ADVANCED MATERIALS

TN Department of Economic & Community Development

Center for Economic Research in Tennessee (CERT)

Contents

Overview

For many years, Tennessee has excelled in advanced materials production. Manufacturers in Tennessee have distinguished themselves from regional and national competitors in glass, rubber, and clay industries. Tennessee's success in this cluster seemed unlikely a century ago. Agriculture was the lynchpin of the Southern economy prior to the Second World War. Wartime mobilization spurred enormous capital investment and industrialization in the American South. Most of this manufacturing investment was short-lived, but some industries like rubber gained a permanent foothold during this time. The nation relied on Tennessee and other Southern states for synthetic rubber production during the war. Conflict in the Pacific resulted in a shortage of natural rubber in the United States. Access to petroleum and alcohol made the Southeast region a prime location for synthetic rubber manufacturing.[1] In the years after the war, Tennessee's advanced materials cluster further developed as manufacturers relocated from coastal regions to inland states with access to major transportation routes. The influx of foreign automotive investment into Tennessee in the 1960's bolstered the advanced materials industries, many of which are closely linked to the automotive cluster.[2] Since then, advanced materials industries in Tennessee have continued to grow and generate substantial revenue for the state. Tennessee currently ranks third in the nation for employment in this cluster.[3] In 2016, Tennessee businesses generated $1.03 billion in earnings, with total sales of $4.29 billion.

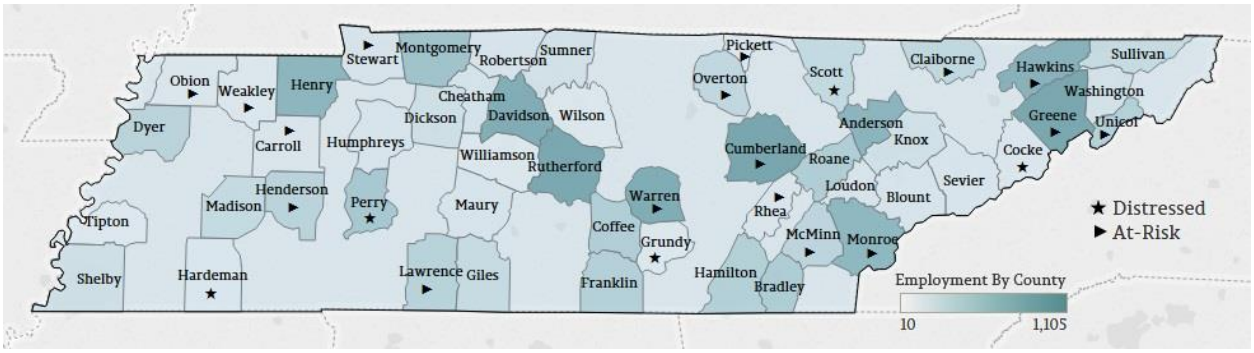
Industry Category	NAICS	2017 Employment	Business Locations
Glass Industries			
Flat Glass Manufacturing	327211	1,356	10
Glass Product Manufacturing Made of Purchased Glass	327212	2,280	28
Other Pressed and Blown Glass and Glassware Manufacturing	327215	373	9
Rubber Industries			
Tire Manufacturing	326211	3,359	12
Tire Retreading	326212	111	9
Rubber and Plastic Hoses and Belting Manufacturing	326220	1,528	19
Rubber Product Manufacturing for Mechanical Use	326291	3,360	17
All Other Rubber Product Manufacturing	326299	962	15
Clay Industries			
Pottery, Ceramics, and Plumbing Fixture Manufacturing	327110	558	17
Clay Building Material and Refractories Manufacturing	327120	1,406	19
Ground or Treated Mineral and Earth Manufacturing	327992	752	8
Kaolin and Ball Clay Mining	212324	202	6

Industries in this cluster employ 16,848 Tennesseans, an 8.2% increase since 2012. Most industries grew during this time. The biggest gains occurred in rubber product manufacturing for mechanical use, which added 755 new jobs. The rubber sub-cluster accounts for the most significant percentage of cluster employment. Nearly 60% of industry jobs are found in the rubber industries. Tire manufacturing alone

[1] Jaworski, T. (2017). World War II and the Industrialization of the American South. *Journal of Economic History*, 77(4).
[2] Crafts, N., & Klein, A. (2017). *A Long-Run Perspective on the Spatial Concentration of Manufacturing Industries in the United States*. CAGE Online Working Paper Series 339.
[3] Institute for Strategy and Competitiveness, Harvard Business School. (2015). *Tennessee: Vulcanized and Fired Materials Cluster*. https://clustermapping.us/region-cluster/vulcanized_and_fired_materials/state/tennessee/subclusters#employment

contributes 20% to total cluster employment. Cluster employment is expected to maintain its current level through 2022. Significant job creation will likely occur in ground or treated mineral and earth manufacturing. Other industries, like ceramics and fixture manufacturing, will also continue to expand.

Cluster Employment by County



Tennessee currently has 170 advanced materials businesses, as compared to 158 in 2012. The rubber belt and hose manufacturing industry, which added seven new businesses, experienced the largest increase in business locations. Glass product manufacturing made of purchased glass has the most establishments for industries in this cluster. Tennessee has 28 manufacturers of this kind.

Industries in this cluster have a significant presence in at-risk and distressed counties. Almost half of cluster employment is concentrated in these counties. Between 2012 and 2017, the employment growth rate was 32.4% for distressed counties and 2.4% for at-risk counties. Rubber manufacturing accounts for nearly all employment in Tennessee's distressed counties. For at-risk counties, the most significant employers are tire manufacturers, mechanical use rubber product manufacturers, and manufacturers of glass products made from purchased glass. At-risk counties experienced a net decrease in business locations despite growing employment, suggesting increased consolidation among Tennessee's manufacturers. Distressed counties added an additional establishment for a total of eight.

