

Tennessee Advanced Energy Economic Impact Report

Tennessee Advanced Energy
Business Council

August 2021

Research conducted by the Howard Baker Jr. Center for Public Policy
at the University of Tennessee



www.TNAdvancedEnergy.com

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Dear Reader:

We are pleased to report that the state of the Advanced Energy (AE) Economy in Tennessee is strong. Our thanks go out to the University of Tennessee and Tennessee Valley Authority for their financial support of this project and to the Howard Baker Jr. Center for Public Policy at the University of Tennessee for crunching the numbers for a third time.

This third Tennessee Advanced Energy Economic Impact Report—which builds on the 2015 baseline establishment of the AE sector and our 2018 update—continues to show trend lines soaring for all aspects of the AE economy. Using 2019 (i.e., pre-pandemic) data, our analysis clearly indicates all signs of robust growth in the advanced energy economy, as evidenced by jobs, tax revenue, payroll expenditures, and the number of establishments doing business in this sector here in Tennessee.

If you're wondering, what is the advanced energy economy, here is the answer. Advanced energy is technology neutral. Any technology that makes energy cleaner, safer, more secure, and more efficient is considered advanced energy. It includes electricity and transportation. Examples include electric and plug-in hybrid cars, lightweight composites for the automotive industry, natural gas fueled trucks, pollution control equipment, bio energy, high-performance buildings, more efficient industrial processes, power reliability, smart grids, combined heat and power, and the latest wind, solar, and nuclear technologies.

AE is a critical component of the Tennessee economy. In fact, with total job growth in the AE sector nearly double the overall job growth in the state and higher average salaries than the state's overall average salary, not to mention AE's significant contribution to the state's GDP, the AE sector is not only strong, it works for all Tennesseans.

As public and corporate demand for efficient and clean energy technologies ramps up, Tennessee is ready with a diversified and strong set of AE activities and skilled employees extending across all 95 counties. We are here to meet 21st century demands and in the process, continue to generate large shares of the state's GDP, contribute to the state's employment ranks, and increase the state's competitiveness and attractiveness to do business.

But don't take our word for it — read for yourself and see how vibrant growth of the AE sector means vibrant growth for the state as a whole.

Sincerely,



Chris Bowles
President
Tennessee Advanced Energy Business Council
Partner, Bradley



Cortney Piper
Executive Director
Tennessee Advanced Energy Business Council
President, Piper Communications

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Executive Summary

This third edition of the Tennessee Advanced Energy Economic Impact Report identifies an ongoing upward trend of the state's Advanced Energy (AE) economy—the \$1.4 trillion global market¹ that in the U.S. generated \$240 billion in revenue in 2020. In fact, consistent with the 2015 benchmark report and the 2018 update, the entire AE sector continues to thrive in all aspects we analyzed, from jobs to salaries to overall contribution to the state Gross Domestic Product.

Why is it important to record Tennessee's portion of this very lucrative global pie? With demand increasing for clean and advanced technologies, this sector is only going to continue to grow. Given that several other states also have a strong foothold in the AE market, including nearby Arkansas and North and South Carolina, it's important we flex our strengths and progress to help attract more AE investments here at home. We can do that by showing how far we've come and what we've achieved.

The numbers confirm our enthusiasm. Using 2019 data from the U.S. Census Bureau to estimate the size of the AE sector and its sub-industries in Tennessee, we calculated:

- The number of AE establishments doing business in the state;
- The number of workers employed; and
- Annual payroll expenditures.

Together, this data reveals a robust AE sector—good news for all Tennesseans, especially as the nation—and the world—leans in to demand and expect more advanced energy and manufacturing.

When it comes to AE, most Tennesseans are likely already familiar with the state's blossoming automotive industry. The more than 16,000 electric vehicles produced here each year accounts for nearly 40 percent of the Southeast's electric vehicle manufacturing jobs and \$4.2 billion in critical investments.² In fact, Tennessee ranks number one in the Southeast for electric vehicle manufacturing, success we can and will continue to build on.

Aside from the automotive industry, Tennessee has a special set of AE assets that set it apart from other states, including our world-class research institutions, economic development organizations, companies and entrepreneurs, and technology training programs.

Given the dominant presence of the automotive industry, it's not surprising that we found the strongest AE industry group in Tennessee continues to be manufacturing. But our analysis shows statewide growth in the other four AE categories—utilities and construction; information; professional, scientific, and technical services; and other services, which includes administrative and support, waste management and remediation services, and health care and social assistance. The AE sector directly enhances Tennessee's competitiveness and attractiveness as a place to do business, a major plus for the state as we establish a foothold in the AE market share.

¹ Advanced Energy Now. 2021 Market Report, Global and U.S. Market Trends by Revenue 2011-2020 and Key Trends in Advanced Energy Growth. <https://info.aee.net/hubfs/AEN%202021%20Market%20Report/AEN%202021%20Market%20Report.pdf>

² Tennessee Department of Economic and Community Development. <https://www.tn.gov/ecd/news/2021/4/16/governor-lee-commissioner-rolfe-announce-general-motors-and-lg-energy-solution-to-invest-2-3-billion-to-build-ultium-cells-manufacturing-plant-in-spring-hill.html>

This report breaks out the impacts of the AE sector not only by sub-industry, but at the county, metropolitan, and state levels. The Nashville metro area continues to be the largest contributor to the AE sector, followed by the Memphis and Knoxville metro areas. About 65 percent of Tennessee's AE employment is concentrated in 20 counties, including two counties that made the top 20 for the first time. While AE activity is centered around the state's metropolitan areas, the AE economy extends across all 95 counties, providing opportunities for rural and urban residents and businesses.

Other highlights from the report:

AE boosts jobs here at home

The AE economy in Tennessee employed nearly 394,000 workers in 2019, a ten percent increase since our last report and double the job growth in the state as a whole. AE accounts for nearly 15 percent of all jobs in the state.

AE jobs pay higher wages on average

Annual payroll for AE firms in Tennessee totals \$25 billion, with the annual wage in this growing sector averaging \$64,000, substantially higher than the state average salary of \$48,000.

AE strengthens the state economy

In the time since our last report, the AE contribution to state GDP has grown to \$45.8 billion, 12.2 percent of total GDP for the state. Output generated by the overall AE sector grew by 8.2 percent since our last report, a very healthy pace of growth.

AE creates more opportunities for Tennessee-based companies, firms, and manufacturing

Advanced energy establishments in Tennessee totaled 20,340, an 11.9 percent increase since 2016 and nearly 15 percent of all establishments in the state.

Overall, the analysis shows that across the board, the AE sector in Tennessee has continued to grow over the last five years at a pace faster than the rest of the overall economy, making AE a significant component of the state economy and also leveraging the state as an AE leader. This means more opportunities for Tennessee businesses, more revenue for our state coffers, and more high paying jobs for our residents. The hope is that the Tennessee Advanced Energy Economic Impact Report provides a context for decisions by public officials and private sector leaders to make lasting contributions to Tennessee's economic base for the next decade and beyond.

Introduction

Advanced energy initiatives and developments continue to flourish and expand — globally, nationally, and regionally here in Tennessee. For example, Tennessee, a leader in automotive manufacturing, is home to an abundance of automotive suppliers and three major plants, General Motors, Volkswagen, and Nissan. Traditional automotive manufacturing centered on the internal combustion engine has proven to be an asset to Tennessee; as the sector expands into advanced manufacturing and innovative markets, including electric vehicles and battery production, that asset will continue to benefit the state. With General Motors' recent investment in building fully electric vehicles, now all three major car manufacturers in Tennessee are producing electric vehicles. This production further attracts electric vehicle suppliers, prompts the development of engineering facilities, and creates additional opportunities across the state. Denso, for example, has expanded its investments in Tennessee to include a new facility that assembles advanced systems for electric vehicles. Volkswagen's Engineering and Planning Center in Tennessee is investing in a laboratory to develop and test electric vehicle cells and battery packs. For stakeholders and consumers in Tennessee, a number of state agencies and other partners have introduced **Drive Electric Tennessee** to develop a shared vision for the transition to electric transportation in Tennessee.

This is just one visible example of progress in the advanced energy (AE) economy in Tennessee. Nationally, AE is a \$1.5 trillion global market that generated \$240 billion in revenue in 2020.³ The evidence presented here for the state, as well as evidence from the national and global economies, shows that AE is generally growing at a faster pace than the overall economy.

Given the emergence, growth, and potential of the AE economy, many states have commissioned reports to document the scope and significance of the AE sector in their state. The AE economy is thriving in Arkansas, California, Iowa, Illinois, Pennsylvania, Florida, Massachusetts, North Carolina, South Carolina, Vermont, Washington, Indiana, and Texas. Data and methods vary for these state-specific reports as some studies have relied on relatively small surveys while other have used more expansive methods. These state studies show that AE employment is roughly one to four percent of overall statewide employment in those states reporting an AE economy. For perspective, Tennessee's transportation equipment sector employed about 75,100 workers in 2019, or 2.4 percent of statewide nonfarm employment.

The Tennessee Advanced Energy Economic Impact Report, a baseline study of the state's AE economy, was originally published in 2015 and then updated in 2018. This report provides a further update to the 2015 and 2018 findings and identifies ongoing trends in the AE economy in Tennessee. All previous reports and the current report use County Business Patterns (CBP) data from the U.S. Census Bureau to estimate the size of the AE sector and its sub-industries in Tennessee. The data include information on the number of business establishments, the number of employees, and annual payroll expenditures, and data are reported by major job classifications using the North American Industrial Classification System (NAICS). Data are analyzed at the county, metropolitan statistical area (MSA), and state level.

³ Guidehouse Insights for Advanced Energy Economy, "Advanced Energy Now: 2021 Market Report", 2021. <https://info.aee.net/aen-2021-market-report>

Consistent with previous reports, 62 four-digit industry groups were identified as constituting Tennessee's AE sector. These industries represent current AE activity and the foundation for future growth opportunities in the AE sector. The 2018 analysis relied on 2016 CBP data and found that Tennessee's AE sector supported 358,360 jobs at 18,170 establishments and generated \$39.7 billion in state gross domestic product (GDP), with impacts spread across every county in the state.

This updated analysis, which uses 2019 CBP data, had to address reporting changes that are discussed more fully below. Nonetheless, the analysis reveals good news: the AE sector has continued to expand in Tennessee at a robust pace. The AE economy in Tennessee employed 393,756 workers in 2019, which is a 9.9 percent increase since 2016. Advanced energy establishments in Tennessee totaled 20,340, an 11.9 percent increase since 2016. AE's contribution to state GDP has grown to \$45.8 billion. The Nashville MSA continues to be the largest contributor to the AE sector and accounts for 30.5 percent of the state's AE employment.

While this report is published in 2021, it is based on 2019 CBP data; thus it examines the AE sector in a pre-COVID-19 time period and the economic outcomes presented here do not capture impacts of the pandemic on employment, the number of business establishments, or the state's economy. While the AE sector was hit by the pandemic, it has likely recovered, as is the case with many other related sectors of the overall economy.

At the state level, growth in employment, payroll spending, and the number of establishments in the AE sector since 2016 has outpaced total growth for the overall Tennessee economy. The takeaway from the following narrative is that the AE sector is continuing to expand in Tennessee and is creating more and more opportunities for the business community and state residents.

TENNESSEE ADVANCED ENERGY CASE STUDY

FedEx

FedEx Corporation provides customers and businesses worldwide with a broad portfolio of transportation, e-commerce, and business services. In 2021, the Memphis-based company announced its commitment to achieve carbon-neutral operations globally by 2040. To achieve this goal, FedEx will focus on three key areas: vehicle

electrification, sustainable energy, and natural carbon sequestration. FedEx also pledged \$100 million to establish the Yale Center for Natural Carbon Capture to accelerate research into methods of carbon sequestration at scale, with an initial focus on helping to offset greenhouse gas emissions equivalent to current airline emissions.

Defining the Advanced Energy Economy

This is the third Tennessee Advanced Energy Economic Impact Report; the first was published in 2015 and the second was published in 2018. Beginning with the first report, the AE sector was defined after a thorough review of multiple studies on AE, clean energy, and green energy, along with Tennessee's AE assets. After performing a review of additional recent studies, the conceptual definition of advanced energy is sustained as follows:

An advanced energy firm is defined as being directly involved with researching, developing, producing, manufacturing, distributing, selling, or implementing components, goods, or services related to advanced energy; energy efficiency; renewable, nuclear, and natural gas electricity generation; distributed generation; advanced manufacturing; lightweight composites for the automotive industry; electric and hybrid vehicles; pollution control technologies; smart grid; and other related technologies. This can include supporting services such as consulting, finance, tax, and legal services related to advanced energy. It includes farm workers involved in growing feedstock (corn, soy, etc.) for advanced fuels.

Defining AE and its size is challenging. AE has been interpreted differently across stakeholders and research studies. Moreover, AE activities cross over traditional industrial and occupational categories which classify business establishments and jobs. Similar challenges arise when defining related "green" or "clean" industries. Unfortunately, there is no consistent publicly available national or regional database on the AE economy and its sub-industries.

Studies undertaken in Arkansas, California, Iowa, Massachusetts, North Carolina, South Carolina, and Vermont have taken a conceptual approach similar to that followed here where AE activity is classified as being directly involved with researching, developing, producing, manufacturing, distributing, selling, or implementing components, goods, or services related to alternative fuels and vehicles; energy efficiency; renewable, nuclear, and natural gas electricity generation; smart grid; and other related technologies. This classification system can include supporting activities such as consulting, finance, tax, and legal services related to AE. This definition characterizes the activities of a firm in the AE industry that is on either the

demand or supply side of the market.⁴ Tennessee has numerous AE assets that are unique to the state. A review of Tennessee's Advanced Energy Asset Inventory⁵ reveals that Tennessee's AE sector is extensive and encompasses a variety of organizations, including research institutions, economic development organizations, companies, and AE entrepreneurs as well as training programs in AE technology. Therefore, it is important to be mindful of these assets, which have likely seen significant expansion, as we define AE for Tennessee.

For example, initiatives at the Tennessee Valley Authority, Oak Ridge National Laboratory, and the University of Tennessee have been responsive to efforts by Tennessee's automotive manufacturers to promote clean and advanced technologies, both in their products and in the operation of their manufacturing facilities. Tennessee has been ranked as the number one state for automotive manufacturing strength in five of the last ten years.⁶ Given the global shift toward energy-efficient and environmentally friendly vehicles, the automotive sector represents a major end-user and manufacturer of AE technologies.

Consistent with previous reports, the familiar NAICS industry accounting scheme is used to identify industries that make up the AE economy. NAICS codes are a common classification system across Canada, Mexico, and the U.S. and cover all economic activity.⁷ NAICS codes identify sectors by grouping firms together that have similar production processes for goods and services. The system, which uses two- through six-digit codes, is hierarchical, where the first two digits identify broad sectors while more digits provide more narrowly defined industry groups.

TENNESSEE ADVANCED ENERGY CASE STUDY

Centrus Energy and HALEU Production

Centrus Energy is a trusted supplier of nuclear fuel and services for the nuclear power industry. Centrus provides value to its utility customers through the reliability and diversity of its supply sources – helping them meet the growing need for clean, affordable, carbon-free electricity. In June 2021, Centrus Energy received approval from the U.S. Nuclear Regulatory Commission to produce high-assay, low-enriched uranium (HALEU) at its

Piketon, Ohio, enrichment facility. The Piketon plant is the only U.S. facility licensed to enrich uranium up to 20 percent Uranium-235 (U-235). Centrus expects to begin demonstrating HALEU production at the facility in Ohio in early 2022. Centrus is building the Piketon cascade to demonstrate the production of HALEU under a three-year, \$115 million cost-shared contract that was signed in 2019 with the Department of Energy Office of Nuclear Energy.

In the original Tennessee Advanced Energy Economic Impact Report, NAICS codes were identified that depict the AE economy by examining previous studies on AE, clean energy, and green energy by other states and national organizations. Each of the selected NAICS codes were identified by either the Center for Community Innovation at the University of California, Berkeley; the Puget Sound Regional Council and the Workforce Development Council of Seattle-King County; Iowa Workforce Development; the Brookings Institution; or the Washington State

4 An alternative means of conceptualizing the advanced energy economy is to consider the characteristics of production and service processes instead of the nature of products and services themselves. This is the approach taken by the Brookings Institution, which examines trends in advanced industries (Muro et al., 2016). Industries are classified as advanced if the R&D spending per worker ranks among the top 20 percent of industries and the share of workers with a high level of STEM knowledge exceeds the national average, which is 21 percent. This results in 50 advanced industries in which output and employment levels are summarized at the national level, state level, and for the largest 100 metropolitan areas. Most definitions of advanced industry, including those discussed in the text, focus on products and services, whereas Brookings seeks to focus on innovation and skills that underlay production processes. This approach is not practical for states since detailed R&D and other data are simply not available.

5 Tennessee Advanced Energy Business Council, "Tennessee Advanced Energy Asset Inventory," September 2013.

6 Tennessee Department of Economic and Community Development. <https://tneecd.com/industries/automotive>

7 North American Industry Classification System, 2017. <https://www.census.gov/naics>

Employment Security Department. This undertaking resulted in a total of 62 four-digit NAICS codes, all of which capture some element of the definition of AE presented above. These selected industries not only include firms that are currently engaged in AE activity but also firms that are poised to take advantage of future growth opportunities in the AE sector.

In this study, we provide an updated impact assessment of the AE sector using the same 62 NAICS codes, with one exception, which we discuss below. Using a similar methodology allows for apple-to-apple comparisons over time. The NAICS codes naturally describe the following five different industry groups:

- AE utilities and construction;
- AE manufacturing;
- AE information;
- AE professional, scientific, and technical services; and
- AE other services (includes administrative and support, waste management and remediation services, and health care and social assistance).

