities listed on Southwest Virginia Community College's website include Heavy Equipment Operator, Flux Core Arc Welding, and Drones.[63] These training opportunities provide "fast track training for high-demand jobs which help the job seeker quickly move into secure, well-paying careers." [64] Mountain Empire Community College offers a multitude of Advanced Manufacturing programs including computerized manufacturing technology; energy technology; industrial maintenance; machinery maintenance; and welding.[65]

Additionally, the four-year colleges and universities in the region are outlined below:

1. The University of Virginia's College at Wise
2. Bluefield College
3. Appalachian School of Law
4. Appalachian College of Pharmacy

Southwest Virginia also offers a variety of other workforce development opportunities to residents and students. Each county in the region has its own career and technical center. These career and technical education programs are offered to students in Virginia public schools in grades 6-12. Over 600,000 students in Virginia are enrolled in these programs in Virginia public schools. The programs prepare students for a future technical career that will meet the workforce needs of the local industry.

The region is also home to Southwest Virginia's Alliance for Manufacturing. This is a non-profit education center that supports the manufacturing companies in the region to meet their workforce needs. They provide companies with tailored training such as advanced manufacturing technology and software programming to close the skills gap and create a robust workforce to support regional manufacturers. They also work to promote manufacturing careers in the region as a potential career path to young students.[66] One such program is the "Manufacture Your Career" program, which provides college students information to learn about career paths in the manufacturing sector. In 2017, the program reached five colleges in the state and had over 190 attendees. Further, the organization travelled to 15 Career and Technology Centers across the Southwest Virginia region, reaching 1,100 students, educating and inspiring them to pursue a career in manufacturing.[67]

Further, the Manufacturing Skills Institute (MSI), located in Richmond, Virginia provides training programs for those seeking careers in advanced manufacturing. MSI offers world-class training programs in advanced technology and automation that are meant to meet the workforce demands of the local industry. MSI is a Virginia based training center and offers their training programs online.

63 https://sw.edu/workforce/
64 https://sw.edu/workforce/
65 https://www.mecc.edu/?pathway-types=manufacturing
66 https://www.swvam.org/
67 https://issuu.com/swvam/docs/2018_annual_report

MANUFACTURING ACTIVITY IN SOUTHWEST VIRGINIA

Manufacturing is the fourth largest sector to employ workers in the region as shown in Figure 14. The major manufacturing firms that are currently under operation in Southwest Virginia are outlined in Table 10.

Table 10: Major Manufacturing Firms in Southwest Virginia

Company	Primary Product	Location
Komatsu Mining Corp.	Mining machinery	Scott County
Lawrence Brothers Inc.	Battery trays for coal and material handling industry	Tazewell County
Mullican Flooring	Hardwood flooring	City of Norton
Pemco – AMR	Electrical power centers and generators	Tazewell County
Pyott-Boone Electronics, Inc.	Safety, communications, and productivity systems	Tazewell County
Samuel Pressure Vessel Group	Pressurized containers	Russell County
Tadano Mantis Corp.	Telescopic-boom crawler cranes	Tazewell County
Tempur Production USA, LLC	Mattresses	Scott County
VFP Inc.	Concrete shelters to protect critical infrastructure	Scott County

Source: Virginia Economic Development Partnership

A From an email communication with Pam Seals of Komatsu "Total employment is typically around 330 in Scott Co, VA; however, the mining industry is currently experiencing a downturn - therefore, we currently have 53 employees on temporary layoff at the Duffield plant. We are hopeful to see an uptick in the business at the end of the calendar year and into early 2021."

B http://www.amrpemco.com/pemco-expands-workforce/

Research and Development

In 2019, the Virginia legislature passed a bill establishing the Southwest Virginia Energy Research and Development Authority. The purpose of this authority is "to promote opportunities for energy development in Southwest Virginia, to create jobs and economic activity in Southwest Virginia consistent with the Virginia Energy Plan, and to position Southwest Virginia and the Commonwealth as a leader in energy workforce and energy technology research and development."[68] The bill specifies for the authority to assist energy technology research by promoting the development of a Southwest Virginia Energy Park in the region as well as to partner with K-12 and higher education leaders to promote research and development activities. This state-led initiative emphasizes the importance that is being placed on research and development in the area, specifically focused on energy technology.