Workforce

Average industry wages in this cluster are $64,765, more than $7,000 higher than the average salary in Tennessee.[4] Wages have grown across the board in rubber, glass, and clay industries during the last several years.[5] The industry with the highest average salary is ground or treated mineral and earth manufacturing, followed by flat glass manufacturing and kaolin and ball clay mining. These industries have a strong emphasis on R&D and other high-skilled positions. The most common occupations in the advanced materials cluster are team assemblers, machine setters, operators and tenders, and inspectors, testers, sorters, samplers, and weighers.

SOC	Description	2017 Employment	Median Hourly Earnings
Management Occupations			
11-1021	General and Operations Managers	45,177	$40.97
Architecture and Engineering Occupations			
17-2112	Industrial Engineers	6,453	$36.93

[4] Industry data related to employment, business locations, earnings, and inputs-outputs were obtained from Economic Modeling Specialists (EMSI).

[5] Institute for Strategy and Competitiveness, Harvard Business School. (2015). *Tennessee: Vulcanized and Fired Materials Cluster*. https://clustermapping.us/region-cluster/vulcanized_and_fired_materials/state/tennessee/subclusters#wages

Sales and Related Employment			
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	21,390	$25.45
Office and Administrative Support Occupations			
43-5071	Shipping, Receiving, and Traffic Clerks	17,397	$14.26
Installation, Maintenance, and Repair Occupations			
49-9041	Industrial Machinery Mechanics	8,683	$22.34
49-9043	Maintenance Workers, Machinery	4,265	$21.87
49-9071	Maintenance and Repair Workers, General	32,394	$17.53
Production Occupations			
51-1011	First-Line Supervisors of Production and Operating Workers	16,197	$25.22
51-2092	Team Assemblers	62,904	$14.51
51-9023	Mixing and Blending Machine Setters, Operators, and Tenders	3,085	$17.82
51-9032	Cutting and Slicing Machine Setters, Operators, and Tenders	1,790	$16.22
51-9041	Extruding, Forming, Pressing, and Compacting Machine Setters, Operators, and Tenders	2,621	$14.07
51-9051	Furnace, Kiln, Oven, Drier, and Kettle Operators and Tenders	946	$15.67
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	13,765	$15.77
51-9195	Molders, Shapers, and Casters, Except Metal and Plastics	1,034	$14.29
51-9197	Tire Builders	510	$20.95
51-9198	Helpers – Production Workers	20,772	$11.49
53-7051	Industrial Truck and Tractor Operators	17,780	$14.28
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	95,488	$12.41
53-7064	Packers and Packagers, Hand	18,534	$10.22

Roughly 51% of the labor force in these industries is 45 or older, whereas 43% of workers are between 25 and 44 years of age. The glass industries have the highest concentration of aging workers. In pressed and blown glass manufacturing, for example, 65% of workers are between the ages 45 and 64.

Males account for 72% of employment in this cluster, 21% more than the average across Tennessee's entire labor force. More than 85% of employees in this cluster are Caucasian, while roughly one out of ten are Black or African-American. Workers who identify as Asian, Latino, or Hispanic, or two or more races combine for less than 5% of total employment.

Glass Industries

The glass sub-cluster includes four industries: flat glass manufacturing, glass product manufacturing made of purchased glass, other pressed and blown glass manufacturing, and glass container manufacturing. Tennessee's combined employment for this sub-cluster (4,099 workers) is the seventh highest in the nation. Tennessee also has many glass companies and glaziers that are not included in this cluster.

In recent years, glass manufacturers in the U.S. have re-captured a competitive advantage over importers while also enjoying new export opportunities. Revenues for Tennessee glass businesses will continue to rise due to growing demand for glass products. Large manufacturers are best suited to adapt to new operating conditions. Small- and medium-sized companies will need to target niche markets to remain competitive.

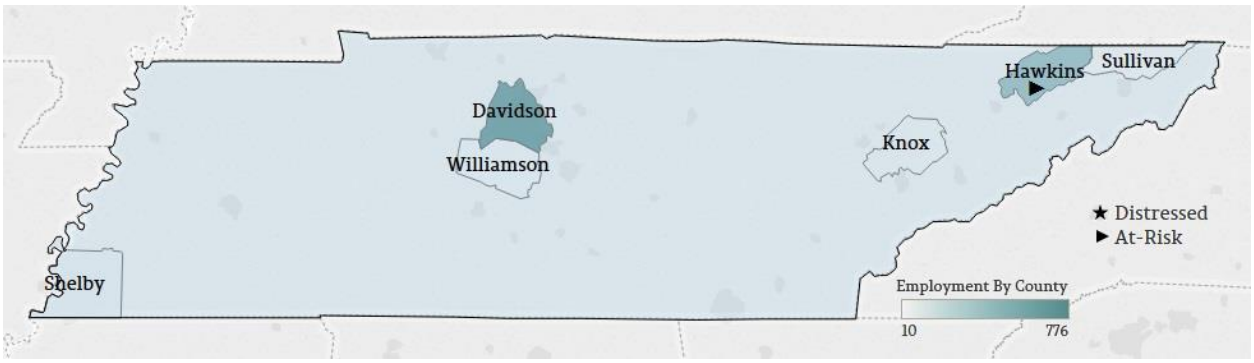
Glass manufacturers in Tennessee rely on a common set of inputs. Major purchases include services from corporate offices, rail transportation, construction sand and gravel, raw glass, bituminous coal and lignite, and natural gas. Manufacturers vary in the degree to which they rely on regional suppliers. Flat glass manufacturers purchase nearly all sand and gravel (93.7%) from in-region suppliers. Other types of glass manufacturers obtain between half to two-thirds of their sand and gravel from suppliers outside the region. More than 90% of sales between purchased, pressed, and blown glass manufacturers occur in-region. Tennessee's flat glass industry obtains roughly 30% of its supply from out-of-region manufacturers.