AE manufacturing is the largest group and is composed of 36 four-digit NAICS industries. AE utilities and construction is the second-largest group with nine NAICS industries. AE information includes seven four-digit NAICS industries, while AE professional, scientific, and technical services has six NAICS industries. Finally, AE other services includes four NAICS industries. The selected NAICS codes that characterize the AE economy are listed in Table 1.

Since the last report in 2018, there have been changes to the telecommunications NAICS codes, which affects one of the NAICS codes within AE information. Previously, NAICS code 5172 (Wireless Telecommunications Carriers) was included to evaluate the impact of the AE sector. This code has now been deleted and is currently combined with previous code 5171 to form NAICS 5173. In other words, NAICS 5173 is a new NAICS code that covers both wired and wireless telecommunications, even though the former was not previously considered to be part of the AE industry. For purposes of this report, we assume that the newly created NAICS 5173 represents AE activity and is included in assessing the impact of the AE sector in Tennessee. Below, we discuss in more detail how this change makes direct comparison in AE information outcomes between 2016 and 2019 more challenging, but including the new category is appropriate in evaluating the impact of the AE sector.

TENNESSEE ADVANCED ENERGY CASE STUDY

Techstars Industries of the Future Accelerator

Oak Ridge National Laboratory (ORNL), the Tennessee Valley Authority (TVA), and the University of Tennessee System (UT) partnered together to announce a **Techstars Industries of the Future Accelerator**, a worldwide network that helps entrepreneurs succeed. Over the next three years, the accelerator will work with 30 startups in East Tennessee that use clean energy, AI, big data, cybersecurity, digital currency, 5G, and other

innovations to transform society. This will be the first Techstars-operated accelerator in Tennessee, the first affiliated with a national laboratory, and the first focused on "Industries of the Future." The effort will combine forces of the country's largest science and energy lab in ORNL, the nation's biggest public power utility in TVA, and UT research and education resources that have won international awards for bringing technology to the marketplace.

Table 1: Advanced Energy NAICS Industry Groups

Industry Group	NAICS	Descriptor
Advanced Energy Utilities and Construction	2211	Electric Power Generation, Transmission and Distribution
	2212	Natural Gas Distribution
	2361	Residential Building Construction
	2362	Nonresidential Building Construction
	2371	Utility System Construction
	2379	Other Heavy and Civil Engineering Construction
	2381	Foundation, Structure, and Building Exterior Contractors
	2382	Building Equipment Contractors
	2383	Building Finishing Contractors
Advanced Energy Manufacturing	3211	Sawmills and Wood Preservation
	3221	Pulp, Paper, and Paperboard Mills
	3241	Petroleum and Coal Products Manufacturing
	3251	Basic Chemical Manufacturing
	3252	Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments Manufacturing
	3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing
	3259	Other Chemical Product and Preparation Manufacturing
	3272	Glass and Glass Product Manufacturing
	3279	Other Nonmetallic Mineral Product Manufacturing
	3315	Foundries
	3331	Agriculture, Construction, and Mining Machinery Manufacturing
	3332	Industrial Machinery Manufacturing
	3333	Commercial and Service Industry Machinery Manufacturing
	3334	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing
	3336	Engine, Turbine, and Power Transmission Equipment Manufacturing
	3339	Other General Purpose Machinery Manufacturing
	3341	Computer and Peripheral Equipment Manufacturing
	3342	Communication Equipment Manufacturing
	3343	Audio and Video Equipment Manufacturing
	3344	Semiconductor and Other Electronic Component Manufacturing
	3345	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing
	3346	Manufacturing and Reproducing Magnetic and Optical Media
	3351	Electric Lighting Equipment Manufacturing
	3352	Household Appliance Manufacturing
	3353	Electrical Equipment Manufacturing
	3359	Other Electrical Equipment and Component Manufacturing
	3361	Motor Vehicle Manufacturing
	3362	Motor Vehicle Body and Trailer Manufacturing
	3363	Motor Vehicle Parts Manufacturing
	3364	Aerospace Product and Parts Manufacturing
	3366	Ship and Boat Building
	3369	Other Transportation Equipment Manufacturing
	3391	Medical Equipment and Supplies Manufacturing
3399	Other Miscellaneous Manufacturing	

Table 1: Advanced Energy NAICS Industry Groups (cont'd)

Industry Group	NAICS	Descriptor
Advanced Energy Information	5112	Software Publishers
	5152	Cable and Other Subscription Programming
	5173	Wired and Wireless Telecommunications Carriers
	5174	Satellite Telecommunications
	5179	Other Telecommunications
	5182	Data Processing, Hosting, and Related Services
Advanced Energy Professional, Scientific, and Technical Services	5191	Other Information Services
	5413	Architectural, Engineering, and Related Services
	5414	Specialized Design Services
	5415	Computer System Design and Related Services
	5416	Management, Scientific, and Technical Consulting Services
Advanced Energy Other Services <i>(Includes Administrative and Support, Waste Management and Remediation Services, and Health Care and Social Assistance)</i>	5417	Scientific Research and Development Services
	5419	Other Professional, Scientific, and Technical Services
	5622	Waste Treatment and Disposal
	6215	Medical and Diagnostic Laboratories
	8112	Electronic and Precision Equipment Repair and Maintenance
	8113	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance

The data used to measure the economic impacts of the AE sector stem from the U.S. Census Bureau’s CBP data. The CBP data provides information on the number of establishments, payroll expenditures, and the number of employees by NAICS code and covers all firms in the state. The most recent available data describes economic activity for 2019, providing an update from the previous report in 2018, which used data from 2016. Data are available at the county, MSA, and state level. To prevent confidential data from being released on individual companies, data is withheld for NAICS codes for which there are disclosure concerns.

Since the last report, there have been changes to how disclosure issues are addressed in the CBP data. Previously, if there were fewer than three establishments, the number of establishments were reported, payroll values were suppressed, and an employment size range was given. In past AE reports on Tennessee, the midpoint of the employment size range was used to estimate employment for AE NAICS with disclosure concerns. Now, if there are fewer than three establishments for a given NAICS and geographical area, no data is published. Therefore, it is no longer possible to distinguish whether data is being withheld or whether there is no economic activity associated with AE for a specific NAICS and geographical area.⁸

In practice, disclosure issues decrease as economic activity becomes larger, i.e., going from county-level data to state-level data and considering small counties versus large counties. This change in reporting does not affect measuring the impact of the AE sector at the state level. In fact, employment, annual payroll, and number of establishments are reported for all 62 NAICS codes for the state in 2019, but changes in reporting disclosures partly explain some of the declines in AE employment that are presented in the MSA-level analysis. We discuss this in more detail below.

⁸ Appendix Tables 2 through 11 list the number of employees, payroll expenditures, and number of establishments for each of the 62 NAICS codes that represent the AE sector for each of the ten metropolitan statistical areas. An “NA” means that either data is being withheld or there is no economic activity associated with the specific NAICS and geographical area.

The University of Tennessee

The University of Tennessee (UT) supports the growth of the advanced energy industry in the state through conducting essential R&D, forging lasting private-public partnerships, and supporting burgeoning and established entrepreneurs and innovators. UT's commitment to collaboration and innovation has boosted Tennessee's economy and played a significant role in establishing the state as a growing leader in advanced energy.



UT-ORII's first SMaRT (Student Mentoring & Research Training) internship program. Photos from UT-Oak Ridge Innovation Institute @ut_orii Twitter account.

UT-Oak Ridge Innovation Institute

The University of Tennessee Oak Ridge Innovation Institute (UT-ORII) was established to further align the expertise and infrastructure of Oak Ridge National Laboratory and UT to create a pipeline of world-leading research and talent development. The state of Tennessee recently made an \$8 million investment in UT-ORII, in addition to the U.S. Department of Energy's \$20 million investment over five years to support workforce development and innovation in emerging fields.

Spark Innovation Center

Launched in 2020, the Spark Innovation Center at the UT Research Park provides early-stage technology companies with the level of support and assistance they need to become successful and continue to grow their companies in East Tennessee. In 2021, the Spark Innovation Center announced it secured a \$900,000 award from the Department of Energy. The funding went to the Midwest Regional Innovation Partnership, which is made up of the Clean Energy Trust, Centropolis Accelerator at Lawrence Technological University, mHUB, and Spark Innovation Center. In part, these funds will support the launch of an annual Spark Cleantech Accelerator in summer 2022 at UT Research Park.



UT Research Park at Cherokee Farm



During an announcement ceremony of a research partnership between the University of Tennessee and Volkswagen at Cherokee Research Park. Photo by Steven Bridges/UT

Volkswagen Innovation Hub

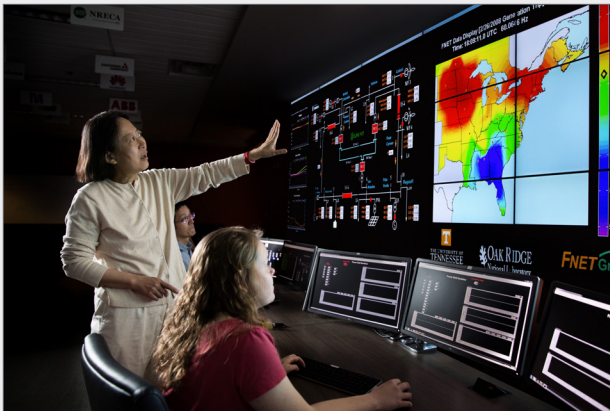
Volkswagen Group of America and UT partnered to create Volkswagen's first innovation hub in North America at the UT Research Park at Cherokee Farm in 2020. The collaboration, which involves Oak Ridge National Laboratory, offers research opportunities for doctoral students and space in the Innovation North building at the UT Research Park at Cherokee Farm in Knoxville. Initial work will focus on developing lighter vehicle components made from composite materials, the electrification of vehicles, and other automotive innovation.

IACMI

Established as a not-for-profit entity under the UT Research Foundation, the Institute of Advanced Composites Manufacturing Innovation (IACMI) provides nationwide open access to a network of existing shared research, development, and demonstration facilities of premier universities and national laboratories located near targeted industry partners. In Morgan County, IACMI designed and built a new composite bridge from fiber-reinforced polymer to replace a damaged, decades-old concrete crossing. This technology is lower cost than traditional methods and can be installed faster, which could benefit the hundreds of structurally deficient bridges across Tennessee. Additionally, IACMI is working with UT, ORNL, and other area partners to train the next generation of the machine tool workforce through local boot camps for high school and college students.



IACMI's Sean Lee and Tessa Patton work on the composite liftgate created for Volkswagen in their lab at SERF (Science Engineering Research Facility) on the campus of UT Knoxville, December 11, 2019. Images by Sam Thomas



Dr. Yilu Liu analyzing data with her students in the control room of the FNET/GridEye system that monitors the nation's power grid

CURRENT

CURRENT, Center for Ultra-Wide-Area Resilient Electric Energy Transmission Networks, is a National Science Foundation Engineering Research Center that is jointly supported by NSF (National Science Foundation) and the DoE (Department of Energy). A collaboration between academia, industry, and national laboratories, CURRENT is led by the University of Tennessee, Knoxville. Partner institutions include: Northeastern University, Rensselaer Polytechnic Institute, and Tuskegee University. CURRENT's vision is a nation-wide or continent-wide transmission grid that is fully monitored and dynamically controlled in real-time for high efficiency, high reliability, low cost, better accommodation of renewable energy sources, full utilization of energy storage, and accommodation of responsive load.

Tennessee's Advanced Energy Economy: Statewide Impacts

Advanced Energy Outcomes

In 2019, there were 393,756 AE jobs in Tennessee, which accounts for 14.5 percent of total jobs in the state. Consistent with the previous report, manufacturing has the largest share of employment at 160,275 jobs or 40.7 percent of total AE employment. Advanced energy utilities and construction continues to be the second largest employer at 104,499 jobs or 26.5 percent of total AE employment. AE professional, scientific, and technical services employs 82,113 workers, representing 20.9 percent of total AE employment. Advanced energy information provides 31,470 jobs (8.0 percent of AE employment), and AE other services provides 15,399 jobs (3.9 percent of AE employment).

As AE manufacturing is the largest employer, it follows that annual payroll is the greatest for AE manufacturing at \$9.4 billion. Consistent with their employment levels, the other AE industry groups follow a similar pattern. Advanced energy professional, scientific, and technical services and AE utilities and construction both incur about \$6 billion in annual payroll expenditures. Firms in AE information spend almost \$2.4 billion in payroll while firms in AE other services spend \$813 million. Together, annual payroll for AE firms in Tennessee totals \$25.0 billion.

TENNESSEE ADVANCED ENERGY CASE STUDY

Bridgestone Invests in Kodiak Robotics

Bridgestone Corporation is the world's largest tire and rubber company, and Bridgestone Americas is headquartered in Nashville, Tennessee. In June 2021, Bridgestone Americas made a minority investment in Kodiak Robotics, a leading U.S.-based self-driving trucking company. The partnership will allow Bridgestone to integrate its smart-sensing tire technologies and fleet solutions into Kodiak's level 4

autonomous trucks. Bridgestone's suite of cloud-based technologies leverages connected vehicle data to help predict tire health and maintenance and optimize tire lifespan. Together, Kodiak and Bridgestone will be able to link vehicle-based and smart-sensing tire technologies to improve vehicle safety, fleet efficiency, and the next generation of autonomous trucking solutions.

Given AE payroll expenditures and employment levels in Tennessee, the overall average AE annual wage is \$63,586, which is substantially higher than the state average for all jobs (\$47,688).⁹ Workers in AE professional, scientific, and technical services and AE information earn the greatest average wage at \$76,938 and \$75,018, respectively. The average wages for AE utilities and construction and AE manufacturing are similar, at about \$58,000, and the average wage for AE other services is \$52,816.

The motor vehicle parts manufacturing (NAICS 3363) sector provides the most jobs at 44,534, which represents 11.3 percent of total AE employment in the state. The second-largest contributing group is building equipment contractors (NAICS 2382), which is under utilities and construction and supports 43,148 jobs or 11.0 percent of total AE employment. The third and fourth category is architectural, engineering, and related services (NAICS 5413) and management, scientific, and technical services (NAICS 5416). Both of these are within AE professional, scientific, and technical services and each supports roughly 20,000 jobs in Tennessee, representing about five percent of total AE employment. Lastly, wire and wireless telecommunications (NAICS 5173), under AE information, is the fifth largest contributor to AE employment at 19,337 workers, which is 4.9 percent of total AE employment. Appendix Table 1 shows employment, annual payroll spending, and the number of establishments for each of the 62 four-digit NAICS codes representing the AE sector in Tennessee.

Table 2: Advanced Energy in Tennessee by Industry Group, 2016

Industry Group	Employment		Payroll (\$1,000)		Number of Establishments	
	Level	% Change 2016-2019	Level	% Change 2016-2019	Level	% Change 2016-2019
AE Utilities and Construction	104,499	5.4%	\$6,108,645	9.2%	9,228	8.4%
AE Manufacturing	160,275	7.5%	\$9,436,825	-0.1%	1,780	-1.7%
AE Information	31,470	56.8%	\$2,360,825	82.9%	1,870	107.8%
AE Professional, Scientific, and Technical Services	82,113	8.6%	\$6,317,624	12.4%	6,506	7.4%
AE Other Services	15,399	6.6%	\$813,316	-1.5%	956	7.4%
Total Advanced Energy Industry	393,756	9.9%	\$25,037,235	9.9%	20,340	11.9%

The number of AE establishments in the state follows a different trend compared to employment and payroll. Similar to the previous report, AE utilities and construction has the largest number of establishments in the state at 9,228, which represents 45.4 percent of all AE establishments in Tennessee. Advanced energy professional, scientific, and technical services has the second-highest number of establishments at 6,506, which is 32.0 percent of all AE establishments. While manufacturing employs the most people in the AE sector, it only has 1,780 establishments. Advanced energy information and AE other services account for 1,870 and 956 establishments, respectively. In total, there are 20,340 AE establishments in Tennessee, which represents 14.6 percent of total establishments in the state.

The number of AE NAICS codes within each AE industry group varies significantly. While the overall AE sector is made up of 62 four-digit NAICS codes, AE manufacturing accounts for 36 of these NAICS codes, while AE utilities and construction is accounts for just nine NAICS codes. As a result, AE utilities and construction has a higher number of employees and establishments per NAICS code compared to AE manufacturing. For example, AE manufacturing has an

⁹ The average annual wage for the AE sector is found by dividing AE payroll spending by AE employment. The state average for all jobs is found by dividing total payroll spending for all sectors by total employment for all sectors, where payroll spending and total employment is from CBP data.

average of 49 establishments and 4,452 employees per NAICS code, while AE utilities and construction has over 21 times as many establishments per NAICS code and more than three times as many employees per NAICS code. A similar pattern holds for AE professional, scientific, and technical services compared to AE manufacturing, which demonstrates the varying density of NAICS codes associated with AE activity within industry groups.

Trends in Advanced Energy Outcomes

Comparing 2019 CBP data to 2016 CBP data used in the 2018 report allows for an analysis of trends in AE outcomes over time. Table 2 shows the percent change from 2016 to 2019 for each outcome, including employment, annual payroll, and the number of establishments for each industry group and for the total AE sector. Since 2016, total AE employment has grown by 9.9 percent, which is nearly double the total job growth in Tennessee (5.1 percent) over the same period of time. Employment in AE professional, scientific, and technical services grew by 8.6 percent while AE manufacturing employment increased by 7.5 percent. Advanced energy other services and AE utilities and construction's employment increased by 6.6 and 5.4 percent, respectively.