The Graphene Research Center located in a 24,000 square foot building in Wise County recently received $1.5 million from Virginia Coalfield Economic Development Authority (VCEDA). The research center is collaborating with universities such as Virginia Tech to expand graphene research in the area and potentially lead to greater development of advanced manufacturing in the region.

68 https://www.richmondsunlight.com/bill/2019/sb1707/

Entrepreneurial Activities

Conversations during focus group meetings included the opportunities available for entrepreneurial activity in Southwest Virginia. One such program mentioned is the Virginia Coalfield Economic Development Agency's (VCEDA) Seed Capital Matching Grant fund. These grants reach up to $10,000 and match dollar for dollar funding from the startup business. These grants have been awarded to 53 start-up businesses, with 17 more prospects as of October 2019. This funding has been awarded to a variety of businesses including an agricultural drone company, photography company, café's, and a fitness center. VCEDA also offers low-interest loans or grants to new or expanding businesses in the region.

Further, the region is home to two entrepreneurial incubators, located in the City of Norton and Abingdon. The University of Virginia's College at Wise opened the Oxbow Center in Norton, VA. This building offers coworking spaces, privacy booths, offices, and conference and meeting spaces to aid entrepreneurial development. The center hopes to create a network of professional support by connecting businesses, projects, ventures, and funds to promote economic development.[69] An interview conducted in this effort revealed a new program being offered at the center – "meet with an entrepreneur" – which will offer weekly office hours with a successful entrepreneur to offer advice and networks to new firms in the region. Further, the center aims to continue to develop programming to support technology companies and support ideas that stem from regional colleges.

Opportunity Southwest Virginia offers a multitude of resources to businesses in the region. Opportunity SWVA is a coalition of 25 small business support and community development organizations. The program aims to spur economic development in the region through collaborative partnerships to create entrepreneurial activity that will lead to long term success and economic growth.[70]

Additionally, the Virginia Tobacco Region Revitalization Commission offers resources for entrepreneurial development. The Commission was founded to use the proceeds of the national tobacco settlement to promote economic growth and development in tobacco-dependent communities.[71] They partnered with Genedge to create the Small Business Entrepreneurship Support Program. This program is focused on growing manufacturing and other small businesses that bring new jobs to the region. The grant and support are intended to accelerate the development of company paths towards commercialization of their product.

Finally, Southwest Virginia Community College in Richlands, and Mountain Empire Community College in Big Stone Gap both house Small Business Development Centers. These centers provides free counseling and educational offerings to help entrepreneurs and small businesses succeed in the region.

69 https://www.oxbowcenter.com/about
70 www.opportunityswva.org
71 https://www.revitalizeva.org/

SOLAR MANUFACTURING POTENTIAL IN SOUTHWEST VIRGINIA

This analysis takes a quantitative and qualitative approach to understanding the potential for solar manufacturing in Southwest Virginia. Quantitative analysis was conducted to understand the demographic, labor, economic, and market activity data while qualitative research stems from focus groups and 1:1 interviews with key stakeholders in Southwest Virginia. The following section combines these approaches to understand the potential for solar manufacturing in the region.

Strengths, Challenges, Opportunities and Threats

Strengths

- Transferability of skills of unemployed mine workers
- Continuous effort to rally the region around the renewable energy industry
- 30+ industrial sites and buildings available
- Broadband infrastructure
- Highway, rail, and port infrastructure
- Incentive packages for new or expanding firms
- Low cost of living and access to outdoor recreation
- Low corporate income tax rate
- Hard-working and dedicated workforce
- Geographic proximity to major markets

Weaknesses

- Mining offers more competitive wages
- Not all industrial sites have necessary infrastructure
- Low educational attainment
- Lack of high funding opportunities for entrepreneurial activity
- Lack of awareness of available incentive packages and resources
- Interviews suggest there may be a negative perception of manufacturing as a career
- Lack of alignment between training programs and private sector needs
- Difficulty finding qualified workers
- Broadband connectivity for residents is patchy

Opportunities

- Solar and storage market is growing
- Solar manufacturing industries in the U.S. growing
- Potential to expand existing manufacturing firms in the region to solar technology
- Favorable state policies driving renewable industry growth

Threats

- Module manufacturing is cheaper overseas
- Section 201 tariffs continue to step-down
- Lack of cell manufacturing in the U.S.
- Uncertainty around trade tariffs
- Impact of automation on jobs of the future.