Flat Glass Manufacturing

This industry is one of Tennessee's strongest in the entire cluster. For many years, Tennessee has ranked first in the nation for total employment and employment concentration. Companies in this industry produce flat glass from melted silica sand and cullet. This industry also includes businesses that utilize flat glass for manufacturing other glass products, such as laminated, insulated, and stained glass used in industrial settings. Major flat glass manufacturers in Tennessee include AGC Flat Glass North America LLC (Hawkins), Carlex Glass America (Davidson), and Contour Industries (Hawkins).

Currently, flat glass manufacturers employ 1,356 Tennesseans, a 15.6% increase in jobs since 2012. Tennessee's employment in this industry accounts for roughly one-third of total regional employment and an eighth of all industry jobs in the United States. The Southeast region is particularly strong in this industry. Five Southeastern states (Tennessee, Georgia, North Carolina, Kentucky, and Florida) rank in the top ten nationally for total employment. Employment data for this industry became available in 2001. Since that time, Tennessee has led the nation in total employment, and analysts predict Tennessee to maintain its number one ranking in coming years. Moreover, Tennessee's growth rate in recent years surpassed every state besides Illinois and Texas. Hawkins County led Tennessee counties in employment growth, adding more than 150 jobs since 2012. Companies in Hawkins include AGC Flat Glass North America in Church Hill and Contour Industries in Surgoinsville. In early 2018, AGC announced that it planned to invest $40.6 million in expanding the plant and adding 85 new jobs as part of a project with TNECD.[6] The company, which specializes in glass products for commercial and residential construction, is a subsidiary of the world's largest glass manufacturing company, Tokyo-based Asahi Glass Co.

[6] TNECD. (2018). *AGC Glass North America to Expand Operations in Church Hill*. http://www.tnecd.com/news/475/agc-glass-north-america-to-expand-operations-in-church-hill/



Tennessee has 10 businesses in this industry, more than any other state in the Southeast and the fourth highest nationally. Flat glass manufacturers in Tennessee account for nearly a quarter of all businesses in the region. Tennessee's manufacturers tend to employ more workers per business location than other states that lead this industry. For example, California has six more manufacturers than Tennessee but less than an eighth of Tennessee's total jobs. Manufacturers in Hawkins and Davidson Counties account for a significant percentage of Tennessee's employment in this industry. Davidson County is home to Carlex Glass America's Nashville headquarters and glass manufacturing plant. Carlex, which also has another plant in Lonore and a distribution center in Lebanon, is an industry leader in glass products for the automotive industry.

Tennessee has not seen an increase in the number of flat glass businesses in recent years, although industry presence shifted. Knox County, which added two manufacturers since 2012, is now tied with Shelby County for the most number of manufacturers. Davidson County, which previously led the state in total business locations, lost two of its three manufacturers in the last few years. Employment in Davidson increased by roughly 100 jobs since 2012 despite the loss of these manufacturers. Sullivan and Wilson Counties experienced both a decline in employment and business locations, with both counties losing their only manufacturer. The Southeast region as a whole did not add many manufacturers in recent years. Georgia was the only state to achieve a net increase in its total number of businesses.

Tennessee's location quotient in this industry is 6.22, the highest in the nation. Kentucky ranks second, with a much lower score of 3.9. Employment concentration in Tennessee has been declining over time. In 2012, Tennessee's location quotient was 6.28. The score is predicted to drop to 5.79 by 2022. The gap between states has narrowed over time. In 2001, Tennessee's location quotient was 8.08, significantly higher than second-ranked Texas' score of 3.76. Nevertheless, it is unlikely that any state will be able to close the gap in coming years. Most states are expected to experience a similar drop in employment concentration, ensuring that Tennessee maintains its number one ranking.

Average industry wages in Tennessee are $77,685, with $64,982 in salaries and an additional $12,703 in supplements. When adjusting for cost of living differences, these wages are $10,000 higher than the regional average and $15,000 higher than the national average. Tennessee ranks second behind Kentucky among all U.S. states for average industry wages. The major occupations in Tennessee for this industry are team assemblers, furnace and kettle operators, and inspectors, testers, sorters, samplers, and weighers. Flat glass manufacturers in Tennessee generated $308.7 million in earnings in 2016, which accounted for 32.0% of all earnings made by this industry in the Southeast region. Total sales by Tennessee businesses were $1.11 billion, $529.2 million of which were in-region.

Revenues for this industry are expected to rise at a per annual rate of 1.6%. Flat glass, a key component in building construction, is in greater demand due to new residential construction and housing renovations. In 2018 alone, housing starts may increase as much as 2.7%. Commercial construction is also on the rise. An increase in nonresidential construction projects allows flat glass manufacturers to increase prices, expanding profit margins across the industry. Moreover, U.S. manufacturers face less competition from importers. Slow economic growth in developing economies has

caused foreign companies to scale down production, resulting in fewer imports into the U.S. and new export opportunities for Tennessee businesses. Manufacturers also benefit from the lack of substitutes for flat glass. Plastics do not provide the same transparent or refractory qualities. Contractors are now using glass as a substitute for other building materials. In particular, seraphic-printed glass, which is made to look like marble or granite, is frequently used on the upper levels of buildings of commercial properties.