TENNESSEE ADVANCED ENERGY CASE STUDY

Volkswagen Electric Vehicle Investment

Volkswagen Group is one of the world's largest producers of passenger cars and Europe's largest automaker. Volkswagen Group of America is expanding its Chattanooga campus to include a new \$800 million battery pack assembly facility and a North American base for manufacturing electric vehicles. With batteries being made and tested in the lab, products

will be able to hit the market faster. Globally, Volkswagen Group plans to commit almost \$50 billion through 2023 toward the development and production of electric vehicles and digital services. Its Tennessee factory will produce electric vehicles using Volkswagen's modular electric toolkit chassis, or MEB, introduced by the company in 2016.

Importantly, AE employment increased overall and for all industry groups; however, comparison between 2016 and 2019 within AE information should be done with caution given the aforementioned changes in the telecommunications NAICS. Table 2 shows that AE information employment has grown by 56.8 percent. Most of this growth is due to combining wired telecommunications, which was not previously considered AE, with wireless telecommunications, which was previously considered AE. If the proportion of employment associated with wired versus wireless telecommunications is assumed to remain constant since 2016, then AE information employment would have held almost steady since 2016.¹⁰ Also playing a role is that employment in some of the other AE information job categories increased since 2016 while other AE information job categories experienced declines in employment. For example, AE employment within software publishers (NAICS 5112) and other telecommunications (NAICS 5179) increased by 59.9 and 20.8 percent, respectively, while other information services (NAICS 5191) and satellite telecommunications (NAICS 5174) decreased by 42.5 and 29.3 percent, respectively. While the change in the information NAICS code is

¹⁰ For reference, in 2016, there were 12,319 employees at 692 establishments in Tennessee for NAICS 5171 (Wired Telecommunications Carriers, which was not considered AE) and 8,369 employees at 342 establishments for NAICS 5172 (Wireless Telecommunications Carriers, which was considered AE). Therefore, only about 40 percent of the combined wired and wireless telecommunications employment was previously considered to be part of the advanced energy sector. In 2019, there were 19,337 employees at 1,200 establishments in Tennessee under NAICS 5173 (Wired and Wireless Telecommunications Carriers).

unfortunate and can make direct comparison for AE information more challenging, occasionally jobs categories have to be altered to better reflect the structure of the economy. Going forward, it is unlikely that there will be multiple changes to the definition of NAICS codes that would in turn impact AE job categories. As changes do take place, they will be discussed in future updates.

Table 2 also shows the growth in annual payroll expenditures for each industry group. To account for the effects of inflation, 2016 payroll (and all other dollar amounts, including state GDP and sales tax revenues) has been adjusted to 2019 dollars using the Consumer Price Index from the Bureau of Labor Statistics. Three out of the five industry groups have experienced growth in adjusted payroll expenditures. Advanced energy manufacturing and AE other services experienced a slight decline in adjusted annual payroll spending. Total adjusted payroll for all AE industries increased by 9.9 percent, which is greater than the growth in payroll spending for all industries in the state (6.2 percent). Advanced energy information's payroll spending increased by 82.9 percent, although changes in information NAICS codes explains some of this change. Advanced energy professional, scientific, and technical services experienced the second-largest growth in annual payroll expenditures at 12.4 percent, followed by AE utilities and construction's payroll spending, which grew by 9.2 percent. Adjusted payroll spending for AE manufacturing and AE other services experienced slight declines in spending (-0.1 and -1.5 percent, respectively).

TENNESSEE ADVANCED ENERGY CASE STUDY

Shoals

Shoals Technologies Group, Inc. (Shoals) is a leading provider of electrical balance of systems solutions for solar, storage, and electric vehicle charging infrastructure. Based in Portland, Tennessee, Shoals marked its Wall Street premiere by raising more than \$2.2 billion in the solar

company's initial public offering (IPO), making it among the most successful IPOs in the solar industry. Shoals' solutions are deployed on more than 20 GW of solar projects globally. The firm and its parent entity first offered 77 million shares of Class A common stock priced at \$25.00 each.

Growth in AE activities is also evident from the rise in AE establishments. The number of total AE establishments increased by 11.9 percent, which is greater than the 3.3 percent growth in total establishments for all industries in Tennessee. Advanced energy information experienced the largest gain in establishments (107.8 percent). The majority of this growth is again due to changes in information NAICS codes; however, without the changes in codes, AE information's establishments are still estimated to have grown by 18.5 percent.¹¹ Establishments in AE utilities and construction grew by 8.4 percent. Advanced energy professional, scientific, and technical services and AE other services both experienced a growth of 7.4 percent in establishments. Establishments in AE manufacturing slightly declined as the number of establishments fell by 1.7 percent.

Analyzing growth in the different AE industry groups reveals that trends may differ depending on whether the outcome is employment, payroll spending, or establishments. For example, employment grew within AE manufacturing even though the number of establishments slightly decreased. This demonstrates how growth can be measured by either the number of employees, establishments, or a combination of these.

¹¹ Estimated growth is calculated assuming that the proportion of establishments associated with wired versus wireless telecommunications is the same as it was in 2016.

Additionally, while there have been changes to how disclosure concerns are reported in the data, there are fewer instances of data not being published, which in and of itself is an indicator of growth. In 2013, data at the state level was withheld for seven NAICS codes for disclosure concerns. In 2016, there was only one instance of state-level data being withheld, and in 2019, there were no instances of data being withheld at the state level because of disclosure concerns.

TENNESSEE ADVANCED ENERGY CASE STUDY

TDEC and Stone Mountain Technologies

The Tennessee Department of Environment and Conservation (TDEC) partnered with TAEBC Member and Energy Mentor Network graduate Stone Mountain Technologies, the National Association of State Energy Officials, and TAEBC to validate a gas absorption hot water heat pump technology for a commercial setting. This

partnership was made possible thanks to funding from the U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy to install promising building technologies and systems in commercial and multifamily buildings that DOE expects to significantly improve energy efficiency, demand flexibility, and building-to-grid capabilities.

Overall, analysis of the updated 2019 CBP data shows that the AE sector in Tennessee and within each industry group has continued to grow since publication of the two previous reports. Moreover, the rate of growth for employment, establishments, and inflation-adjusted payroll expenditures associated with AE activities is higher than the growth rates for all industries within Tennessee.

Showing longer-term trends in AE activity in Tennessee, Figures 1 through 3 show employment, inflation-adjusted payroll, and the number of establishments in 2013, 2016, and 2019 for each industry group. Consistent with the discussion above, the AE sector in Tennessee continues to grow, within the industry sub-groups and overall.

Figure 1: Trends in Advanced Energy Employment, 2013-2019

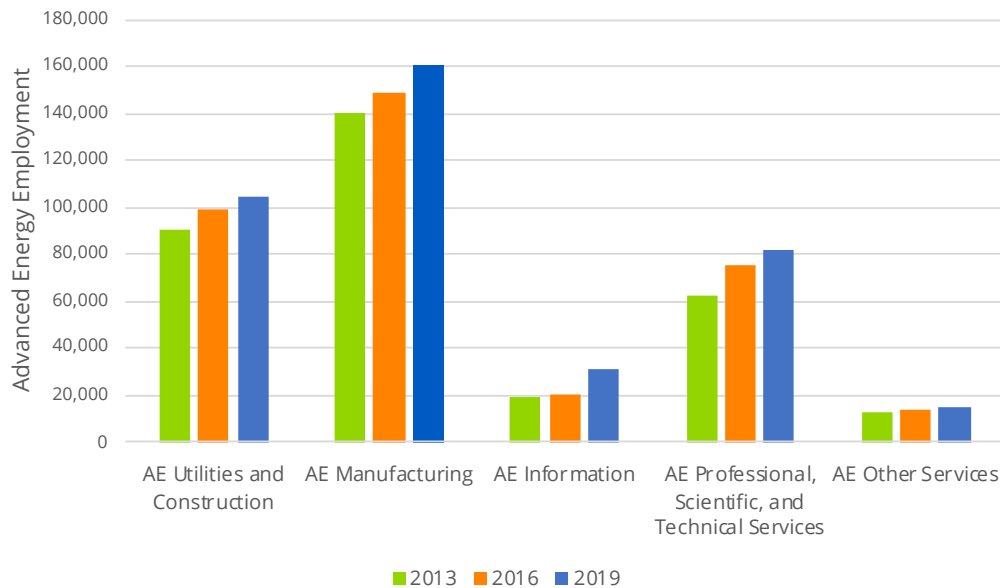


Figure 2: Trends in Advanced Energy, Inflation-Adjusted Payroll, 2013-2019 (\$1,000 2019 Dollars)

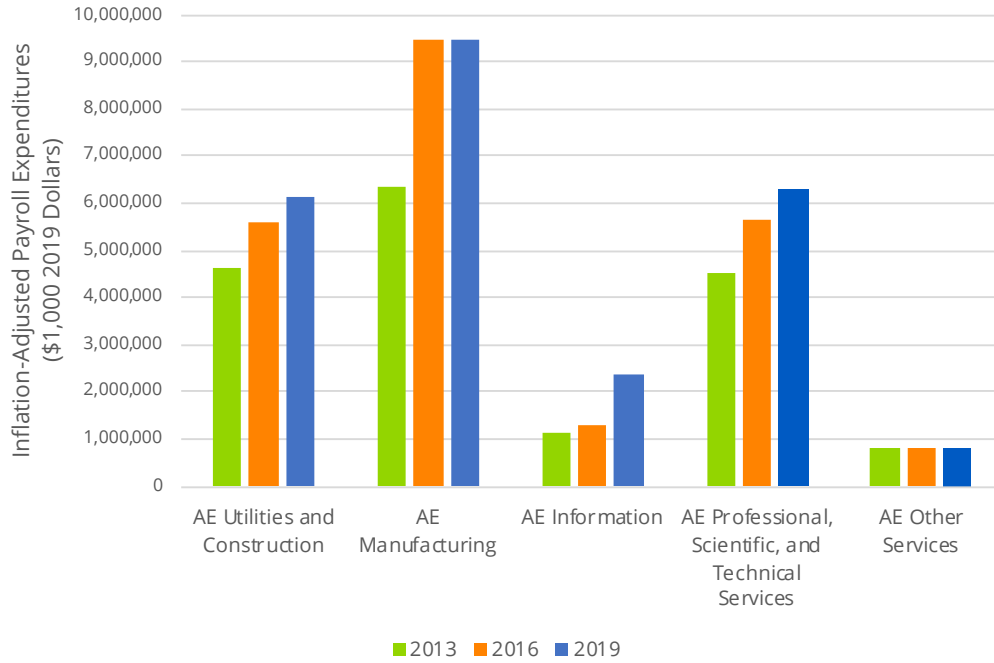
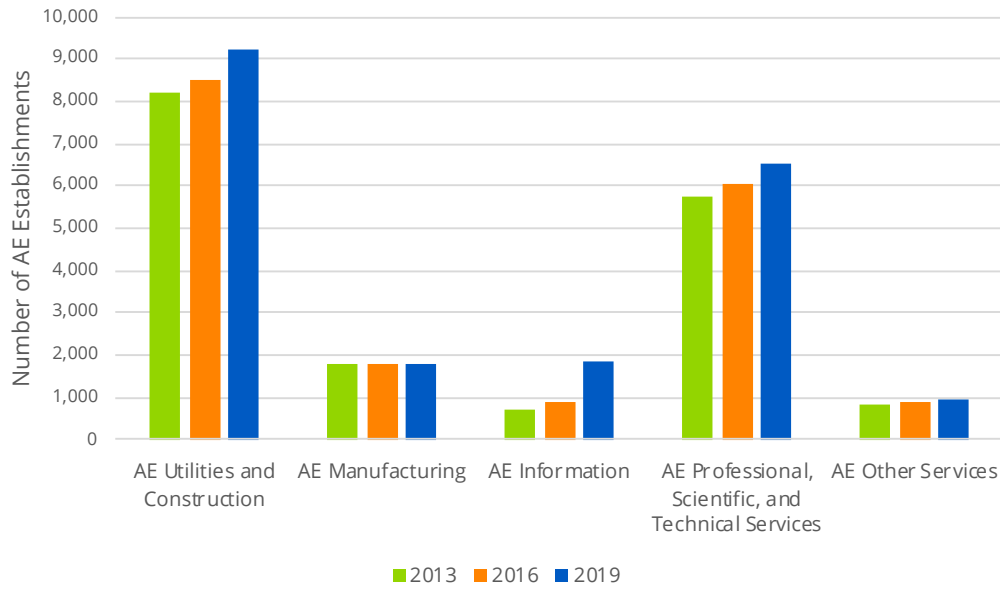


Figure 3: Trends in Advanced Energy Establishments, 2013-2019



Output and Impact on Tax Revenues

Data from the U.S. Bureau of Economic Analysis (BEA) is used to estimate the output or GDP that is generated by the AE sector in Tennessee. Specifically, the ratio of output per worker from BEA is multiplied by the number of employees in each AE industry group (from CBP data) to estimate GDP. Consistent with the previous report, AE manufacturing continues to contribute the most to state GDP and provides \$23.6 billion in output (see Table 3). Advanced energy utilities and construction and AE professional, scientific, and technical services produce similar amounts of output at \$7.7 and \$7.6 billion, respectively. Advanced energy information generated \$6.0 billion in state GDP while AE other services supplied \$932.2 million.

TENNESSEE ADVANCED ENERGY CASE STUDY

Energy Mentor Network

The Energy Mentor Network (EMN) is run by TAEBEC in partnership with Launch Tennessee. Its goal is to foster the growth of Tennessee's advanced energy technologies and startups by connecting entrepreneurs with mentors and industry-specific expertise. The program is modeled after CONNECT San Diego's 30+-year-old Springboard program. The purpose of the program is to develop quality startups. After completing the program, startups will have an investable pitch deck, a rock-solid business model, and a plan to establish more traction. These tools will position Tennessee's entrepreneurs to raise capital, request other funds like Small Business Innovation Research (SBIR) grants, and scale their companies. Many EMN companies are also enrolled in Oak Ridge National Laboratory's Innovation Crossroads program, where they gain expert support and mentorship that will lead to successful commercialization. Three notable EMN graduates include SkyNano Technologies, Active Energy Systems, and Nth Cycle.



SkyNano Technologies: A 2019 EMN graduate, SkyNano Technologies was co-founded by Anna Douglas and Cary Pint to develop a novel technique that makes the production of highly sought-after carbon nanotubes much more efficient, affordable, and scalable. Among other developments, SkyNano Technologies has won a National Science Foundation (NSF) SBIR Phase I grant and a \$2.5 million Department of Energy award, and landed its first customer.



Active Energy Systems: A 2019 EMN graduate, Active Energy Systems was co-founded by Mitchell Ishmael and Levon Atoyan to develop an innovative ice thermal storage system to provide cooling that is affordable, efficient, and resilient. In April 2021, Active Energy Systems was awarded a \$999,444 NSF Phase II SBIR grant.



Nth Cycle: A 2020 EMN graduate, Nth Cycle was co-founded by Megan O'Connor to scale its technology for battery recycling for sustainable mining, which leverages the power of electro-extraction: clean and modular technology for reliably recovering critical minerals from e-waste, low-grade ore, and mine tailings using electricity. In April 2021, Nth Cycle secured \$3.2 million in seed funding from Clean Energy Ventures.

Together, the AE sector in Tennessee generated a total of \$45.8 billion in state GDP in 2019, which represents 12.2 percent of total GDP for the state. Output generated by the overall AE sector grew by 8.2 percent since 2016, a very healthy pace of growth. (The growth rates for GDP and sales tax revenues in Table 3 have been adjusted for inflation similar to the dollar amounts for 2016 payroll expenditures.)

Table 3: Advanced Energy State GDP and Sales Tax Revenues in Tennessee by Industry Group, 2019

Industry Group	GDP		State Sales Tax Revenue		Local Sales Tax Revenue	
	Level (\$1,000)	% Change 2013-2016	Level (\$1,000)	% Change 2013-2016	Level (\$1,000)	% Change 2013-2016
AE Utilities and Construction	\$7,726,997	2.8%	\$193,100	-10.3%	\$58,094	-23.2%
AE Manufacturing	\$23,563,169	-1.6%	\$588,852	62.0%	\$177,155	38.7%
AE Information	\$5,973,162	65.2%	\$149,271	200.4%	\$44,908	157.2%
AE Professional, Scientific, and Technical Services	\$7,616,143	18.5%	\$190,330	-12.1%	\$57,260	-24.7%
AE Other Services	\$932,208	11.4%	\$23,296	-26.7%	\$7,009	-37.3%
Total Advanced Energy Industry	\$45,811,680	8.2%	\$1,144,850	30.6%	\$344,426	11.8%

The ratio of sales tax revenue to GDP for all industries and the GDP specific to each AE industry group is used to estimate sales tax revenues.¹² Consistent with 2016, AE manufacturing generates the most in state and local sales tax revenues at \$588.9 million and \$177.2 million, respectively. Advanced energy utilities and construction provides a slightly larger amount of sales tax revenue at the state (\$193.1 million) and local (\$58.1 million) levels than AE professional, scientific, and technical services (\$190.3 million for the state and \$57.3 million locally). Advanced energy information generated \$149.3 million in state sales tax revenue and \$44.9 million in local sales tax revenue. Finally, AE other services produced \$23.3 million and \$7.0 million in state and local sales tax revenues, respectively. Advanced energy manufacturing and AE information experienced the largest gains in sales tax revenues. In total, state sales tax revenue totaled \$1.1 billion and local sales tax revenue totaled \$344.4 million in 2019.