BUSINESS EXPANSION, RETENTION, AND ATTRACTION

Expansion Potential of Existing Manufacturing Firms in Southwest Virginia

Business retention and expansion is a key economic development tool to grow local economies. These programs focus on assisting local businesses to grow and expand by offering technical assistance and other support services. [72] Business retention and expansion is an important economic driver as one study found that 80% of a community's new jobs stem from existing businesses.[73] By growing and expanding existing businesses in the region to enter the solar industry, the region can increase economic development and create stable, well-paying jobs.

Though Southwest Virginia does not currently have any manufacturing firms in the region specifically tailored to the solar market, these technologies can be transformed to serve the solar industry. By leveraging the manufacturing assets already in the region and offering assistance to expand their technology into the solar market, the region can create clean energy jobs. (See Table 10 for a list of the major existing manufacturing firms in Southwest Virginia and their technologies.)

For example, Lawrence Brothers currently manufactures battery trays for batteries used in the mines as well as batteries used in the material handling industry, i.e. forklifts. This battery tray technology can be easily transformed to work with lithium-ion battery packs to be used for energy storage systems. As mentioned previously, BMZ in Virginia Beach, VA imports their manufactured cells to be used by local companies. Lawrence Brothers could utilize this partnership and manufacture lithium-ion battery packs using BMZ cells. As the lithium-ion battery deployment grows, with projected 110% growth in energy storage installations from 2018 to 2040, Lawrence Brothers can strategically expand to the renewable energy storage industry.

VFP Inc already markets their technology to the renewable energy industry. Their concrete shelter technology can house the critical components of utility-scale solar farms such as the electric combiner boxes, inverters, transformers, meters, and other balance of system or monitoring equipment. As demand for solar continues to grow and utilities in Virginia seek to fulfill renewable energy requirements, VFP can expand into the solar market and offer this technology to solar installations across Virginia and the outlying areas. Further, as identified in stakeholder interviews, about once a year VFP Inc. is hired to fulfill a manufacturing order for utility-scale inverters. As solar demand grows, VFP may seek to fulfill a greater number of these orders and expand their operations to consistently manufacturer inverters for utility-scale solar.

Pemco – AMR provides another opportunity for business expansion. Pemco offers "electronic monitoring, atmospheric monitoring, wireless communications, underground tracking, and electrical products as well as custom engineered solutions for mid-to-high voltage electrical distribution equipment."[74] The custom engineering solutions for electrical distribution equipment can be engineered for utility-scale solar installations. Electrical balance of system components that are already manufactured at Pemco such as panel wiring, transformers, and high voltage ground monitors can be expanded and offered to solar companies.

72 http://www.oas.org/en/sedi/dsd/Biodiversity/Sustainable_Cities/Sustainable_Communities/Events/SC%20Course%20Jamaica%202016/Module%20VI/PLED_business%20retention%20and%20expansion_2010%20paper.pdf
73 https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1510007
74 http://www.amrpemco.com/

Expansion Potential of Existing Solar Manufacturing Firms in the Surrounding Region

Given the current upward trajectory of the solar industry, various parts of the solar value chain will be in high demand. As discussed in the solar manufacturing trends section, module, inverter, racking, and storage manufacturing are expected to grow in the U.S. There are a number of these manufacturing firms already in the surrounding area that may seek business expansion or relocation as demand for their products continues to grow. Southwest Virginia presents several benefits for manufacturing firms looking to expand operations to the region including state and regional incentive packages and a dedicated workforce. These are discussed in more detail in the Characteristics of Southwest Virginia section. Tables 11 and 12 list the solar-related manufacturing firms within 100 miles of Southwest Virginia and within 150 miles of the region.

Table 11: Solar related manufacturing activity within 100 miles of Southwest Virginia

Company	Primary Product	Location
Eastman Chemical	Heat exchangers; Adhesive-Coating-Insulation; Chemicals, Metals	Kingsport, TN
Short Mountain Silica	Silicon	Mooresburg, TN
Unlimited Power	Portable off-grid power systems	Fletcher, NC

Source: Solar Energy Industry Association National Solar Database

Table 12: Solar related manufacturing activity within 150 miles of Southwest Virginia