Unfortunately, this industry's recent successes are partly owed to the failure of small business. Many manufacturers lost profitability and had to close up shop, while large companies engaged in an aggressive acquisitions strategy to reduce input costs. The biggest companies are now using these substantial resources to open distribution centers in neighboring regional markets. With locations nationwide, these manufacturers are best suited to secure long-term supply contracts with major automotive companies. Small-sized companies, particularly new market entrants, achieve profitability by manufacturing niche products like flat glass sheets with high UV laminates or modular windows for residential housing. Flat glass manufacturing does not require much start-up capital or overhead. Business owners with knowledge of the industry and quality products are therefore able to carve out market share.

Companies based in Tennessee have built-in advantages in the regional market. Since glass is such a fragile product, companies aim to minimize the distance at which inventory is transported. Tennessee has easy access to transportation routes and is within driving distance of several major cities, making the state an ideal place to base a manufacturing operation.[7]

Glass Product Manufacturing Made of Purchased Glass

Glass product manufacturing is also one of Tennessee's strongest industries in the advanced materials cluster. Tennessee is the regional leader in glass product manufacturing and consistently places in the top five nationally on several metrics. Businesses in this industry create products by coating, laminating, tempering, and shaping purchased glass. Tennessee's glass product manufacturers produce anything from medical glassware and safety glass to aquariums and Christmas ornaments. Major manufacturers in Tennessee include Techni-Glass (Hawkins), DWK Life Sciences (Roane), and Nashville Tempered Glass Corporation (Davidson).

This industry employs 2,280 Tennesseans, nearly one-quarter of all industry jobs in the region. Tennessee currently ranks first in the Southeast for employment and seventh nationally. Monroe County leads Tennessee counties for employment in this industry. Businesses in Monroe employ 773 workers, a 13.5% increase since 2012.[8] Employment growth has been erratic across Tennessee in this industry. Roane County, second among the counties for employment, has 100 fewer jobs than in 2012. DWK Life Sciences, based in Rockwood in Monroe County, is one of the world's leading manufacturers of scientific glassware.[9] Cumberland County saw employment decline from 419 in 2012 to 237 today. These losses were largely offset by expanded operations of pre-existing manufacturers in counties like Lawrence, Cheatham, Blount, Maury, and Obion counties. Part of DURA Automotive Systems' glass division is located in Lawrenceburg. Overall, Tennessee experienced a net decrease of roughly 50 jobs since 2012. This decline in employment was unusual during this time period. Total U.S. employment grew at a per annual rate of 3%. Nevertheless, the national growth rate is expected to reverse in coming years. Many states will experience a net reduction in jobs. Michigan, for example, is predicted to lose 600 net jobs. By 2022, Tennessee will likely rank sixth in the nation for employment.

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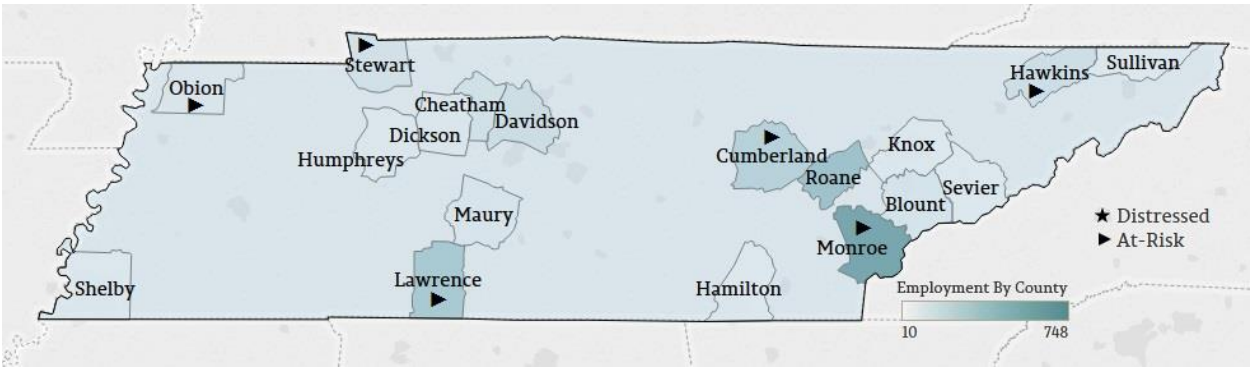
[7] IBISWorld. (2017). *Crystal clear: Revenue will grow as downstream industries continue to expand*.

[8] Employment data for this industry includes Carlex Glass America's glass fabrication plant in Vonore and AGC's Knoxville facility.