¹² GDP data is from the U.S. Bureau of Economic Analysis and state and local sales tax revenue data is from the Tennessee Department of Revenue, State Sales Tax Revenue Data, 2019.

Energy System of the Future: TVA Powers the Valley's Economy

The Tennessee Valley Authority is preparing for the economic future of the Valley by planning the Energy System of the Future. Low-carbon, low-cost, and highly reliable energy will power the strategies and climate goals of large and small businesses and will continue to attract industries and jobs that support the Valley's economic growth and prosperity.



Already a leader in low-carbon energy, TVA aspires to achieve a net-zero-carbon energy future by 2050. Our robust, diverse power generation mix has already led to a 63 percent reduction in total mass carbon emissions since 2005 – and current plans put TVA on a trajectory to achieve 70 percent reduction by 2030 and an approximately 80 percent reduction in carbon emissions by 2035. We are committed to achieving these goals while continuing to deliver low-cost energy with 99.999 percent reliability.

Low-carbon, low-cost, and highly reliable energy creates a powerful competitive advantage for the Valley. During the past five years, TVA has attracted and retained approximately 341,000 jobs and more than \$45.4 billion in direct investment. Even in 2020 during the COVID-19 pandemic, our ability to decrease carbon emissions and grow innovative programs – such as TVA Green Invest, energy storage, and the electric vehicle fast charge network – helped to attract and keep approximately 67,000 jobs and \$8.6 billion in invested capital in the Valley.



Project	Customer	Capacity (MW _{DC})	Developer	TN County
Bell Buckle	Vanderbilt	35	Silicon Ranch	Bedford
Elora	Facebook	150	NantEtra	Lincoln
Graceland	Facebook / TVA	150	RWE	Shelby
McKellar	Facebook	70	Silicon Ranch	Madison
Moore	Vanderbilt, Metro Nashville, KUB, Jack Daniels	200	Silicon Ranch	Moore
Ridgely	KUB	177	First Solar	Lake
Skyhawk	Google	100	Origis	Obion
Yum Yum	Google	147	Invenergy	Fayette

*In addition to current Tennessee projects, five projects within the TVA service region will have 950 MW_{DC} capacity with 180 MW of battery storage.

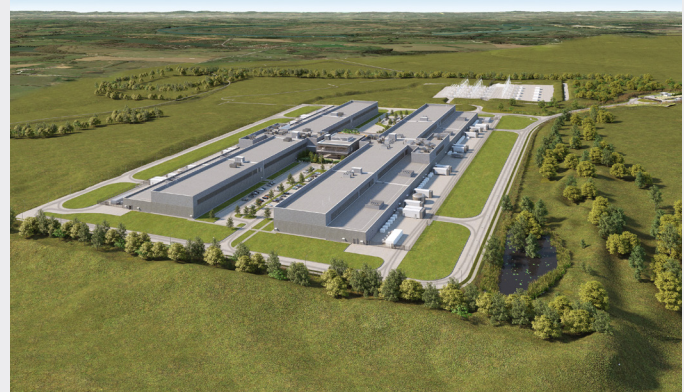
TVA Green Invest Solar Projects
As of June 25, 2021

TVA's Green Invest program matches customer demand for renewable energy with in-Valley, large-scale renewable projects.

Green Invest

Global technology companies that require vast data centers and computing power are serious about the Valley, in part because of TVA Green Invest. Through a competitive procurement process, this award-winning program leverages a unique private-public partnership structure that matches customer demand for renewable energy with in-Valley, large-scale renewable projects like the 150-megawatt Elora Solar Project in Lincoln County, Tennessee. This unique approach benefits the region with jobs and investments from new solar facilities and businesses that locate in the Valley.

Facebook and Google have both established major operations across TVA's seven-state region because Green Invest can help meet their ambitious environmental goals at a competitive price. Local power companies that purchase power from TVA also leverage the Green Invest program to meet sustainability needs for customers that include General Motors, Vanderbilt



TVA is partnering with RWE Renewables to deliver 110 MW of solar energy to support the \$800 million, nearly 1 million square-foot Facebook data operations center in Gallatin, Tennessee.

University, Metro Government of Nashville, and Jack Daniel's Distillery. And, Knoxville Utilities Board and Starkville Utilities have Green Invest commitments to help them meet community and local government renewable energy goals. In total, since 2018, the Green Invest program has generated nearly \$2.7 billion in solar investment and more than 2,100 MW of power.

Energy Storage

A key part of TVA's long-term energy strategy is battery storage expansion. TVA has procured 180 MW of battery storage in conjunction with solar projects, and we are installing our first owned and operated grid-scale battery energy storage system near Vonore, Tennessee. The Vonore Battery Energy Storage System (BESS) will use lithium-ion batteries – the same battery chemistry technology used in most electric vehicles – to store 40 megawatt-hours of energy. The Vonore BESS will be TVA's first battery storage system to go online, but not the only grid-scale battery storage system TVA will use. Battery storage projects are part of the TVA Integrated Resource Plan (IRP), a comprehensive study for how TVA can provide low-carbon, low-cost, and highly reliable energy for the next 20 years. The IRP calls for adding up to 5 gigawatts of energy storage capacity through 2038.

Electric Vehicles

Electric vehicles are the cars of the future – and TVA is driving electric vehicle innovation forward in the Valley. Through partnerships with state agencies, local power companies and third-party battery charging developers, we are creating a foundational network of public fast-charging stations along major travel routes in our seven-state region. TVA's collaboration with the Tennessee Department of Environment and Conservation is a prime example of these important partnerships. Following federal Department of Transportation guidelines, TDEC and TVA are developing and helping to fund a network of fast-charging stations that will be located at least every 50 miles along Tennessee interstates and major highways. When completed by 2026, these fast-charging corridors will provide electric vehicle drivers added confidence to travel long distances throughout the region in emissions-free battery powered vehicles.

A View to the Future

Today's businesses choose locations served by dependable and environmentally conscious power companies that can help them achieve their sustainability goals. TVA supports their targets by innovating for the future of the Valley. Our on-going investments in, and investigations of, safe, reliable, affordable, flexible, and carbon-free power generation technologies will provide the clean energy people and businesses expect today... and are demanding for the future.

Learn more about TVA's mission of service at www.tva.com.



Allen Combined Cycle Plant in Memphis is the most efficient combined cycle plant in the TVA gas fleet and includes more than 3,000 solar panels that provide just under 1 megawatt of renewable energy capacity.



TVA and the Tennessee Department of Environment and Conservation are developing a network of fast-charging stations along Tennessee's interstates and major highways.

The Advanced Energy Economy in Tennessee's Metropolitan Areas

CBP data at the MSA level are used to identify where economic activity for the AE sector is occurring across Tennessee's largest cities. In Tables 4 through 13, employment, annual payroll, and the number of establishments by AE industry group are shown for all 10 metropolitan areas in Tennessee. Similar to above, growth rates between 2016 and 2019 are shown for each outcome, and 2016 annual payroll expenditures are adjusted to account for inflation.

Table 4 presents economic data for the **Nashville MSA**, which is the largest MSA in Tennessee and includes AE activity in Cannon, Cheatham, Davidson, Dickson, Hickman, Macon, Maury, Robertson, Rutherford, Smith, Sumner, Trousdale, Williamson, and Wilson Counties. In 2019, there were 119,924 AE employees in the Nashville MSA, which represents 13.5 percent of total employment in the MSA. Similar to 2016, AE utilities and construction is the largest employer with 39,604 jobs. Advanced energy professional, scientific, and technical services is the second largest employer with 31,664 jobs, followed by AE manufacturing, which employs 27,313 workers. With the exception of AE manufacturing, all AE industry groups experienced gains in employment since 2016, and total AE employment in the Nashville MSA grew by 4.2 percent. Annual payroll expenditures in the Nashville MSA totaled \$8.0 billion, and AE utilities and construction, AE information, and AE other services experienced growth in payroll spending. As is the case for almost all the MSAs, the largest growth in outcomes occurred within AE information. Some of this growth demonstrates gains in the AE sector, but some growth is attributable to the aforementioned changes in NAICS codes, which now include wireless and wired telecommunications carriers. Lastly, establishments associated with AE activity in the Nashville MSA totaled 7,314, which reflects 14.4 percent growth since 2016.

Given that employment ranges are no longer produced in the CBP data in cases where there are disclosure concerns for a given NAICS and geographical area, employment for some MSAs may decrease from 2016. For example, for the Nashville MSA, there was one instance of no activity and eight instances of data being withheld in 2016. However, for those eight instances of data being withheld, employment ranges were still given, and the midpoint was used to estimate employment for each of the affected NAICS codes in 2016. In 2019, there were eight instances of data not being published, due to either no activity or data being withheld. (The data do not distinguish between these two scenarios.) Seven of these eight instances in 2019 are within AE manufacturing, which helps to explain the 21.6 percent decline in AE manufacturing employment in the Nashville MSA (see Table 4). However, while employment ranges and establishments are not reported in disclosure cases in the 2019 data, total AE

activity increased in the Nashville MSA for all economic outcomes, including employment, payroll, and establishments.

While reporting changes make it more difficult to directly compare changes in employment between 2016 and 2019 at the MSA level, these changes can be necessary for publicly available data. Importantly, for nine out of the 10 metropolitan areas in Tennessee, there were fewer instances of no activity or data being withheld in 2019 compared to 2016, which is an indicator of growth in AE activity within each MSA.

Table 4: Advanced Energy in Nashville-Davidson-Murfreesboro-Franklin, TN MSA by Industry Group, 2019

Industry Group	Employment		Annual Payroll (\$1,000)		Number of Establishments	
	Level	% Change 2016 - 2019	Level	% Change 2016 - 2019	Level	% Change 2016 - 2019
AE Utilities and Construction	39,604	6.5%	\$2,484,021	9.5%	3,290	13.8%
AE Manufacturing	27,313	-21.6%	\$1,427,343	-8.4%	445	-5.7%
AE Information	15,098	57.2%	\$1,246,981	71.6%	666	66.9%
AE Professional, Scientific, & Technical Services	31,664	13.4%	\$2,564,192	16.2%	2,621	11.2%
AE Other Services	6,245	12.9%	\$289,438	-2.3%	292	5.0%
Total Advanced Energy Industry	119,924	4.2%	\$8,011,975	13.5%	7,314	14.4%

The **Memphis MSA** is the second largest AE employer. The Memphis MSA includes Fayette, Shelby, and Tipton Counties in Tennessee; Crittenden County in Arkansas; and Benton, DeSoto, Marshall, Tate, and Tunica Counties in Mississippi. In 2019, there were 55,153 workers in the AE sector, which is 10.0 percent of total employment in the Memphis MSA. Advanced energy utilities and construction and AE manufacturing continue to be the largest employers, with 19,760 and 14,457 employees, respectively. Again, changes in disclosure reporting help to explain some of the declines in employment for the AE industry groups, but even in light of these changes, total AE employment for the Memphis MSA only slightly decreased from 2016 (by -1.1 percent). Total payroll spending related to AE activity in the Memphis MSA totaled \$3.4 billion. The total number of AE establishments is 3,210, which is a 7.4 percent increase from 2016.

Table 5: Advanced Energy in Memphis, TN-MS-AR MSA by Industry Group, 2019

Industry Group	Employment		Annual Payroll (\$1,000)		Number of Establishments	
	Level	% Change 2016 - 2019	Level	% Change 2016 - 2019	Level	% Change 2016 - 2019
AE Utilities and Construction	19,760	7.6%	\$1,143,209	6.8%	1,463	5.5%
AE Manufacturing	14,457	-21.2%	\$969,700	2.6%	227	-12.0%
AE Information	4,544	19.1%	\$236,357	86.5%	337	105.5%
AE Professional, Scientific, & Technical Services	13,268	13.7%	\$846,671	17.2%	1,032	1.3%
AE Other Services	3,124	-12.0%	\$174,786	-13.5%	151	-6.8%
Total Advanced Energy Industry	55,153	-1.1%	\$3,370,723	9.9%	3,210	7.4%

The **Knoxville MSA** is the third-largest employer of AE workers. Table 6 lists employment, annual payroll, and the number of establishments for AE activity in the Knoxville MSA, which includes Anderson, Blount, Campbell, Grainger, Knox, Loudon, Morgan, Roane, and Union Counties. Employment in the AE sector totaled 50,529, which is 14.7 percent of total employment in the MSA. The Knoxville MSA is unique in that AE professional, scientific, and technical services employs the most workers (17,169) while either AE utilities and construction or AE manufacturing is the leading employer in all the other MSAs. Annual payroll spending associated with AE activity totaled \$3.6 billion, which is an increase of 10.3 percent since 2016. Advanced energy establishments grew for all the industry groups, with the exception of manufacturing. Together, there are 2,984 AE establishments in the Knoxville MSA, which is an increase of 9.7 percent since 2016.

Table 6: Advanced Energy in Knoxville, TN MSA by Industry Group, 2019

Industry Group	Employment		Annual Payroll (\$1,000)		Number of Establishments	
	Level	% Change 2016 - 2019	Level	% Change 2016 - 2019	Level	% Change 2016 - 2019
AE Utilities and Construction	13,497	0.2%	\$732,186	5.1%	1,280	7.8%
AE Manufacturing	14,558	-7.5%	\$858,362	24.4%	209	-9.1%
AE Information	3,265	-1.7%	\$202,256	82.2%	255	136.1%
AE Professional, Scientific, & Technical Services	17,169	-0.9%	\$1,686,946	4.7%	1,077	2.0%
AE Other Services	2,040	-24.2%	\$142,386	-18.1%	163	17.3%
Total Advanced Energy Industry	50,529	-3.8%	\$3,622,136	10.3%	2,984	9.7%

Table 7 lists the economic outcomes associated with AE activity in the **Chattanooga MSA**, which includes Hamilton, Marion, and Sequatchie Counties in Tennessee and Catoosa, Dade, and Walker Counties in Georgia. Total employment for the AE sector was 30,447 in 2019, which is 13.2 percent of total employment in the Chattanooga MSA. Following the general trend, AE utilities and construction and AE manufacturing are the largest employers with 10,847 and 9,859 workers, respectively. Advanced energy payroll spending summed to \$1.8 billion, and there were 1,780 AE establishments in the Chattanooga MSA. As is the case for the top four MSAs, AE utilities and construction has the largest number of establishments (757), followed by AE professional, scientific, and technical services (620). The addition of wired to wireless telecommunications in one of the AE information NAICS codes explains some of the growth seen in all outcomes for the AE information sector.

Table 7: Advanced Energy in Chattanooga, TN-GA MSA by Industry Group, 2019

Industry Group	Employment		Annual Payroll (\$1,000)		Number of Establishments	
	Level	% Change 2016 - 2019	Level	% Change 2016 - 2019	Level	% Change 2016 - 2019
AE Utilities and Construction	10,847	9.6%	\$694,047	14.0%	757	9.4%
AE Manufacturing	9,859	-22.3%	\$558,615	18.3%	171	1.8%
AE Information	2,227	60.8%	\$120,426	67.0%	143	104.3%
AE Professional, Scientific, & Technical Services	6,221	3.5%	\$359,510	8.9%	620	11.5%
AE Other Services	1,293	10.9%	\$63,492	-7.5%	89	8.5%
Total Advanced Energy Industry	30,447	-2.2%	\$1,796,090	15.8%	1,780	13.5%

The next largest employer in the AE sector is the **Kingsport MSA**, which includes Hawkins and Sullivan Counties in Tennessee and Scott County, Washington County, and Bristol City in Virginia. In 2019, the AE sector in the Kingsport MSA supported 19,437 jobs, which is 18.9 percent of total employment in the area. Total AE employment decreased by 13.1 percent since 2016. The Kingsport MSA had the most data withheld in 2016 (25 instances) in which there were employment ranges provided but no payroll data reported. In 2019, data were reported and not withheld for 10 of the 25 instances, which demonstrates growth in the AE sector, which is especially evident from AE manufacturing's payroll spending. However, in 15 of the 25 instances, data is not reported in 2019, which explains the decrease in AE employment for the Kingsport MSA. In 2019, annual payroll spending totaled \$1.34 billion. The significant increase in payroll spending is due to instances where payroll was not reported in 2016 due to disclosure concerns but was reported in 2019 due to growth in the AE sector. Lastly, AE establishments in the Kingsport MSA totaled 734 in 2019.

Table 8: Advanced Energy in Kingsport-Bristol-Bristol, TN-VA MSA by Industry Group, 2019

Industry Group	Employment		Annual Payroll (\$1,000)		Number of Establishments	
	Level	% Change 2016 - 2019	Level	% Change 2016 - 2019	Level	% Change 2016 - 2019
AE Utilities and Construction	4,618	1.0%	\$232,567	6.6%	348	-0.9%
AE Manufacturing	11,815	-16.4%	\$952,888	907.3%	69	-20.7%
AE Information	775	16.4%	\$40,966	204.2%	58	152.2%
AE Professional, Scientific, & Technical Services	1,144	-48.8%	\$63,495	-68.4%	191	0.0%
AE Other Services	1,085	41.3%	\$50,086	24.0%	68	21.4%
Total Advanced Energy Industry	19,437	-13.1%	\$1,340,002	136.2%	734	3.7%

Table 9 presents economic data for the **Clarksville MSA**, which includes Montgomery County in Tennessee and Christian and Trigg Counties in Kentucky. In 2019, the AE sector supported 11,401 jobs in the Clarksville MSA, which is 15.6 percent of total employment. Consistent with 2016, AE manufacturing is the largest employer with 6,315 workers, followed by AE utilities and construction (2,383 employees) and AE professional, scientific, and technical services (2,223 employees). Annual payroll spending associated with AE activity totaled \$611.9 million. Again, changes in disclosure reporting explain declines in employment. The considerable increase in all economic outcomes for AE information is due to changes in the AE information NAICS codes. Finally, there were 621 AE establishments in the Clarksville MSA in 2019.