Company	Primary Product	Location
Thomas & Betts	Conduit, grounding systems	Athens, TN
Storm Power Components Co.	Back-up power storage technology	Decatur, TN
Silrec Corporation	Wafers and bulk silicon	Lexington, KY
Covestro LLC	High-tech polymer materials for coating modules	South Charleston, WV
TMEIC Corporation	Inverters	Roanoke, VA
VA Transformer Corp.	Transformers	Roanoke, VA
CPFilms	Film technology	Fieldale, VA
Suntek	Film technology	Martinsville, VA
Smart Era Lighting System	Solar lighting systems	Winston-Salem, NC
Gesipa Fasteners	Fasteners	Mocksville, NC
Avdel USA	Fasteners	Stanfield, NC
SBM Solar	Non-glass PV Modules	Concord, NC
Aerocompact	Racking and mounting	Matthews, NC
Nucor Corporation	Steel products for mounting	Charlotte, NC
HAWE Service Solutions	Hydraulics for PV trackers	Charlotte, NC
DCE Solar	Racking	Cornelius, NC
Schletter Inc.	Mounting and tracking	Shelby, NC
Advanced Digital Cable	Cables for balance of systems	Hayesville, NC
Jetion Solar	Modules	Charlotte, NC

Source: Solar Energy Industry Association National Solar Database

An additional resource available to new or expanding firms includes the surrounding manufacturing activity. Companies in the surrounding area that manufacture supporting technologies such as bulk silicon, film technology, and hydraulic technology may provide necessary value chain components to a new or expanding solar manufacturing firm in the region.

Silrec Corporation, located in Lexington, KY, just under 150 miles to the region, manufactures bulk silicon products (including polysilicon) and wafers of all sizes. These technologies could be used to support the manufacturing of semiconductors, wafers, and OEM module assemblers. By having a silicon and wafer production facility nearby, solar manufacturing firms can reduce costs and receive supplies from a local

company. This should be utilized as an attraction point for potential semiconductor, wafer, and OEM manufacturing firms looking to expand or locate to the area.

Further, there are multiple coating and film technology firms in the area that can provide coating and film materials for solar modules. These include Covestro in South Charleston, WV; CPFilms and Suntek in Virginia; and Eastman Chemical in Kingsport, TN. These coating and film technology firms could be used to support the assembly of solar modules. Additionally, as the solar market continues to grow, these firms may expand further to the solar market and require additional production capacity which could be sited in Southwest Virginia.

HAWE Service Solutions in Charlotte, North Carolina manufactures hydraulics. Their hydraulic technology can be directly utilized to produce solar tracking technology. This technology can be utilized to support the manufacturing of tracking technology for the solar industry.

Additionally, Powerfield Energy, a company based out of Falls Church is currently working to commercialize their solar racking technology. While this company is not yet in production, Southwest Virginia may appeal to set up production facilities for this solar racking firm.

KEY RECOMMENDATIONS

Given the findings presented throughout this report, below is a presentation of the key recommendations. These recommendations should be utilized by leaders in the Southwest Virginia community to position the region as a solar manufacturing hub to support economic development and ensure the region's place in the clean energy economy.

1. **Workforce**. As shown through the quantitative and qualitative approaches of this analysis, the workforce in Southwest Virginia is easily adaptable to support solar manufacturing. Many of the same qualifications that apply to coal workers apply to solar manufacturing positions. The younger population could be a good source for a growing manufacturing workforce. Conversations with local stakeholders conveyed difficulty finding qualified manufacturing workers in the region. Stakeholders shared the sentiment that the K-12 population does not perceive manufacturing as a viable career option. To spark interest in manufacturing careers, K-12 institutions may seek to offer real-world opportunities in the manufacturing industry for students. Providing hands-on training and experience through internships and training opportunities will offer young students insight into the manufacturing industry. Leaders in the region must tap into the emerging talent pool of young adults to prepare them for manufacturing positions.