[9] DWK Life Sciences. (2016). *Duran Group Acquires Kimble Chase Life-Science & Research Products*. http://www.duran-group.com/en/meta-navigation-header/news/news-archive/news-info/article/156.html



Currently, Tennessee has 28 glass product manufacturers, compared to 32 in 2012. Seven counties in Tennessee had a manufacturer shut down or relocate during this time period. Hamilton, Hamblen, and Coffee lost their sole manufacturer. Cumberland, Blount, Knox, and Sevier each lost a manufacturer but still maintain some industry presence. Gilded Mirrors, Inc. is the primary manufacturer in Blount County. Three counties were able to grow this industry. Davidson and Hawkins achieved a net increase in business locations, and Humphreys added its first glass product manufacturer. Techni-Glass, a custom glass manufacturer in Hawkins County, announced a $1.5 million investment to expand existing operations and add 54 new jobs.[10]

Consolidation has been common in this industry in recent years. Thirty-five states in the U.S., including every state in the Southeast besides Florida, saw a net reduction in manufacturing operations. Businesses in this industry vary greatly in size, due to the wide variety of products made by this industry. Monroe County only has two glass product manufacturers, despite having one-third of total employment. SCHOTT Gemtron Corporation, a joint venture between AFG and Germany-based Schott AG, has its corporate headquarters and glass manufacturing facility in Monroe. Davidson County has four manufacturers but less than 10 employees overall. Most of Tennessee's glass product businesses are small-sized operations. Tennessee has 18 counties with presence in this industry, 10 of which have fewer than 50 total jobs. Even still, manufacturers in Tennessee employ on average more workers per business location than regional competitors. Florida has three times as many businesses in this industry but 700 fewer workers.

Tennessee's location quotient for this industry (2.45) is the highest in the Southeast and the fourth highest nationally. Employment concentration has declined in recent years. In 2012, Tennessee had a location quotient of 2.97, which was the second highest in the nation at that time. Analysts expect Tennessee's location quotient to continue to decline, but not enough to disrupt its competitive edge in the region. Alabama and Kentucky, the only Southeastern states besides Tennessee to rank in the top ten for employment concentration, also have declining location quotients. By 2022, Tennessee's location quotient will likely remain the highest in the region and the sixth highest nationwide.

Average industry wages in Tennessee ($53,923) are close to the regional average. This industry shares the same staffing patterns as flat glass manufacturing. Glass product manufacturers in Tennessee generated $125.5 million in earnings in 2016, more than 20% of all industry profit in the region. Tennessee businesses made $464.9 million in sales, $155.3 of which were in-region.

This industry will benefit from greater consumer spending. With more money in their pockets, consumers will purchase greater quantities of kitchenware and home decorations as well as electronics products with glass components. Sales to research institutions of scientific glassware will also increase. Part of this demand will be captured by imports, which have created greater pressure on Tennessee businesses in markets for flexible and durable glass products. In the years ahead, Tennessee

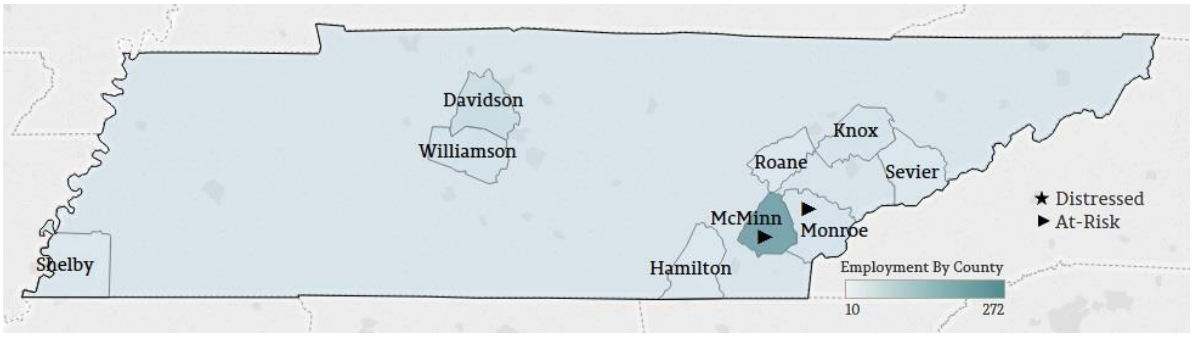
[10] TNECD. (2017). *Techni-Glass, Inc. to Expand in Surgoinsville*. https://www.tnecd.com/news/455/techni-glass-inc-to-expand-in-surgoinsville/

manufacturers will also have to reckon with rising energy prices. Glass manufacturers consume substantial energy by melting raw materials in furnaces. Utility-related expenses can eat up as much as 20% of revenue.

Other Pressed and Blown Glass and Glassware Manufacturing

This industry is one of the smallest in Tennessee's advanced materials cluster. Industry products include hand-blown glass, decorative and novelty glassware, and other miscellaneous glass products. Most companies in this industry are small-sized operations with custom glass offerings, like Genesis Glass & Mirror of Tennessee, LLC (Williamson).

Pressed and blown glass manufacturers employ 373 Tennesseans, an increase of 82 jobs since 2012.[11] Total U.S. employment for this industry declined sharply in recent years, particularly in the Southeast. Businesses in the region now employ 1,000 fewer workers than several years ago. While Tennessee grew employment 28.3% during this time period, other states lost jobs at nearly the same rate. Kentucky saw a net reduction of almost 150 jobs. By 2022, the Southeast is predicted to have lost an additional 800 jobs, while Tennessee's job creation is expected to continue.



Tennessee currently has 9 businesses of this kind, the same number as 2012. Expansion of pre-existing manufacturers explains the rise in employment. Monroe and McMinn Counties saw total employment increase without adding an additional manufacturer. Davidson County added 30 jobs despite losing one of its two manufacturers. Knox County was the only county in Tennessee to add an additional business during this time. This trend of consolidation was characteristic of what was happening in the region. South Carolina, Kentucky, West Virginia, Florida, Arkansas, and Virginia saw a net reduction in total manufacturing operations. North Carolina, which added 15 new manufacturers, was the only state with a net increase. Overall, the Southeast lost two manufacturers even as North Carolina doubled the size of its industry.