Table 9: Advanced Energy in Clarksville, TN-KY MSA by Industry Group, 2019

Industry Group	Employment		Annual Payroll (\$1,000)		Number of Establishments	
	Level	% Change 2016 - 2019	Level	% Change 2016 - 2019	Level	% Change 2016 - 2019
AE Utilities and Construction	2,383	22.9%	\$125,086	47.6%	337	7.0%
AE Manufacturing	6,315	-27.6%	\$310,696	59.6%	47	-24.2%
AE Information	370	245.8%	\$23,383	279.0%	47	235.7%
AE Professional, Scientific, & Technical Services	2,223	33.7%	\$148,284	49.6%	159	8.9%
AE Other Services	110	-41.2%	\$4,490	-47.5%	31	-6.1%
Total Advanced Energy Industry	11,401	-9.6%	\$611,939	55.6%	621	8.9%

Table 10 presents economic data for Chester, Crockett, and Madison Counties in Tennessee, which make up the **Jackson MSA**. In 2019, total AE employment for this area was 5,280, which is 9.0 percent of total employment. Consistent with 2016, AE manufacturing and AE utilities and construction account for the majority of the AE jobs at 2,181 and 1,967, respectively. Changes for one of the NAICS codes within AE information drives some of the more substantial increases in all outcomes for AE information. However, the significant growth in employment and payroll within AE other services is due to increases in AE activity, particularly within the medical and diagnostic laboratories NAICS code. Total payroll associated with AE activity in the Jackson MSA was \$302.8 million, and AE establishments totaled 331 in 2019.

Table 10: Advanced Energy in Jackson, TN MSA by Industry Group, 2019

Industry Group	Employment		Annual Payroll (\$1,000)		Number of Establishments	
	Level	% Change 2016 - 2019	Level	% Change 2016 - 2019	Level	% Change 2016 - 2019
AE Utilities and Construction	1,967	-11.4%	\$119,023	-1.6%	188	-2.6%
AE Manufacturing	2,181	-30.2%	\$115,284	89.8%	29	-34.1%
AE Information	270	203.4%	\$16,256	275.5%	22	120.0%
AE Professional, Scientific, & Technical Services	420	-4.5%	\$24,022	3.8%	75	-11.8%
AE Other Services	442	689.3%	\$28,215	397.5%	17	0.0%
Total Advanced Energy Industry	5,280	-10.9%	\$302,800	41.0%	331	-5.2%

Economic data for the **Morristown MSA**, which consists of Hamblen and Jefferson Counties, is presented in Table 11. Total AE employment totaled 5,024 in 2019, which represents 12.5 percent of total employment in the MSA. Advanced energy manufacturing and AE utilities and construction continue to be the largest AE employers at 3,526 and 1,090, respectively. Once again, changes in an AE information NAICS code drives most of the growth in the AE information sector, and changes in reporting disclosure issues drives a lot of the declines in employment. Within AE professional, scientific, and technical services, AE activity has decreased some, particularly for computer system design and related services and management, scientific, and technical consulting services. Total payroll for all AE industry groups in the Morristown MSA totaled \$265.2 million, and there were 204 establishments associated with AE activity.

Table 11: Advanced Energy in Morristown, TN MSA by Industry Group, 2019

Industry Group	Employment		Annual Payroll (\$1,000)		Number of Establishments	
	Level	% Change 2016 - 2019	Level	% Change 2016 - 2019	Level	% Change 2016 - 2019
AE Utilities and Construction	1,090	-10.8%	\$59,492	36.4%	118	4.4%
AE Manufacturing	3,526	-21.3%	\$186,956	2.0%	14	-62.2%
AE Information	137	114.1%	\$8,297	217.3%	14	75.0%
AE Professional, Scientific, & Technical Services	208	-31.6%	\$7,317	-14.1%	46	-2.1%
AE Other Services	63	-51.5%	\$3,117	NA	12	100.0%
Total Advanced Energy Industry	5,024	-19.0%	\$265,179	11.4%	204	-3.3%

Table 12 presents employment, payroll, and establishment data for the **Johnson City MSA**, which consists of Carter, Unicoi, and Washington Counties in Tennessee. Total employment for the AE sector is 4,574 workers, which is 6.8 percent of total employment in the area. Advanced energy utilities and construction is the largest AE employer (1,687 jobs), followed by AE information (1,100 jobs). Declines in employment since 2016, especially within AE manufacturing, can be explained by withheld data in 2019. Total payroll spending related to AE activity totaled \$229.5 million. Total AE establishments increased by 7.7 percent since 2016 to 491 establishments.

Table 12: Advanced Energy in Johnson City, TN MSA by Industry Group, 2019

Industry Group	Employment		Annual Payroll (\$1,000)		Number of Establishments	
	Level	% Change 2016 - 2019	Level	% Change 2016 - 2019	Level	% Change 2016 - 2019
AE Utilities and Construction	1,687	-4.5%	\$78,092	19.3%	261	7.0%
AE Manufacturing	685	-80.5%	\$31,283	25.9%	24	-35.1%
AE Information	1,100	65.7%	\$57,320	177.6%	48	152.6%
AE Professional, Scientific, & Technical Services	924	-12.4%	\$48,849	27.9%	132	-0.8%
AE Other Services	178	-7.8%	\$13,925	112.8%	26	13.0%
Total Advanced Energy Industry	4,574	-36.3%	\$229,469	47.4%	491	7.7%

Lastly, **Table 13** summarizes employment, payroll spending, and the number of establishments related to AE activities for the **Cleveland MSA**, which includes Bradley and Polk Counties in Tennessee. Total AE employment in 2019 was 2,740 jobs, which represents 6.4 percent of total jobs in the area. Advanced energy utilities and construction is the largest AE employer with 1,133 jobs, while AE manufacturing is the second-largest AE employer with 900 jobs. Data being withheld in 2019 rather than an employment range being supplied as in 2016 drives declines in employment, especially within AE manufacturing and AE other services. However, AE activity increased by 30.5 percent for AE utilities and construction and by 31.6 percent for AE professional, scientific, and technical services. Payroll spending related to AE activities totaled \$147.7 million in the Cleveland area, and the total number of establishments was 245 in 2019.

Table 13: Advanced Energy in Cleveland, TN MSA by Industry Group, 2019

Industry Group	Employment		Annual Payroll (\$1,000)		Number of Establishments	
	Level	% Change 2016 - 2019	Level	% Change 2016 - 2019	Level	% Change 2016 - 2019
AE Utilities and Construction	1,133	30.5%	\$58,807	51.0%	129	10.3%
AE Manufacturing	900	-78.0%	\$58,386	202.3%	19	-38.7%
AE Information	158	177.2%	\$11,574	441.1%	20	122.2%
AE Professional, Scientific, & Technical Services	517	31.6%	\$17,364	0.4%	73	0.0%
AE Other Services	32	-73.3%	\$1,558	-21.4%	4	-60.0%
Total Advanced Energy Industry	2,740	-50.5%	\$147,689	85.4%	245	2.1%

County-Level Economic Impacts from the Advanced Energy Economy

A small number of counties account for a large portion of AE activity in the state. The top 20 AE counties support 255,669 AE jobs at 14,883 establishments, spending \$17.2 billion in payroll expenditures. Employment for the top 20 AE counties account for 64.9 percent of total AE employment in Tennessee.

Table 14 lists the county-level CBP data for the top 20 counties and partially disaggregates the MSA-level data to show employment, payroll spending, and the number of establishments for the largest AE counties in Tennessee. Eighteen of the top 20 counties in 2016 remained in the top 20 in 2019. New to the top 20 are Putnam and Monroe Counties, which are ranked 15th and 20th in 2019 but were ranked 22nd and 21st in 2016, respectively. Falling out of the top 20 are Bradley and Robertson Counties, which were ranked 11th and 12th in 2016 and just missed the top 20 in 2019 at 22nd and 23rd, respectively. Seven counties moved up in the rankings within the top 20 and five counties held steady in their ranking.

Davidson, Shelby, Hamilton, and Knox Counties continue to be in the top five AE counties. Williamson and Rutherford switched fifth and sixth place between 2016 and 2019, resulting in Williamson being the fifth top AE county in 2019. Davidson County is the largest AE employer in the state with AE employment totaling 54,745, which is an 18.2 percent increase since 2016 and pushed Davidson from ranking second in 2016 to ranking first in 2019. There are 2,998 advanced energy establishments in Davidson County, and payroll spending sums to \$4.0 billion. Shelby County is the second-largest AE employer in the state. In 2019, there 44,259 AE employees in Shelby County at 2,417 establishments with \$2.8 billion in payroll expenditures. Hamilton County is the third-largest AE county in Tennessee at 25,491 workers, although its employment is 57.6 percent of Shelby's AE employment. Payroll spending in Hamilton County amounted to \$1.6 billion for 1,423 AE establishments. Following Hamilton County is Knox County with 20,632 AE employees at 1,867 establishments. Williamson, Rutherford, Sullivan, and Anderson Counties support between 12,901 and 18,386 AE employees. The rest of the top 20 AE sector counties in Tennessee are Sumner, Blount, Wilson, Madison, Montgomery, Coffee, Putnam, Washington, Hamblen, Maury, McMinn, and Monroe Counties. All top 20 AE counties in Tennessee are represented in the MSA-level data with the exception of Coffee, Putnam, McMinn, and Monroe Counties.

Table 14: Advanced Energy Outcomes in Top 20 Tennessee Counties by Employment, 2019

County	Employment	Annual Payroll (\$1,000)	Number of Establishments	2019 Ranking	2016 Ranking
Davidson	54,745	\$3,958,798	2,998	1	2
Shelby	44,259	\$2,834,680	2,417	2	1
Hamilton	25,491	\$1,577,710	1,423	3	3
Knox	20,632	\$1,303,478	1,867	4	4
Williamson	18,386	\$1,567,166	1,379	5	6
Rutherford	14,554	\$785,576	810	6	5
Sullivan	13,688	\$1,031,840	399	7	7
Anderson	12,901	\$1,103,308	279	8	8
Sumner	6,703	\$405,980	570	9	10
Blount	4,981	\$466,398	365	10	9
Wilson	4,953	\$251,541	477	11	19
Madison	4,722	\$276,838	271	12	18
Montgomery	4,394	\$253,380	404	13	15
Coffee	3,986	\$265,520	129	14	14
Putnam	3,806	\$175,679	215	15	
Washington	3,801	\$193,118	371	16	17
Hamblen	3,540	\$197,259	106	17	20
Maury	3,510	\$197,476	237	18	16
McMinn	3,341	\$187,238	89	19	13
Monroe	3,276	\$151,852	77	20	
Total for Top 20 Counties	255,669	\$17,184,835	14,883		

TENNESSEE ADVANCED ENERGY CASE STUDIES

Silicon Ranch Corporation

Silicon Ranch Corporation is the U.S. solar platform for Shell and one of the nation's largest independent power producers. Headquartered in Nashville, the company is a fully integrated provider of customized renewable energy and storage solutions for a wide range of partners. The company's portfolio includes more than 2.5 GW of PV systems that are contracted, under construction,

or operating in over 15 states. Since Shell invested an initial \$217 million, Silicon Ranch has helped bring an \$800 million investment from Facebook to Tennessee and completed numerous renewable projects, including a 5-MW solar farm outside of Jonesborough, Tennessee. In December 2020, Silicon Ranch closed an investment round that attracted \$225 million in new equity capital.

TNECD EV Supply Chain Commitment

In 2019, Tennessee Economic and Community Development (TNECD) Commissioner Bob Rolfe declared that the state would become the No. 1 state in the country for the electric vehicle supply chain. As demand is increasing for electric vehicles nationwide, Tennessee is already on its way to leading the southeast in the production of electric

vehicles with Nissan, Volkswagen, and GM all in production and dozens of original equipment manufacturers across the state. To date, TNECD reports there has been over \$6.2 billion in capital investment from EV projects, over 19,700 Tennesseans employed by companies with EV operations, and over 4,200 new job commitments.

Conclusion

Like the two previous reports on the Advanced Energy Economy in Tennessee, the 2021 update shows a sector of the state economy that is not only thriving, but also contributing greatly to the overall economic health of the state. Using 2019 CBP data (the most recent available) from the U.S. Census Bureau to evaluate the impacts of the AE sector in Tennessee, trends in economic outcomes are positive for all five AE categories: AE utilities and construction; AE manufacturing; AE information; AE professional, scientific, and technical services; and AE other services.

Good news for those looking to enter the AE workforce: the sector pays, on average, much higher than the state's average salary (\$63,586 compared to \$47,688). With nearly 394,000 AE employees at 20,340 AE establishments statewide, total payroll spending amounted to \$25.0 billion. Given the strength of the state's auto industry, it's no surprise that manufacturing is the largest AE employer, followed by AE utilities and construction and AE professional, scientific, and technical services. Statewide and in all 10 metropolitan areas, AE utilities and construction has the most establishments, followed by AE professional, scientific, and technical services.

As demonstrated in the two previous reports, AE employment, payroll spending, and the number of establishments continue to grow. The AE sector experienced employment growth at a pace higher than overall employment growth (10 percent compared to 5.1 percent). Total AE establishments in Tennessee have risen by 11.9 percent, annual payroll expenditures have increased by 9.9 percent, and state GDP is up 8.2 percent since 2016.

While some changes in data reporting made comparing MSA data from 2016 to 2019 more complicated, our analysis shows that all ten of Tennessee's MSAs experienced growth in payroll spending and eight of the 10 metropolitan areas experienced growth in the number of AE establishments. As in 2018, the Nashville MSA continues to be the largest contributor to the AE sector, supporting 30.5 percent of the state's AE employment, followed by the Memphis and Knoxville MSAs, which account for 14.0 and 12.8 percent of the state's AE employment, respectively. About 64.9 percent of Tennessee's AE employment is concentrated in 20 counties. While AE activity is centered around the state's metropolitan areas, the AE economy extends across all 95 counties in the state.

As this report shows, the AE sector is vitally important to the Tennessee economy, accounting for \$45.8 billion in state GDP in 2019, 12.2 percent of total state GDP. Inflation-adjusted output generated by the AE sector also grew since 2016, which demonstrates the vibrant growth in the AE economy. While this output is produced in Tennessee, much of it is sold outside the state, thus providing a significant net increase in statewide employment. The AE sector directly enhances Tennessee's competitiveness and attractiveness as a place to do business, a major plus for the state. By providing goods and services to other firms in the state, the AE sector also indirectly boosts the state's competitive position throughout the supply chain.

Overall, Tennessee's AE economy has continued to expand over the last several years and will undoubtedly continue to grow in the years ahead as producers and consumers strive to reduce energy use and seek more energy-efficient products and manufacturing processes.

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Appendix

Appendix Table 1: Advanced Energy by NAICS in Tennessee, 2019

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Utilities and Construction	2211	Electric Power Generation, Transmission and Distribution	2,413	\$199,804	107
	2212	Natural Gas Distribution	554	\$39,653	19
	2361	Residential Building Construction	10,586	\$579,234	2,218
	2362	Nonresidential Building Construction	12,784	\$911,735	741
	2371	Utility System Construction	7,872	\$500,177	337
	2379	Other Heavy and Civil Engineering Construction	839	\$57,310	73
	2381	Foundation, Structure, and Building Exterior Contractors	15,084	\$829,544	1,400
	2382	Building Equipment Contractors	43,148	\$2,454,050	2,902
	2383	Building Finishing Contractors	11,219	\$537,138	1,431
		Subtotal		104,499	\$6,108,645
Advanced Energy Manufacturing	3211	Sawmills and Wood Preservation	2,320	\$84,944	138
	3221	Pulp, Paper, and Paperboard Mills	2,990	\$263,784	13
	3241	Petroleum and Coal Products Manufacturing	1,020	\$86,582	58
	3251	Basic Chemical Manufacturing	12,351	\$1,125,780	63
	3252	Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments Manufacturing	2,474	\$163,719	27
	3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	250	\$15,312	16
	3259	Other Chemical Product and Preparation Manufacturing	4,294	\$284,270	59
	3272	Glass and Glass Product Manufacturing	4,295	\$227,774	29
	3279	Other Nonmetallic Mineral Product Manufacturing	1,675	\$73,125	91
	3311	Iron and Steel Mills and Ferroalloy Manufacturing	1,124	\$88,467	13
	3313	Alumina and Aluminum Production and Processing	2,759	\$172,904	16
	3315	Foundries	3,669	\$197,201	30
	3331	Agriculture, Construction, and Mining Machinery Manufacturing	5,468	\$274,861	45
	3332	Industrial Machinery Manufacturing	1,000	\$58,812	42
	3333	Commercial and Service Industry Machinery Manufacturing	1,805	\$93,607	25
	3334	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	8,705	\$374,237	42
	3336	Engine, Turbine, and Power Transmission Equipment Manufacturing	982	\$57,769	14
	3339	Other General Purpose Machinery Manufacturing	5,305	\$314,929	97