2. **Business expansion and attraction.** The following is a list of the most promising opportunities for manufacturing companies in Southwest Virginia to pivot their markets to solar technology and utilize the surrounding firms and technology to attract potential solar manufacturing.

    a. **Expand Lawrence Brothers Inc.** technology to produce battery trays for lithium-ion batteries for utility-scale energy storage. By connecting them with BMZ in Virginia Beach, they could utilize BMZ's battery cells and produce battery packs using these cells. Utilize VCEDA low-interest loans for any necessary production upgrades. Utilize Genedge resources to ensure successful expansion to the lithium-ion battery market.

    b. **Expand VFP Inc.** technology to produce concrete shelter technology for electrical system components for utility-scale solar projects. Given the Governor's recent call for increased utility-scale solar in Virginia, VFP Inc. can tap into this market. Utilize VCEDA low-interest loans for any necessary production upgrades. Utilize Genedge resources to ensure successful expansion to the utility-scale solar market.

    c. **Expand Pemco – AMR technology** to produce balance of system technology for utility-scale solar installations. Given the Governor's recent call for increased utility-scale solar in Virginia, Pemco can tap into this market. Utilize VCEDA low-interest loans for any necessary production upgrades. Utilize Genedge resources to ensure successful expansion to the utility-scale solar market.

    d. **Attract a solar module company or OEM module facility.** Connect the potential company with Covestro, CPFilms, Suntek, and Eastman Chemical to provide coating and film material. Utilize a combination of the new business incentives that are available at the state level to encourage economic development.

    e. **Attract a solar tracking company.** Connect the potential company with HAWE, which produces hydraulics to be used in the tracker technology and with Nucor Corporation, which provides steel for mounting structures. Utilize a combination of the new business incentives that are available at the state level to encourage economic development.

f. **Continue conversations with Powerfield Energy** to locate any future production facility of their racking technology in Southwest Virginia. Utilize a combination of the new business incentives that are available at the state level to encourage economic development.

g. **Develop a deep understanding of existing firms.** Local and regional economic development organizations should develop a deep understanding of existing manufacturing firms, their capabilities, and their workforce. With such knowledge, economic development professionals will be well prepared to identify collaborative opportunities for their home based firms.

3. **Marketing.** Southwest Virginia has a multitude of resources available to foster the growth of manufacturing in the region. There are many regional and state financial incentives available that should be strongly marketed to incoming firms. In fact, the region offers a variety of unique incentives such as the VCEDA financing which offers low-interest loans to businesses in the region. The region can broadly market these incentives to attract and retain new solar manufacturing firms in the region. Further, there are over 30 industrial buildings and sites in the region that are available for occupancy. These sites are varied in the available infrastructure, but they still provide basic advantages of an already constructed industrial park. These industrial sites can be strongly marketed to incoming firms to provide a lower cost option than building a new facility. Finally, industrial sites with the highest potential to collocate a manufacturing plant with a solar installation (ground mount or rooftop) should be identified and promoted to new and expanding firms.

4. **Entrepreneurial Development.** Further develop programs at the Oxbow Center to attract high growth entrepreneurial development to the region. To support these firms, create a high dollar funding opportunity for firms to support their expansion and commercialization. One approach is for financial institutions or other parties to set up qualified opportunity funds to invest in opportunity zones. There are numerous opportunity zones in SW Virginia where such investment could go.[75]

   Manufacturing startups face unique challenges compared to other new firms as they require high capital investment and production space. Creating high dollar funding opportunities for the region can help to remove these barriers of entry and support entrepreneurial development.

75 See map http://vedp.maps.arcgis.com/apps/webappviewer/index.html?id=bf7c530d8e0240c6a911a4b40fb0a357

APPENDIX A

Interview and Focus Group Participants

Vivek Patil – Ascent Virginia

Sam Wolford – Genedge

Ben Spear – Antares Group

Kevin Comer – Antares Group

James Crawford – Urban Grid Solar

Karla Loeb – Sigora Solar

Parker Sloan – Cypress Creek Renewables

Matt Meares – Virginia Solar LLC

Leton Harding –Powell Valley National Bank

Melanie Protti-Lawrence –Lawrence Brothers Inc.

Jean Jordan – Virginia Coalfield Economic Development Authority

Jim Baldwin – Cumberland Plateau Planning District Commission

Charlie Perkins – Cumberland Plateau Planning District Commission

Josh Sawyers – UVa Wise Office of Economic Development

Mary Major – Virginia Department of Environmental Quality Solar Permitting

Vince Maiden – Virginia Department of Environmental Quality Brownfields

Daniel Kestner – Virginia Department of Mines, Minerals and Energy Mapping

Nick Polier – Virginia Department of Mines, Minerals and Energy

Ernie McFadden – Russell County Industrial Development Authority

Michael Wampler – Wise County Tourism and Community Development

Denechia Edwards – Dickenson County Schools

Robert Brandon – Southwest Virginia Community College

Becki Joyce – UVa Wise