Employment concentration in this industry has been consistently improving. Tennessee's location quotient rose from 0.92 in 2012 to 1.25 in 2017, the biggest improvement in the region and the seventh largest increase for all U.S. states. Tennessee now ranks eleventh in the nation for location quotient. By 2022, Tennessee's location quotient is predicted to increase to 1.39.

Pressed and blown glass manufacturers in Tennessee pay wages on par with the national average. Industry wages in Tennessee are $65,736 on average, with $54,986 in salaries and $10,749 in supplements. In Tennessee, this industry relies on the same set of occupations as manufacturers of flat glass and purchased glass. Tennessee businesses earned $24.8 million in 2016 and completed $91.5 million in sales transactions. Nearly half of these sales were made in-region. Revenue for this industry will grow in the long-term due to a recovery of the automotive industry. Pressed and blown glass has many automotive applications, including windscreens, mirrors, and headlights.[12]

[11] Employment estimates for this industry include SCHOTT Gemtron. This company is more accurately classified as a glass product manufacturer using purchased glass.
[12] IBISWorld. (2017). *Crystal clear: Revenue will grow as downstream industries continue to expand*.

Glass Container Manufacturing

Tennessee does not currently have a presence in glass container manufacturing. Tennessee's glass container companies are primarily focused on decoration and labeling, such as Chattanooga Labeling Systems (Hamilton).[13] Nationwide, this industry employs 15,244 workers and 3,028 in the Southeast specifically. Industry employment in the U.S. has shrunk 1.1% per year since 2012. Employment is predicted to continue declining for the foreseeable future. By 2022, U.S. businesses in this industry will employ roughly 13,000 workers.

Industry wages are strong compared to other industries in this cluster. Average national wages for glass container manufacturing are $86,775. Average regional wages are even higher ($87,162). Common occupations include paving, surfacing, and tamping equipment operators, construction laborers, pile-driver operators, drywall and ceiling tile installers, and other construction equipment operators. Manufacturers in the region made $897.8 million in sales in 2016, only $182.9 of which were out-of-region. Total earnings by glass container manufacturers in the Southeast were $249.2 million in 2016. Revenue for U.S. companies will be constrained by an increase in affordable imports and product substitutes like plastic, aluminum, and cardboard. Manufacturers in the U.S. will consolidate further to grapple with declining revenues. Employment is expected to decrease due to automation and other laborsaving technologies. Keys to success in this industry will be diversification of downstream markets and investing in R&D to create more lightweight, environmentally friendly containers.[14]

[13] Chattanooga Labeling Systems. (2018). https://clsdeco.com/services

[14] IBISWorld. (2017). *Crystal clear: Revenue will grow as downstream industries continue to expand*.

Rubber Industries

The rubber sub-cluster includes five industries: tire manufacturing, tire retreading, rubber and plastic hoses and belts manufacturing, rubber product manufacturing for mechanical use, and all other rubber product manufacturing. Total employment in Tennessee for this sub-cluster (9,320) is the third highest in the nation.

The major trend in rubber manufacturing has been a transition toward new markets in response to recent challenges. Tire manufacturers, facing a decline in sales to Canada, are now focusing their export strategy on China, India, and Mexico. Tire retreading companies, grappling with an uptick in new tire purchases, are banking on increased demand from long-distance truckers. Hose and belt manufacturers will benefit from increased hydrocarbon exploration in the U.S. at a time when new automotive sales have stagnated. Manufacturers of miscellaneous and mechanical use rubber products will compensate for decreased sales to the automotive industry by capitalizing on the revitalization of the construction industry.

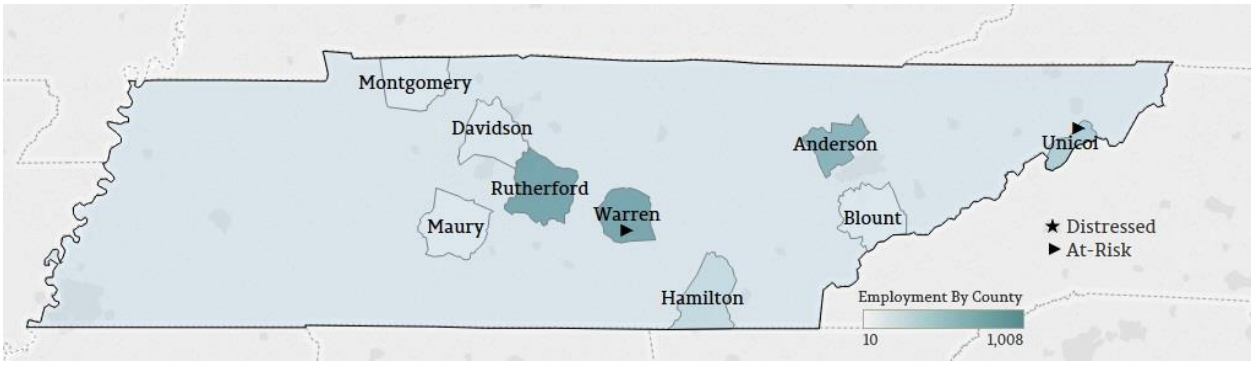
In Tennessee, these industries rely on a common set of occupations: team assemblers, tire builders, first-line supervisors of production and operating workers, inspectors and testers, and machine operators and tenders, including cutting and slicing machines, crushing and grinding machines, mixing and blending machines, molding and casting machines, chemical equipment, and furnaces and kettles. These industries also utilize a common set of inputs, including artificial and synthetic fibers and filaments, purchases from the logging industry, freight and long-distance trucking, and professional services like corporate offices and wholesale trade agents and brokers. The entire sub-cluster relies on purchases from manufacturers of rubber products for mechanical use and miscellaneous rubber products. Tire manufacturers and re-treaders account for the most significant percentage of purchases from the logging industry, although only 20-40% of these purchases are made in-region. Belt and hose manufacturers utilize a great deal of fibers and filaments, half of which are purchased in-region. Manufacturers in this industry rely on out-of-region suppliers for most plastics and general hardware needs.