Appendix Table 1, continued

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Manufacturing	3341	Computer and Peripheral Equipment Manufacturing	316	\$24,376	6
	3342	Communication Equipment Manufacturing	351	\$33,016	6
	3343	Audio and Video Equipment Manufacturing	25	\$752	11
	3344	Semiconductor and Other Electronic Component Manufacturing	2,820	\$142,056	18
	3345	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	3,222	\$192,541	54
	3346	Manufacturing and Reproducing Magnetic and Optical Media	632	\$24,160	10
	3351	Electric Lighting Equipment Manufacturing	520	\$26,558	16
	3352	Household Appliance Manufacturing	8,298	\$351,806	19
	3353	Electrical Equipment Manufacturing	2,093	\$109,750	29
	3359	Other Electrical Equipment and Component Manufacturing	2,376	\$161,476	28
	3361	Motor Vehicle Manufacturing	10,449	\$862,560	7
	3362	Motor Vehicle Body and Trailer Manufacturing	2,483	\$126,957	46
	3363	Motor Vehicle Parts Manufacturing	44,534	\$2,265,437	199
	3364	Aerospace Product and Parts Manufacturing	1,467	\$100,607	16
	3366	Ship and Boat Building	3,598	\$179,865	25
	3369	Other Transportation Equipment Manufacturing	237	\$10,183	16
	3391	Medical Equipment and Supplies Manufacturing	8,562	\$617,735	177
	3399	Other Miscellaneous Manufacturing	5,806	\$248,913	279
	Subtotal		160,275	\$9,436,825	1,780
Advanced Energy Information	5112	Software Publishers	3,811	\$431,766	196
	5152	Cable and Other Subscription Programming	1,298	\$224,522	11
	5173	Wired and Wireless Telecommunications Carriers	19,337	\$1,109,370	1,200
	5174	Satellite Telecommunications	29	\$1,066	4
	5179	Other Telecommunications	755	\$25,299	85
	5182	Data Processing, Hosting, and Related Services	4,931	\$448,925	255
	5191	Other Information Services	1,309	\$119,877	119
		Subtotal		31,470	\$2,360,825

Appendix Table 1, continued

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Professional, Scientific, and Technical Services	5413	Architectural, Engineering, and Related Services	21,125	\$1,679,974	1,547
	5414	Specialized Design Services	1,399	\$74,065	342
	5415	Computer System Design and Related Services	18,711	\$1,599,375	1,311
	5416	Management, Scientific, and Technical Consulting Services	20,164	\$1,559,815	2,031
	5417	Scientific Research and Development Services	8,092	\$918,691	186
	5419	Other Professional, Scientific, and Technical Services	12,622	\$485,704	1,089
	Subtotal			82,113	\$6,317,624
Advanced Energy Other Services (Includes Administrative and Support, Waste Management and Remediation Services, and Health Care and Social Assistance)	5622	Waste Treatment and Disposal	1,453	\$95,033	80
	6215	Medical and Diagnostic Laboratories	7,181	\$401,746	370
	8112	Electronic and Precision Equipment Repair and Maintenance	3,099	\$127,593	180
	8113	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	3,666	\$188,944	326
	Subtotal			15,399	\$813,316
All Advanced Energy Industry	Total		393,756	\$25,037,235	20,340

Appendix Table 2: Advanced Energy by NAICS in Chattanooga, TN-GA MSA, 2019

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Utilities and Construction	2211	Electric Power Generation, Transmission and Distribution	119	\$8,869	6
	2212	Natural Gas Distribution	NA	NA	NA
	2361	Residential Building Construction	660	\$31,464	178
	2362	Nonresidential Building Construction	1,098	\$82,932	73
	2371	Utility System Construction	1,423	\$130,732	30
	2379	Other Heavy and Civil Engineering Construction	176	\$12,924	12
	2381	Foundation, Structure, and Building Exterior Contractors	1,076	\$50,986	100
	2382	Building Equipment Contractors	5,589	\$344,394	256
	2383	Building Finishing Contractors	706	\$31,746	102
		Subtotal		10,847	\$694,047
Advanced Energy Manufacturing	3211	Sawmills and Wood Preservation	NA	NA	NA
	3221	Pulp, Paper, and Paperboard Mills	NA	NA	NA
	3241	Petroleum and Coal Products Manufacturing	82	\$5,186	6
	3251	Basic Chemical Manufacturing	284	\$15,906	12
	3252	Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments Manufacturing	623	\$43,669	7
	3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	NA	NA	NA
	3259	Other Chemical Product and Preparation Manufacturing	117	\$4,787	7
	3272	Glass and Glass Product Manufacturing	46	\$2,260	5
	3279	Other Nonmetallic Mineral Product Manufacturing	157	\$9,236	11
	3311	Iron and Steel Mills and Ferroalloy Manufacturing	NA	NA	NA
	3313	Alumina and Aluminum Production and Processing	NA	NA	NA
	3315	Foundries	578	\$26,392	8
	3331	Agriculture, Construction, and Mining Machinery Manufacturing	2,021	\$146,236	7
	3332	Industrial Machinery Manufacturing	393	\$23,207	8
	3333	Commercial and Service Industry Machinery Manufacturing	NA	NA	NA
	3334	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	35	\$769	3
	3336	Engine, Turbine, and Power Transmission Equipment Manufacturing	NA	NA	NA
3339	Other General Purpose Machinery Manufacturing	776	\$52,937	15	

Appendix Table 2, continued

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Manufacturing	3341	Computer and Peripheral Equipment Manufacturing	NA	NA	NA
	3342	Communication Equipment Manufacturing	NA	NA	NA
	3343	Audio and Video Equipment Manufacturing	NA	NA	NA
	3344	Semiconductor and Other Electronic Component Manufacturing	NA	NA	NA
	3345	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	107	\$5,458	6
	3346	Manufacturing and Reproducing Magnetic and Optical Media	NA	NA	NA
	3351	Electric Lighting Equipment Manufacturing	NA	NA	NA
	3352	Household Appliance Manufacturing	NA	NA	NA
	3353	Electrical Equipment Manufacturing	20	\$7,602	3
	3359	Other Electrical Equipment and Component Manufacturing	255	\$13,617	3
	3361	Motor Vehicle Manufacturing	NA	NA	NA
	3362	Motor Vehicle Body and Trailer Manufacturing	764	\$48,771	4
	3363	Motor Vehicle Parts Manufacturing	2,278	\$98,097	12
	3364	Aerospace Product and Parts Manufacturing	NA	NA	NA
	3366	Ship and Boat Building	30	\$1,221	3
	3369	Other Transportation Equipment Manufacturing	146	\$6,706	5
	3391	Medical Equipment and Supplies Manufacturing	550	\$23,444	19
3399	Other Miscellaneous Manufacturing	597	\$23,114	27	
	Subtotal		9,859	\$558,615	171
Advanced Energy Information	5112	Software Publishers	63	\$4,688	11
	5152	Cable and Other Subscription Programming	NA	NA	NA
	5173	Wired and Wireless Telecommunications Carriers	1,707	\$90,914	108
	5174	Satellite Telecommunications	NA	NA	NA
	5179	Other Telecommunications	94	\$1,668	9
	5182	Data Processing, Hosting, and Related Services	345	\$22,470	12
	5191	Other Information Services	18	\$686	3
	Subtotal		2,227	\$120,426	143

Appendix Table 2, continued

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Professional, Scientific, and Technical Services	5413	Architectural, Engineering, and Related Services	2,616	\$162,695	166
	5414	Specialized Design Services	94	\$3,062	32
	5415	Computer System Design and Related Services	709	\$50,415	122
	5416	Management, Scientific, and Technical Consulting Services	1,081	\$85,383	179
	5417	Scientific Research and Development Services	157	\$8,485	20
	5419	Other Professional, Scientific, and Technical Services	1,564	\$49,470	101
	Subtotal			6,221	\$359,510
Advanced Energy Other Services (Includes Administrative and Support, Waste Management and Remediation Services, and Health Care and Social Assistance)	5622	Waste Treatment and Disposal	35	\$2,014	6
	6215	Medical and Diagnostic Laboratories	687	\$29,482	31
	8112	Electronic and Precision Equipment Repair and Maintenance	44	\$2,132	15
	8113	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	527	\$29,864	37
	Subtotal			1,293	\$63,492
All Advanced Energy Industry	Total		30,447	\$1,796,090	1,780

Appendix Table 3: Advanced Energy by NAICS in Clarksville, TN-KY MSA, 2019

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Utilities and Construction	2211	Electric Power Generation, Transmission and Distribution	207	\$16,977	4
	2212	Natural Gas Distribution	NA	NA	NA
	2361	Residential Building Construction	277	\$15,911	93
	2362	Nonresidential Building Construction	371	\$20,535	34
	2371	Utility System Construction	204	\$11,321	18
	2379	Other Heavy and Civil Engineering Construction	NA	NA	NA
	2381	Foundation, Structure, and Building Exterior Contractors	257	\$12,789	28
	2382	Building Equipment Contractors	849	\$39,701	107
	2383	Building Finishing Contractors	218	\$7,852	53
		Subtotal		2,383	\$125,086
Advanced Energy Manufacturing	3211	Sawmills and Wood Preservation	83	\$2,738	6
	3221	Pulp, Paper, and Paperboard Mills	NA	NA	NA
	3241	Petroleum and Coal Products Manufacturing	100	\$6,592	4
	3251	Basic Chemical Manufacturing	113	\$7,724	4
	3252	Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments Manufacturing	NA	NA	NA
	3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	NA	NA	NA
	3259	Other Chemical Product and Preparation Manufacturing	NA	NA	NA
	3272	Glass and Glass Product Manufacturing	NA	NA	NA
	3279	Other Nonmetallic Mineral Product Manufacturing	NA	NA	NA
	3311	Iron and Steel Mills and Ferroalloy Manufacturing	NA	NA	NA
	3313	Alumina and Aluminum Production and Processing	NA	NA	NA
	3315	Foundries	NA	NA	NA
	3331	Agriculture, Construction, and Mining Machinery Manufacturing	NA	NA	NA
	3332	Industrial Machinery Manufacturing	NA	NA	NA
	3333	Commercial and Service Industry Machinery Manufacturing	NA	NA	NA
	3334	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	NA	NA	NA
	3336	Engine, Turbine, and Power Transmission Equipment Manufacturing	NA	NA	NA
3339	Other General Purpose Machinery Manufacturing	444	\$21,687	3	

Appendix Table 3, continued

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Manufacturing	3341	Computer and Peripheral Equipment Manufacturing	NA	NA	NA
	3342	Communication Equipment Manufacturing	NA	NA	NA
	3343	Audio and Video Equipment Manufacturing	NA	NA	NA
	3344	Semiconductor and Other Electronic Component Manufacturing	NA	NA	NA
	3345	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	NA	NA	NA
	3346	Manufacturing and Reproducing Magnetic and Optical Media	NA	NA	NA
	3351	Electric Lighting Equipment Manufacturing	NA	NA	NA
	3352	Household Appliance Manufacturing	NA	NA	NA
	3353	Electrical Equipment Manufacturing	NA	NA	NA
	3359	Other Electrical Equipment and Component Manufacturing	NA	NA	NA
	3361	Motor Vehicle Manufacturing	NA	NA	NA
	3362	Motor Vehicle Body and Trailer Manufacturing	290	\$9,444	3
	3363	Motor Vehicle Parts Manufacturing	5,075	\$252,080	12
	3364	Aerospace Product and Parts Manufacturing	NA	NA	NA
	3366	Ship and Boat Building	NA	NA	NA
	3369	Other Transportation Equipment Manufacturing	NA	NA	NA
	3391	Medical Equipment and Supplies Manufacturing	40	\$1,384	8
	3399	Other Miscellaneous Manufacturing	170	\$9,047	7
	Subtotal		6,315	\$310,696	47
Advanced Energy Information	5112	Software Publishers	NA	NA	NA
	5152	Cable and Other Subscription Programming	NA	NA	NA
	5173	Wired and Wireless Telecommunications Carriers	341	\$21,322	42
	5174	Satellite Telecommunications	NA	NA	NA
	5179	Other Telecommunications	NA	NA	NA
	5182	Data Processing, Hosting, and Related Services	NA	NA	NA
	5191	Other Information Services	29	\$2,061	5
		Subtotal		370	\$23,383

Appendix Table 3, continued

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Professional, Scientific, and Technical Services	5413	Architectural, Engineering, and Related Services	229	\$16,569	32
	5414	Specialized Design Services	NA	NA	NA
	5415	Computer System Design and Related Services	1,527	\$112,079	62
	5416	Management, Scientific, and Technical Consulting Services	146	\$6,242	38
	5417	Scientific Research and Development Services	NA	NA	NA
	5419	Other Professional, Scientific, and Technical Services	321	\$13,394	27
	Subtotal		2,223	\$148,284	159
Advanced Energy Other Services (Includes Administrative and Support, Waste Management and Remediation Services, and Health Care and Social Assistance)	5622	Waste Treatment and Disposal	NA	NA	NA
	6215	Medical and Diagnostic Laboratories	23	\$928	9
	8112	Electronic and Precision Equipment Repair and Maintenance	56	\$1,999	9
	8113	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	31	\$1,563	13
	Subtotal		110	\$4,490	31
All Advanced Energy Industry	Total		11,401	\$611,939	621

Appendix Table 4: Advanced Energy by NAICS in Cleveland, TN MSA, 2019

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Utilities and Construction	2211	Electric Power Generation, Transmission and Distribution	NA	NA	NA
	2212	Natural Gas Distribution	NA	NA	NA
	2361	Residential Building Construction	270	\$11,496	22
	2362	Nonresidential Building Construction	98	\$7,793	12
	2371	Utility System Construction	115	\$7,268	5
	2379	Other Heavy and Civil Engineering Construction	NA	NA	NA
	2381	Foundation, Structure, and Building Exterior Contractors	176	\$8,428	22
	2382	Building Equipment Contractors	410	\$21,383	49
	2383	Building Finishing Contractors	64	\$2,439	19
		Subtotal	1,133	\$58,807	129
Advanced Energy Manufacturing	3211	Sawmills and Wood Preservation	NA	NA	NA
	3221	Pulp, Paper, and Paperboard Mills	NA	NA	NA
	3241	Petroleum and Coal Products Manufacturing	NA	NA	NA
	3251	Basic Chemical Manufacturing	312	\$30,094	4
	3252	Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments Manufacturing	NA	NA	NA
	3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	NA	NA	NA
	3259	Other Chemical Product and Preparation Manufacturing	353	\$21,898	3
	3272	Glass and Glass Product Manufacturing	NA	NA	NA
	3279	Other Nonmetallic Mineral Product Manufacturing	NA	NA	NA
	3311	Iron and Steel Mills and Ferroalloy Manufacturing	NA	NA	NA
	3313	Alumina and Aluminum Production and Processing	NA	NA	NA
	3315	Foundries	NA	NA	NA
	3331	Agriculture, Construction, and Mining Machinery Manufacturing	NA	NA	NA
	3332	Industrial Machinery Manufacturing	NA	NA	NA
	3333	Commercial and Service Industry Machinery Manufacturing	NA	NA	NA
	3334	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	NA	NA	NA
	3336	Engine, Turbine, and Power Transmission Equipment Manufacturing	NA	NA	NA
	3339	Other General Purpose Machinery Manufacturing	NA	NA	NA

Appendix Table 4, continued

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Manufacturing	3341	Computer and Peripheral Equipment Manufacturing	NA	NA	NA
	3342	Communication Equipment Manufacturing	NA	NA	NA
	3343	Audio and Video Equipment Manufacturing	NA	NA	NA
	3344	Semiconductor and Other Electronic Component Manufacturing	NA	NA	NA
	3345	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	NA	NA	NA
	3346	Manufacturing and Reproducing Magnetic and Optical Media	NA	NA	NA
	3351	Electric Lighting Equipment Manufacturing	NA	NA	NA
	3352	Household Appliance Manufacturing	NA	NA	NA
	3353	Electrical Equipment Manufacturing	NA	NA	NA
	3359	Other Electrical Equipment and Component Manufacturing	NA	NA	NA
	3361	Motor Vehicle Manufacturing	NA	NA	NA
	3362	Motor Vehicle Body and Trailer Manufacturing	NA	NA	NA
	3363	Motor Vehicle Parts Manufacturing	NA	NA	NA
	3364	Aerospace Product and Parts Manufacturing	NA	NA	NA
	3366	Ship and Boat Building	NA	NA	NA
	3369	Other Transportation Equipment Manufacturing	NA	NA	NA
	3391	Medical Equipment and Supplies Manufacturing	78	\$1,959	6
	3399	Other Miscellaneous Manufacturing	157	\$4,435	6
	Subtotal		900	\$58,386	19
Advanced Energy Information	5112	Software Publishers	NA	NA	NA
	5152	Cable and Other Subscription Programming	NA	NA	NA
	5173	Wired and Wireless Telecommunications Carriers	158	\$11,574	20
	5174	Satellite Telecommunications	NA	NA	NA
	5179	Other Telecommunications	NA	NA	NA
	5182	Data Processing, Hosting, and Related Services	NA	NA	NA
	5191	Other Information Services	NA	NA	NA
		Subtotal		158	\$11,574

Appendix Table 4, continued

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Professional, Scientific, and Technical Services	5413	Architectural, Engineering, and Related Services	71	\$2,568	15
	5414	Specialized Design Services	12	\$322	5
	5415	Computer System Design and Related Services	51	\$2,743	11
	5416	Management, Scientific, and Technical Consulting Services	124	\$5,528	19
	5417	Scientific Research and Development Services	NA	NA	NA
	5419	Other Professional, Scientific, and Technical Services	259	\$6,203	23
	Subtotal			517	\$17,364
Advanced Energy Other Services (Includes Administrative and Support, Waste Management and Remediation Services, and Health Care and Social Assistance)	5622	Waste Treatment and Disposal	NA	NA	NA
	6215	Medical and Diagnostic Laboratories	NA	NA	NA
	8112	Electronic and Precision Equipment Repair and Maintenance	NA	NA	NA
	8113	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	32	\$1,558	4
	Subtotal			32	\$1,558
All Advanced Energy Industry	Total		2,740	\$147,689	245