Tire Manufacturing (Except Retreading)

Tennessee's tire manufacturing industry is the largest in the advanced materials cluster. In this industry, businesses produce tires and inner tubes using natural and synthetic rubber. Major Tennessee employers include Bridgestone Americas (Rutherford, Morrison), Carlstar Group (Anderson), Hankook Tire America Corporation (Montgomery), Specialty Tires of America (Unicoi), and Mitchell Industrial Tire Company (Hamilton).

Tire manufacturers in Tennessee currently employ 3,659 workers, an increase of roughly 150 jobs in the last few years.[15] Tennessee has a long history in tire manufacturing. Bridgestone Americas, headquartered in Nashville, has tire operations in LaVergne and Morrison. Bridgestone's LaVerge plant was the company's first tire plant and now produces 5,800 tires per day.[16] Hankook Tire America Corporation, also headquartered in Nashville, opened its first U.S. manufacturing operation in Clarksville late last year. The facility employs more than 300 workers, and the company expects an additional 1,500 jobs to be added within the next few years.[17]

[15] EMSI's employment estimate omitted the new Hankook facility in Clarksville.
[16] TNECD. (2017). *Tennessee Makers: Bridgestone*. http://www.tnecd.com/blog/121/tennessee-makers-bridgestone
[17] Hankook Tire America Corp. (2017). *Hankook Tire Celebrates Grand Opening of U.S. Manufacturing Plant*.



Most counties in Tennessee expanded employment during this time. Job creation occurred in Rutherford, Hamilton, Montgomery, Davidson, Blount, and Maury Counties. However, significant job losses in Obion County due to the closing of the Goodyear plant in Union City offset most of these gains in statewide employment.[18] While analysts expect industry employment to contract in Tennessee and other states through 2022, future expansions by Hankook will ensure growth in this industry. The Southeast is a very important region for this industry. More than 60% of industry jobs are located in the Southeast. Tennessee ranks sixth in the nation for employment and fourth in the region behind South Carolina, North Carolina, and Alabama. Tennessee is predicted to maintain these rankings while also improving on other industry metrics.

Currently, 12 tire manufacturing operations are located in Tennessee, a net increase of two locations since 2012. Blount and Montgomery Counties acquired their first tire manufacturer, and Hamilton County added its second. Many states have seen businesses consolidate or relocate out of the region in the last few years, while Tennessee's businesses have grown in number. Since 2004, Ohio has lost 40% of its manufacturers in this industry. Arizona lost 20 of its 21 manufacturers (the highest in the nation at the time) in the last five years. In Tennessee, eight counties have at least one tire manufacturer. Rutherford, Unicoi, Warren, and Hamilton Counties each have two. Labor intensity of manufacturing operations varies substantially between counties. Tire makers in Rutherford County employ almost ten times as many employees as Hamilton manufacturers. Overall, Tennessee manufacturers employ fewer workers per business location than other states in the region. The average number of employees per manufacturer is 274 in Tennessee, as compared with approximately 1,000 per location in South Carolina, Virginia, and Arkansas.

The location quotient for this industry (3.38) is the seventh highest in the nation and fifth in the region behind South Carolina, Alabama, Mississippi, and Arkansas. Since 2012, Tennessee surpassed North Carolina and Kansas in rank. Employment concentration may decline slightly in the next few years. Other states will experience a sharper decline. By 2022, Tennessee will likely replace Iowa as the sixth highest employment concentration in the nation.

Average industry wages in Tennessee are $76,735 per year, higher than both the regional and national average. Tire manufacturers in Tennessee generated $1.06 billion in sales in 2016 ($212.3 million of which were in-region) and earned $249.6 million. Capital investment in tire manufacturing is increasing due to recovery of downstream markets. Rising per capita disposable income is positively correlated with greater demand for new tires as well as increased road trips and air travel. Companies like Bridgestone and Hankook are ramping up U.S. manufacturing operations to be closer to these downstream markets. Some of this demand will be captured by foreign producers. Tennessee manufacturers now have to contend with falling global prices for natural rubber and the recent removal of tariffs against Chinese tire manufacturers. These tariffs controlled the volume of low-priced, Chinese-made tires that entered U.S.

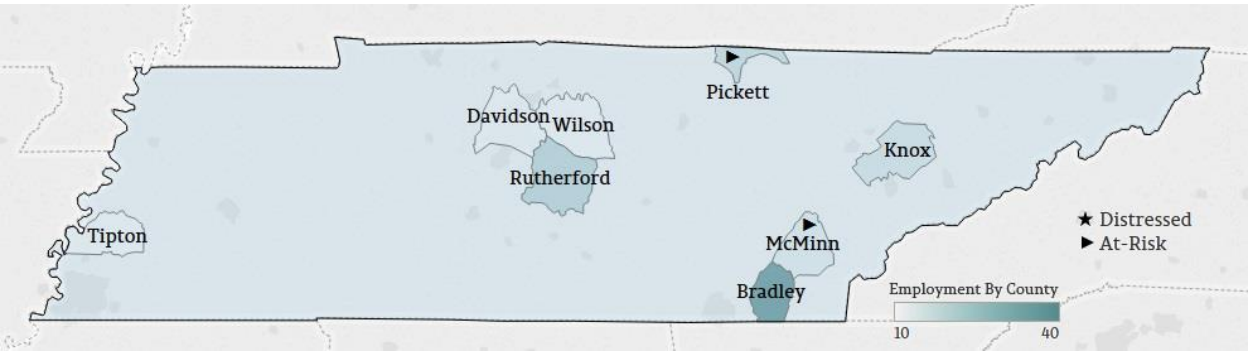
[18] Reuters. (2011). *Goodyear closes Tennessee plant ahead of schedule*. https://www.reuters.com/article/goodyear/goodyear-closes-tennessee-plant-ahead-of-schedule-idUSN1E76A0CG20110711