Appendix Table 5: Advanced Energy by NAICS in Jackson, TN MSA, 2019

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Utilities and Construction	2211	Electric Power Generation, Transmission and Distribution	53	\$3,631	3
	2212	Natural Gas Distribution	NA	NA	NA
	2361	Residential Building Construction	145	\$5,428	36
	2362	Nonresidential Building Construction	267	\$22,950	17
	2371	Utility System Construction	60	\$2,892	5
	2379	Other Heavy and Civil Engineering Construction	NA	NA	NA
	2381	Foundation, Structure, and Building Exterior Contractors	209	\$12,643	30
	2382	Building Equipment Contractors	1,167	\$69,321	69
	2383	Building Finishing Contractors	66	\$2,158	28
		Subtotal		1,967	\$119,023
Advanced Energy Manufacturing	3211	Sawmills and Wood Preservation	114	\$4,106	3
	3221	Pulp, Paper, and Paperboard Mills	NA	NA	NA
	3241	Petroleum and Coal Products Manufacturing	NA	NA	NA
	3251	Basic Chemical Manufacturing	NA	NA	NA
	3252	Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments Manufacturing	NA	NA	NA
	3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	NA	NA	NA
	3259	Other Chemical Product and Preparation Manufacturing	NA	NA	NA
	3272	Glass and Glass Product Manufacturing	NA	NA	NA
	3279	Other Nonmetallic Mineral Product Manufacturing	NA	NA	NA
	3311	Iron and Steel Mills and Ferroalloy Manufacturing	NA	NA	NA
	3313	Alumina and Aluminum Production and Processing	330	\$24,643	3
	3315	Foundries	NA	NA	NA
	3331	Agriculture, Construction, and Mining Machinery Manufacturing	NA	NA	NA
	3332	Industrial Machinery Manufacturing	NA	NA	NA
	3333	Commercial and Service Industry Machinery Manufacturing	NA	NA	NA
	3334	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	NA	NA	NA
	3336	Engine, Turbine, and Power Transmission Equipment Manufacturing	NA	NA	NA
3339	Other General Purpose Machinery Manufacturing	520	\$26,211	5	

Appendix Table 5, continued

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Manufacturing	3341	Computer and Peripheral Equipment Manufacturing	NA	NA	NA
	3342	Communication Equipment Manufacturing	NA	NA	NA
	3343	Audio and Video Equipment Manufacturing	NA	NA	NA
	3344	Semiconductor and Other Electronic Component Manufacturing	NA	NA	NA
	3345	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	NA	NA	NA
	3346	Manufacturing and Reproducing Magnetic and Optical Media	NA	NA	NA
	3351	Electric Lighting Equipment Manufacturing	NA	NA	NA
	3352	Household Appliance Manufacturing	NA	NA	NA
	3353	Electrical Equipment Manufacturing	NA	NA	NA
	3359	Other Electrical Equipment and Component Manufacturing	NA	NA	NA
	3361	Motor Vehicle Manufacturing	NA	NA	NA
	3362	Motor Vehicle Body and Trailer Manufacturing	28	\$829	3
	3363	Motor Vehicle Parts Manufacturing	1,146	\$57,976	5
	3364	Aerospace Product and Parts Manufacturing	NA	NA	NA
	3366	Ship and Boat Building	NA	NA	NA
	3369	Other Transportation Equipment Manufacturing	NA	NA	NA
	3391	Medical Equipment and Supplies Manufacturing	15	\$682	4
	3399	Other Miscellaneous Manufacturing	28	\$837	6
	Subtotal		2,181	\$115,284	29
Advanced Energy Information	5112	Software Publishers	NA	NA	NA
	5152	Cable and Other Subscription Programming	NA	NA	NA
	5173	Wired and Wireless Telecommunications Carriers	270	\$16,256	22
	5174	Satellite Telecommunications	NA	NA	NA
	5179	Other Telecommunications	NA	NA	NA
	5182	Data Processing, Hosting, and Related Services	NA	NA	NA
	5191	Other Information Services	NA	NA	NA
		Subtotal		270	\$16,256

Appendix Table 5, continued

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Professional, Scientific, and Technical Services	5413	Architectural, Engineering, and Related Services	179	\$14,029	27
	5414	Specialized Design Services	NA	NA	NA
	5415	Computer System Design and Related Services	20	\$1,282	6
	5416	Management, Scientific, and Technical Consulting Services	94	\$4,005	21
	5417	Scientific Research and Development Services	NA	NA	NA
	5419	Other Professional, Scientific, and Technical Services	127	\$4,706	21
	Subtotal		420	\$24,022	75
Advanced Energy Other Services (Includes Administrative and Support, Waste Management and Remediation Services, and Health Care and Social Assistance)	5622	Waste Treatment and Disposal	NA	NA	NA
	6215	Medical and Diagnostic Laboratories	418	\$26,568	13
	8112	Electronic and Precision Equipment Repair and Maintenance	24	\$1,647	4
	8113	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	NA	NA	NA
	Subtotal		442	\$28,215	17
All Advanced Energy Industry	Total		5,280	\$302,800	331

Appendix Table 6: Advanced Energy by NAICS in Johnson City, TN MSA, 2019

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Utilities and Construction	2211	Electric Power Generation, Transmission and Distribution	13	\$842	3
	2212	Natural Gas Distribution	NA	NA	NA
	2361	Residential Building Construction	235	\$8,082	64
	2362	Nonresidential Building Construction	230	\$14,279	19
	2371	Utility System Construction	39	\$1,888	7
	2379	Other Heavy and Civil Engineering Construction	NA	NA	NA
	2381	Foundation, Structure, and Building Exterior Contractors	226	\$10,369	41
	2382	Building Equipment Contractors	636	\$31,183	88
	2383	Building Finishing Contractors	308	\$11,449	39
		Subtotal		1,687	\$78,092
Advanced Energy Manufacturing	3211	Sawmills and Wood Preservation	67	\$3,937	6
	3221	Pulp, Paper, and Paperboard Mills	NA	NA	NA
	3241	Petroleum and Coal Products Manufacturing	NA	NA	NA
	3251	Basic Chemical Manufacturing	NA	NA	NA
	3252	Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments Manufacturing	NA	NA	NA
	3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	NA	NA	NA
	3259	Other Chemical Product and Preparation Manufacturing	NA	NA	NA
	3272	Glass and Glass Product Manufacturing	NA	NA	NA
	3279	Other Nonmetallic Mineral Product Manufacturing	51	\$1,283	4
	3311	Iron and Steel Mills and Ferroalloy Manufacturing	NA	NA	NA
	3313	Alumina and Aluminum Production and Processing	NA	NA	NA
	3315	Foundries	NA	NA	NA
	3331	Agriculture, Construction, and Mining Machinery Manufacturing	NA	NA	NA
	3332	Industrial Machinery Manufacturing	NA	NA	NA
	3333	Commercial and Service Industry Machinery Manufacturing	NA	NA	NA
	3334	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	NA	NA	NA
	3336	Engine, Turbine, and Power Transmission Equipment Manufacturing	NA	NA	NA
	3339	Other General Purpose Machinery Manufacturing	125	\$7,611	3

Appendix Table 6, continued

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Manufacturing	3341	Computer and Peripheral Equipment Manufacturing	NA	NA	NA
	3342	Communication Equipment Manufacturing	NA	NA	NA
	3343	Audio and Video Equipment Manufacturing	NA	NA	NA
	3344	Semiconductor and Other Electronic Component Manufacturing	NA	NA	NA
	3345	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	NA	NA	NA
	3346	Manufacturing and Reproducing Magnetic and Optical Media	NA	NA	NA
	3351	Electric Lighting Equipment Manufacturing	NA	NA	NA
	3352	Household Appliance Manufacturing	NA	NA	NA
	3353	Electrical Equipment Manufacturing	NA	NA	NA
	3359	Other Electrical Equipment and Component Manufacturing	NA	NA	NA
	3361	Motor Vehicle Manufacturing	NA	NA	NA
	3362	Motor Vehicle Body and Trailer Manufacturing	NA	NA	NA
	3363	Motor Vehicle Parts Manufacturing	NA	NA	NA
	3364	Aerospace Product and Parts Manufacturing	NA	NA	NA
	3366	Ship and Boat Building	NA	NA	NA
	3369	Other Transportation Equipment Manufacturing	NA	NA	NA
	3391	Medical Equipment and Supplies Manufacturing	341	\$14,260	6
3399	Other Miscellaneous Manufacturing	101	\$4,192	5	
	Subtotal		685	\$31,283	24
Advanced Energy Information	5112	Software Publishers	76	\$10,153	5
	5152	Cable and Other Subscription Programming	NA	NA	NA
	5173	Wired and Wireless Telecommunications Carriers	911	\$42,660	35
	5174	Satellite Telecommunications	NA	NA	NA
	5179	Other Telecommunications	16	\$332	3
	5182	Data Processing, Hosting, and Related Services	97	\$4,175	5
	5191	Other Information Services	NA	NA	NA
	Subtotal		1,100	\$57,320	48

Appendix Table 6, continued

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Professional, Scientific, and Technical Services	5413	Architectural, Engineering, and Related Services	184	\$10,467	34
	5414	Specialized Design Services	11	\$471	4
	5415	Computer System Design and Related Services	236	\$11,234	26
	5416	Management, Scientific, and Technical Consulting Services	152	\$13,155	31
	5417	Scientific Research and Development Services	13	\$855	5
	5419	Other Professional, Scientific, and Technical Services	328	\$12,667	32
	Subtotal			924	\$48,849
Advanced Energy Other Services (Includes Administrative and Support, Waste Management and Remediation Services, and Health Care and Social Assistance)	5622	Waste Treatment and Disposal	NA	NA	NA
	6215	Medical and Diagnostic Laboratories	73	\$7,330	14
	8112	Electronic and Precision Equipment Repair and Maintenance	8	\$401	3
	8113	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	97	\$6,194	9
	Subtotal			178	\$13,925
All Advanced Energy Industry	Total		4,574	\$229,469	491

Appendix Table 7: Advanced Energy by NAICS in Kingsport-Bristol-Bristol, TN-VA MSA, 2019

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Utilities and Construction	2211	Electric Power Generation, Transmission and Distribution	218	\$19,686	11
	2212	Natural Gas Distribution	NA	NA	NA
	2361	Residential Building Construction	335	\$11,780	90
	2362	Nonresidential Building Construction	1,072	\$47,857	27
	2371	Utility System Construction	191	\$12,860	14
	2379	Other Heavy and Civil Engineering Construction	53	\$3,187	4
	2381	Foundation, Structure, and Building Exterior Contractors	512	\$23,282	55
	2382	Building Equipment Contractors	2,013	\$106,273	117
	2383	Building Finishing Contractors	224	\$7,642	30
		Subtotal	4,618	\$232,567	348
Advanced Energy Manufacturing	3211	Sawmills and Wood Preservation	29	\$1,084	5
	3221	Pulp, Paper, and Paperboard Mills	NA	NA	NA
	3241	Petroleum and Coal Products Manufacturing	NA	NA	NA
	3251	Basic Chemical Manufacturing	7,693	\$730,617	4
	3252	Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments Manufacturing	NA	NA	NA
	3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	9	\$351	3
	3259	Other Chemical Product and Preparation Manufacturing	612	\$60,568	3
	3272	Glass and Glass Product Manufacturing	711	\$40,586	4
	3279	Other Nonmetallic Mineral Product Manufacturing	NA	NA	NA
	3311	Iron and Steel Mills and Ferroalloy Manufacturing	NA	NA	NA
	3313	Alumina and Aluminum Production and Processing	NA	NA	NA
	3315	Foundries	99	\$4,227	3
	3331	Agriculture, Construction, and Mining Machinery Manufacturing	346	\$20,988	3
	3332	Industrial Machinery Manufacturing	NA	NA	NA
	3333	Commercial and Service Industry Machinery Manufacturing	NA	NA	NA
	3334	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	NA	NA	NA
	3336	Engine, Turbine, and Power Transmission Equipment Manufacturing	NA	NA	NA
	3339	Other General Purpose Machinery Manufacturing	352	\$19,379	5

Appendix Table 7, continued

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Manufacturing	3341	Computer and Peripheral Equipment Manufacturing	NA	NA	NA
	3342	Communication Equipment Manufacturing	NA	NA	NA
	3343	Audio and Video Equipment Manufacturing	NA	NA	NA
	3344	Semiconductor and Other Electronic Component Manufacturing	NA	NA	NA
	3345	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	NA	NA	NA
	3346	Manufacturing and Reproducing Magnetic and Optical Media	NA	NA	NA
	3351	Electric Lighting Equipment Manufacturing	NA	NA	NA
	3352	Household Appliance Manufacturing	NA	NA	NA
	3353	Electrical Equipment Manufacturing	403	\$16,843	4
	3359	Other Electrical Equipment and Component Manufacturing	95	\$2,300	3
	3361	Motor Vehicle Manufacturing	NA	NA	NA
	3362	Motor Vehicle Body and Trailer Manufacturing	NA	NA	NA
	3363	Motor Vehicle Parts Manufacturing	1,185	\$45,086	9
	3364	Aerospace Product and Parts Manufacturing	NA	NA	NA
	3366	Ship and Boat Building	NA	NA	NA
	3369	Other Transportation Equipment Manufacturing	NA	NA	NA
	3391	Medical Equipment and Supplies Manufacturing	102	\$4,567	12
	3399	Other Miscellaneous Manufacturing	179	\$6,292	11
	Subtotal		11,815	\$952,888	69
Advanced Energy Information	5112	Software Publishers	NA	NA	NA
	5152	Cable and Other Subscription Programming	NA	NA	NA
	5173	Wired and Wireless Telecommunications Carriers	705	\$39,034	51
	5174	Satellite Telecommunications	NA	NA	NA
	5179	Other Telecommunications	51	\$1,438	4
	5182	Data Processing, Hosting, and Related Services	NA	NA	NA
	5191	Other Information Services	19	\$494	3
		Subtotal		775	\$40,966

Appendix Table 7, continued

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Professional, Scientific, and Technical Services	5413	Architectural, Engineering, and Related Services	313	\$28,930	61
	5414	Specialized Design Services	39	\$891	6
	5415	Computer System Design and Related Services	179	\$9,694	25
	5416	Management, Scientific, and Technical Consulting Services	125	\$7,665	46
	5417	Scientific Research and Development Services	17	\$815	5
	5419	Other Professional, Scientific, and Technical Services	471	\$15,500	48
	Subtotal			1,144	\$63,495
Advanced Energy Other Services (Includes Administrative and Support, Waste Management and Remediation Services, and Health Care and Social Assistance)	5622	Waste Treatment and Disposal	NA	NA	NA
	6215	Medical and Diagnostic Laboratories	320	\$12,148	44
	8112	Electronic and Precision Equipment Repair and Maintenance	89	\$5,095	9
	8113	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	676	\$32,843	15
	Subtotal			1,085	\$50,086
All Advanced Energy Industry	Total		19,437	\$1,340,002	734

Appendix Table 8: Advanced Energy by NAICS in Knoxville, TN MSA, 2019

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Utilities and Construction	2211	Electric Power Generation, Transmission and Distribution	30	\$3,026	5
	2212	Natural Gas Distribution	14	\$1,034	3
	2361	Residential Building Construction	1,516	\$74,542	341
	2362	Nonresidential Building Construction	2,037	\$128,556	107
	2371	Utility System Construction	658	\$35,381	34
	2379	Other Heavy and Civil Engineering Construction	199	\$17,162	18
	2381	Foundation, Structure, and Building Exterior Contractors	1,471	\$63,930	173
	2382	Building Equipment Contractors	5,653	\$312,188	388
	2383	Building Finishing Contractors	1,919	\$96,367	211
		Subtotal		13,497	\$732,186
Advanced Energy Manufacturing	3211	Sawmills and Wood Preservation	121	\$4,498	9
	3221	Pulp, Paper, and Paperboard Mills	457	\$39,484	3
	3241	Petroleum and Coal Products Manufacturing	65	\$2,785	6
	3251	Basic Chemical Manufacturing	189	\$10,093	5
	3252	Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments Manufacturing	291	\$16,073	3
	3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	NA	NA	NA
	3259	Other Chemical Product and Preparation Manufacturing	319	\$21,209	4
	3272	Glass and Glass Product Manufacturing	670	\$30,314	6
	3279	Other Nonmetallic Mineral Product Manufacturing	65	\$2,995	10
	3311	Iron and Steel Mills and Ferroalloy Manufacturing	167	\$14,808	3
	3313	Alumina and Aluminum Production and Processing	411	\$40,443	3
	3315	Foundries	NA	NA	NA
	3331	Agriculture, Construction, and Mining Machinery Manufacturing	NA	NA	NA
	3332	Industrial Machinery Manufacturing	260	\$19,787	5
	3333	Commercial and Service Industry Machinery Manufacturing	NA	NA	NA
	3334	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	92	\$3,897	4
	3336	Engine, Turbine, and Power Transmission Equipment Manufacturing	NA	NA	NA
	3339	Other General Purpose Machinery Manufacturing	526	\$27,378	17

Appendix Table 8, continued

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Manufacturing	3341	Computer and Peripheral Equipment Manufacturing	NA	NA	NA
	3342	Communication Equipment Manufacturing	NA	NA	NA
	3343	Audio and Video Equipment Manufacturing	NA	NA	NA
	3344	Semiconductor and Other Electronic Component Manufacturing	NA	NA	NA
	3345	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	1,093	\$91,245	27
	3346	Manufacturing and Reproducing Magnetic and Optical Media	NA	NA	NA
	3351	Electric Lighting Equipment Manufacturing	NA	NA	NA
	3352	Household Appliance Manufacturing	388	\$18,068	4
	3353	Electrical Equipment Manufacturing	105	\$6,391	4
	3359	Other Electrical Equipment and Component Manufacturing	118	\$7,832	5
	3361	Motor Vehicle Manufacturing	NA	NA	NA
	3362	Motor Vehicle Body and Trailer Manufacturing	476	\$16,242	9
	3363	Motor Vehicle Parts Manufacturing	6,990	\$398,331	17
	3364	Aerospace Product and Parts Manufacturing	NA	NA	NA
	3366	Ship and Boat Building	822	\$47,635	5
	3369	Other Transportation Equipment Manufacturing	38	\$1,010	4
	3391	Medical Equipment and Supplies Manufacturing	543	\$21,263	20
	3399	Other Miscellaneous Manufacturing	352	\$16,581	36
	Subtotal		14,558	\$858,362	209
Advanced Energy Information	5112	Software Publishers	327	\$23,406	23
	5152	Cable and Other Subscription Programming	NA	NA	NA
	5173	Wired and Wireless Telecommunications Carriers	2,600	\$159,565	186
	5174	Satellite Telecommunications	NA	NA	NA
	5179	Other Telecommunications	99	\$2,646	13
	5182	Data Processing, Hosting, and Related Services	186	\$11,871	24
	5191	Other Information Services	53	\$4,768	9
		Subtotal		3,265	\$202,256

Appendix Table 8, continued

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Professional, Scientific, and Technical Services	5413	Architectural, Engineering, and Related Services	4,160	\$390,959	304
	5414	Specialized Design Services	211	\$9,241	42
	5415	Computer System Design and Related Services	1,543	\$106,245	197
	5416	Management, Scientific, and Technical Consulting Services	4,545	\$519,231	315
	5417	Scientific Research and Development Services	5,153	\$601,199	40
	5419	Other Professional, Scientific, and Technical Services	1,557	\$60,071	179
	Subtotal			17,169	\$1,686,946
Advanced Energy Other Services (Includes Administrative and Support, Waste Management and Remediation Services, and Health Care and Social Assistance)	5622	Waste Treatment and Disposal	612	\$51,176	18
	6215	Medical and Diagnostic Laboratories	950	\$65,628	75
	8112	Electronic and Precision Equipment Repair and Maintenance	86	\$3,278	30
	8113	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	392	\$22,304	40
	Subtotal			2,040	\$142,386
All Advanced Energy Industry	Total		50,529	\$3,622,136	2,984

Appendix Table 9: Advanced Energy by NAICS in Memphis, TN-MS-AR MSA, 2019

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Utilities and Construction	2211	Electric Power Generation, Transmission and Distribution	295	\$22,609	14
	2212	Natural Gas Distribution	NA	NA	NA
	2361	Residential Building Construction	1,528	\$88,989	272
	2362	Nonresidential Building Construction	2,106	\$142,396	124
	2371	Utility System Construction	705	\$38,233	38
	2379	Other Heavy and Civil Engineering Construction	296	\$18,386	12
	2381	Foundation, Structure, and Building Exterior Contractors	2,922	\$177,783	194
	2382	Building Equipment Contractors	9,492	\$534,646	570
	2383	Building Finishing Contractors	2,416	\$120,167	239
		Subtotal		19,760	\$1,143,209
Advanced Energy Manufacturing	3211	Sawmills and Wood Preservation	32	\$1,169	5
	3221	Pulp, Paper, and Paperboard Mills	NA	NA	NA
	3241	Petroleum and Coal Products Manufacturing	786	\$61,573	11
	3251	Basic Chemical Manufacturing	1,475	\$135,877	15
	3252	Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments Manufacturing	199	\$16,717	5
	3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	255	\$8,329	11
	3259	Other Chemical Product and Preparation Manufacturing	228	\$13,666	10
	3272	Glass and Glass Product Manufacturing	NA	NA	NA
	3279	Other Nonmetallic Mineral Product Manufacturing	535	\$30,936	19
	3311	Iron and Steel Mills and Ferroalloy Manufacturing	NA	NA	NA
	3313	Alumina and Aluminum Production and Processing	NA	NA	NA
	3315	Foundries	NA	NA	NA
	3331	Agriculture, Construction, and Mining Machinery Manufacturing	NA	NA	NA
	3332	Industrial Machinery Manufacturing	99	\$5,865	8
	3333	Commercial and Service Industry Machinery Manufacturing	397	\$16,682	3
	3334	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	2,143	\$88,977	9
	3336	Engine, Turbine, and Power Transmission Equipment Manufacturing	390	\$30,796	3
	3339	Other General Purpose Machinery Manufacturing	611	\$34,242	12

Appendix Table 9, continued

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Manufacturing	3341	Computer and Peripheral Equipment Manufacturing	NA	NA	NA
	3342	Communication Equipment Manufacturing	NA	NA	NA
	3343	Audio and Video Equipment Manufacturing	NA	NA	NA
	3344	Semiconductor and Other Electronic Component Manufacturing	540	\$21,480	3
	3345	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	21	\$1,527	6
	3346	Manufacturing and Reproducing Magnetic and Optical Media	NA	NA	NA
	3351	Electric Lighting Equipment Manufacturing	316	\$11,690	4
	3352	Household Appliance Manufacturing	NA	NA	NA
	3353	Electrical Equipment Manufacturing	46	\$2,060	4
	3359	Other Electrical Equipment and Component Manufacturing	NA	NA	NA
	3361	Motor Vehicle Manufacturing	NA	NA	NA
	3362	Motor Vehicle Body and Trailer Manufacturing	NA	NA	NA
	3363	Motor Vehicle Parts Manufacturing	1,193	\$64,596	14
	3364	Aerospace Product and Parts Manufacturing	285	\$13,162	5
	3366	Ship and Boat Building	NA	NA	NA
	3369	Other Transportation Equipment Manufacturing	24	\$1,103	3
	3391	Medical Equipment and Supplies Manufacturing	4,454	\$391,032	45
	3399	Other Miscellaneous Manufacturing	428	\$18,221	32
	Subtotal		14,457	\$969,700	227
Advanced Energy Information	5112	Software Publishers	356	\$24,178	28
	5152	Cable and Other Subscription Programming	NA	NA	NA
	5173	Wired and Wireless Telecommunications Carriers	3,190	\$180,126	236
	5174	Satellite Telecommunications	NA	NA	NA
	5179	Other Telecommunications	237	\$5,414	16
	5182	Data Processing, Hosting, and Related Services	718	\$22,266	48
	5191	Other Information Services	43	\$4,373	9
		Subtotal		4,544	\$236,357

Appendix Table 9, continued

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Professional, Scientific, and Technical Services	5413	Architectural, Engineering, and Related Services	3,582	\$219,627	224
	5414	Specialized Design Services	220	\$11,886	54
	5415	Computer System Design and Related Services	2,792	\$214,398	216
	5416	Management, Scientific, and Technical Consulting Services	3,325	\$199,237	329
	5417	Scientific Research and Development Services	1,268	\$108,230	39
	5419	Other Professional, Scientific, and Technical Services	2,081	\$93,293	170
	Subtotal			13,268	\$846,671
Advanced Energy Other Services (Includes Administrative and Support, Waste Management and Remediation Services, and Health Care and Social Assistance)	5622	Waste Treatment and Disposal	282	\$16,191	13
	6215	Medical and Diagnostic Laboratories	2,038	\$117,256	44
	8112	Electronic and Precision Equipment Repair and Maintenance	214	\$10,357	36
	8113	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	590	\$30,982	58
	Subtotal			3,124	\$174,786
All Advanced Energy Industry	Total		55,153	\$3,370,723	3,210

Appendix Table 10: Advanced Energy by NAICS in Morristown, TN MSA, 2019

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Utilities and Construction	2211	Electric Power Generation, Transmission and Distribution	NA	NA	NA
	2212	Natural Gas Distribution	NA	NA	NA
	2361	Residential Building Construction	122	\$4,229	29
	2362	Nonresidential Building Construction	149	\$9,990	11
	2371	Utility System Construction	195	\$16,250	6
	2379	Other Heavy and Civil Engineering Construction	NA	NA	NA
	2381	Foundation, Structure, and Building Exterior Contractors	265	\$13,331	21
	2382	Building Equipment Contractors	196	\$8,531	33
	2383	Building Finishing Contractors	163	\$7,161	18
		Subtotal	1,090	\$59,492	118
Advanced Energy Manufacturing	3211	Sawmills and Wood Preservation	NA	NA	NA
	3221	Pulp, Paper, and Paperboard Mills	NA	NA	NA
	3241	Petroleum and Coal Products Manufacturing	NA	NA	NA
	3251	Basic Chemical Manufacturing	NA	NA	NA
	3252	Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments Manufacturing	NA	NA	NA
	3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	NA	NA	NA
	3259	Other Chemical Product and Preparation Manufacturing	NA	NA	NA
	3272	Glass and Glass Product Manufacturing	NA	NA	NA
	3279	Other Nonmetallic Mineral Product Manufacturing	NA	NA	NA
	3311	Iron and Steel Mills and Ferroalloy Manufacturing	NA	NA	NA
	3313	Alumina and Aluminum Production and Processing	NA	NA	NA
	3315	Foundries	NA	NA	NA
	3331	Agriculture, Construction, and Mining Machinery Manufacturing	NA	NA	NA
	3332	Industrial Machinery Manufacturing	NA	NA	NA
	3333	Commercial and Service Industry Machinery Manufacturing	NA	NA	NA
	3334	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	NA	NA	NA
	3336	Engine, Turbine, and Power Transmission Equipment Manufacturing	NA	NA	NA
	3339	Other General Purpose Machinery Manufacturing	34	\$1,353	3

Appendix Table 10, continued

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Manufacturing	3341	Computer and Peripheral Equipment Manufacturing	NA	NA	NA
	3342	Communication Equipment Manufacturing	NA	NA	NA
	3343	Audio and Video Equipment Manufacturing	NA	NA	NA
	3344	Semiconductor and Other Electronic Component Manufacturing	NA	NA	NA
	3345	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	NA	NA	NA
	3346	Manufacturing and Reproducing Magnetic and Optical Media	NA	NA	NA
	3351	Electric Lighting Equipment Manufacturing	NA	NA	NA
	3352	Household Appliance Manufacturing	NA	NA	NA
	3353	Electrical Equipment Manufacturing	NA	NA	NA
	3359	Other Electrical Equipment and Component Manufacturing	NA	NA	NA
	3361	Motor Vehicle Manufacturing	NA	NA	NA
	3362	Motor Vehicle Body and Trailer Manufacturing	NA	NA	NA
	3363	Motor Vehicle Parts Manufacturing	2,881	\$160,441	7
	3364	Aerospace Product and Parts Manufacturing	NA	NA	NA
	3366	Ship and Boat Building	NA	NA	NA
	3369	Other Transportation Equipment Manufacturing	NA	NA	NA
	3391	Medical Equipment and Supplies Manufacturing	NA	NA	NA
	3399	Other Miscellaneous Manufacturing	611	\$25,162	4
	Subtotal		3,526	\$186,956	14
Advanced Energy Information	5112	Software Publishers	NA	NA	NA
	5152	Cable and Other Subscription Programming	NA	NA	NA
	5173	Wired and Wireless Telecommunications Carriers	137	\$8,297	14
	5174	Satellite Telecommunications	NA	NA	NA
	5179	Other Telecommunications	NA	NA	NA
	5182	Data Processing, Hosting, and Related Services	NA	NA	NA
	5191	Other Information Services	NA	NA	NA
		Subtotal		137	\$8,297

Appendix Table 10, continued

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Professional, Scientific, and Technical Services	5413	Architectural, Engineering, and Related Services	20	\$563	12
	5414	Specialized Design Services	NA	NA	NA
	5415	Computer System Design and Related Services	9	\$505	9
	5416	Management, Scientific, and Technical Consulting Services	30	\$1,518	8
	5417	Scientific Research and Development Services	NA	NA	NA
	5419	Other Professional, Scientific, and Technical Services	149	\$4,731	17
	Subtotal		208	\$7,317	46
Advanced Energy Other Services (Includes Administrative and Support, Waste Management and Remediation Services, and Health Care and Social Assistance)	5622	Waste Treatment and Disposal	NA	NA	NA
	6215	Medical and Diagnostic Laboratories	13	\$688	6
	8112	Electronic and Precision Equipment Repair and Maintenance	NA	NA	NA
	8113	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	50	\$2,429	6
	Subtotal		63	\$3,117	12
All Advanced Energy Industry	Total		5,024	\$265,179	204

Appendix Table 11: Advanced Energy by NAICS in Nashville-Davidson--Murfreesboro--Franklin, TN MSA, 2019

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Utilities and Construction	2211	Electric Power Generation, Transmission and Distribution	697	\$64,063	28
	2212	Natural Gas Distribution	335	\$29,489	7
	2361	Residential Building Construction	4,377	\$288,657	854
	2362	Nonresidential Building Construction	3,973	\$339,418	244
	2371	Utility System Construction	2,925	\$164,782	107
	2379	Other Heavy and Civil Engineering Construction	70	\$4,323	13
	2381	Foundation, Structure, and Building Exterior Contractors	6,368	\$391,530	531
	2382	Building Equipment Contractors	16,301	\$966,120	966
	2383	Building Finishing Contractors	4,558	\$235,639	540
		Subtotal		39,604	\$2,484,021
Advanced Energy Manufacturing	3211	Sawmills and Wood Preservation	337	\$12,895	19
	3221	Pulp, Paper, and Paperboard Mills	NA	NA	NA
	3241	Petroleum and Coal Products Manufacturing	95	\$7,926	14
	3251	Basic Chemical Manufacturing	231	\$16,652	6
	3252	Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments Manufacturing	130	\$4,529	4
	3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	NA	NA	NA
	3259	Other Chemical Product and Preparation Manufacturing	659	\$51,060	23
	3272	Glass and Glass Product Manufacturing	857	\$47,307	5
	3279	Other Nonmetallic Mineral Product Manufacturing	449	\$20,992	27
	3311	Iron and Steel Mills and Ferroalloy Manufacturing	NA	NA	NA
	3313	Alumina and Aluminum Production and Processing	1,029	\$51,811	4
	3315	Foundries	719	\$42,207	3
	3331	Agriculture, Construction, and Mining Machinery Manufacturing	127	\$7,497	9
	3332	Industrial Machinery Manufacturing	132	\$5,916	8
	3333	Commercial and Service Industry Machinery Manufacturing	533	\$33,482	9
	3334	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	444	\$26,353	10
	3336	Engine, Turbine, and Power Transmission Equipment Manufacturing	NA	NA	NA
3339	Other General Purpose Machinery Manufacturing	852	\$58,923	18	

Appendix Table 11, continued

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Manufacturing	3341	Computer and Peripheral Equipment Manufacturing			
	3342	Communication Equipment Manufacturing	30	\$1,469	3
	3343	Audio and Video Equipment Manufacturing	8	\$378	6
	3344	Semiconductor and Other Electronic Component Manufacturing	83	\$2,249	4
	3345	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	641	\$31,035	7
	3346	Manufacturing and Reproducing Magnetic and Optical Media	204	\$6,019	6
	3351	Electric Lighting Equipment Manufacturing	280	\$14,928	8
	3352	Household Appliance Manufacturing	3,476	\$144,383	4
	3353	Electrical Equipment Manufacturing	564	\$27,765	6
	3359	Other Electrical Equipment and Component Manufacturing	829	\$55,692	13
	3361	Motor Vehicle Manufacturing	NA	NA	NA
	3362	Motor Vehicle Body and Trailer Manufacturing	245	\$11,494	13
	3363	Motor Vehicle Parts Manufacturing	10,049	\$504,730	62
	3364	Aerospace Product and Parts Manufacturing	NA	NA	NA
	3366	Ship and Boat Building	401	\$23,371	4
	3369	Other Transportation Equipment Manufacturing	19	\$975	3
	3391	Medical Equipment and Supplies Manufacturing	2,228	\$131,089	45
	3399	Other Miscellaneous Manufacturing	1,662	\$84,216	102
		Subtotal		27,313	\$1,427,343
Advanced Energy Information	5112	Software Publishers	2,461	\$299,930	107
	5152	Cable and Other Subscription Programming	71	\$5,504	3
	5173	Wired and Wireless Telecommunications Carriers	8,103	\$473,110	323
	5174	Satellite Telecommunications	NA	NA	NA
	5179	Other Telecommunications	234	\$11,301	36
	5182	Data Processing, Hosting, and Related Services	3,165	\$355,796	126
	5191	Other Information Services	1,064	\$101,340	71
		Subtotal		15,098	\$1,246,981

Appendix Table 11, continued

Industry Group	NAICS	Descriptor	Employment	Payroll (\$1,000)	Number of Establishments
Advanced Energy Professional, Scientific, and Technical Services	5413	Architectural, Engineering, and Related Services	7,664	\$637,246	542
	5414	Specialized Design Services	796	\$48,046	189
	5415	Computer System Design and Related Services	9,790	\$932,004	568
	5416	Management, Scientific, and Technical Consulting Services	7,403	\$566,312	924
	5417	Scientific Research and Development Services	1,312	\$183,093	60
	5419	Other Professional, Scientific, and Technical Services	4,699	\$197,491	338
	Subtotal			31,664	\$2,564,192
Advanced Energy Other Services (Includes Administrative and Support, Waste Management and Remediation Services, and Health Care and Social Assistance)	5622	Waste Treatment and Disposal	224	\$11,655	22
	6215	Medical and Diagnostic Laboratories	2,758	\$143,038	109
	8112	Electronic and Precision Equipment Repair and Maintenance	2,424	\$90,868	63
	8113	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	839	\$43,877	98
	Subtotal			6,245	\$289,438
All Advanced Energy Industry	Total		119,924	\$8,011,975	7,314