markets. Manufacturers in Korea and Thailand rushed to fill the gap in U.S. markets while these tariffs were imposed, which diversified the competition in this industry. To remain competitive, tire manufacturers in the U.S. had to drop prices. Export markets are also changing quickly. Historically, Canada has been the biggest consumer of U.S. tire exports. The recent slowdown in Canada's economy has resulted in manufacturers looking to new markets for high-performance tires. Countries with growing middle classes, like China, India, and Mexico, are now major targets. Overall, revenue is expected to rise slightly in coming years. Increased foreign direct investment will continue to benefit Tennessee. Investors prefer the Southeast region for its transportation access, low union costs, and ample supply of high-skilled automotive workers.[19]

Tire Retreading

Unlike most industries in the cluster, tire retreading is a service industry and does not involve manufacturing original products. Companies in this industry retread, recap, and rebuild tires. Tennessee has a very small presence in this industry. Tennessee does not have major employers on the scale of tire manufacturers. Most retreading companies employ 10 or less workers, like Best-One Retreading (Bradley, Knox, and Davidson).

Tire retreading businesses in Tennessee employ 111 workers, as compared with 122 in 2012. Some counties (Bradley, Rutherford, Wilson, and Tipton) added jobs during this time period. Job losses were mostly concentrated in at-risk counties like McMinn, Pickett, and Union. Tennessee's net job losses in this industry were unusual among Southeastern states. Regionally, industry employment grew 1.5% per year over this time period. By 2022, Tennessee will likely recover these jobs and achieve a growth rate comparable to the regional average.



The silver lining in recent years was that Tennessee maintained its nine tire retreading businesses, while many states lost industry presence. In the Southeast, only three states (Tennessee, Georgia, and Mississippi) avoided a net decrease in business locations. Arkansas lost 9 of its 16 tire retreading companies. Moreover, Tennessee's location quotient (0.88) is virtually the same as it was five years ago and will likely remain steady in coming years.

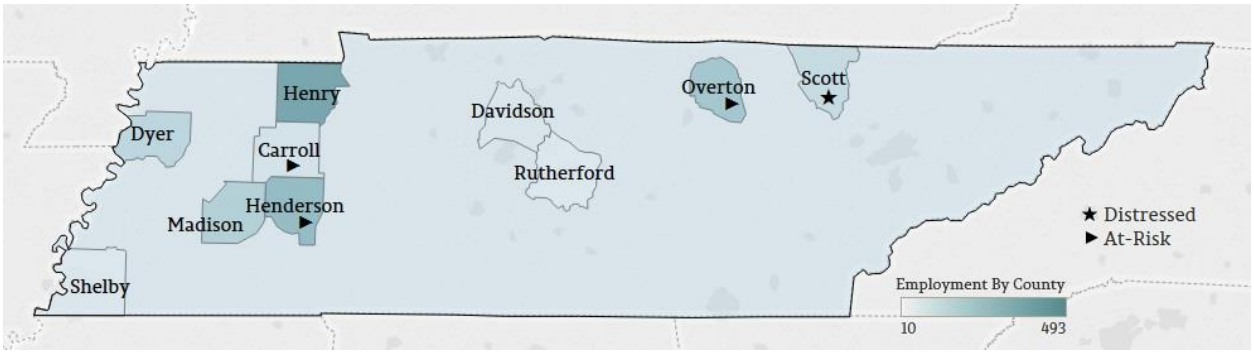
Average wages in Tennessee are $52,439 per year, with $43,659 in wages and $8,780 in supplements. These wages are slightly higher than the national average and on par with the regional average. In 2016, tire retreading businesses in Tennessee generated $7.1 million in earnings. Of the $30.4 million in sales, $7.8 million were in-region. Revenue in this industry may decline slightly in the next few years. Sales for new tires have increased, cutting into demand for retreading and recapping. In other ways, the tire retreading industry will benefit from economic recovery. The total number of U.S. exports is expected to increase, resulting in more freight trucking to coastal ports. Trucks will need their tires retreaded more frequently due to this wear and tear.[20]

[19] IBISWorld. (2017). *Falling flat: Low unemployment rates and rising consumer incomes will lead to revenue growth*.
[20] IBISWorld. (2017). *iExpert Industry Summary OD4988: Tire Retreading and Recapping*.

Rubber and Plastics Hoses and Belting Manufacturing

This type of manufacturing is one of Tennessee's strongest in the rubber sub-cluster. Businesses in this industry create hoses and belting using natural and synthetic rubber and plastic resins. Industry products include garden hoses, hydraulic hoses, motor vehicle hoses, pneumatic hoses, radiator hoses, water hoses, conveyor belts, fan belts, motor vehicle belts, timing belts, transmission belts, vacuum cleaner belts, and V-belts for power transmission. Tennessee's major hose and belting manufacturers are Fluid Routing Solutions (Henderson), HBD Industries (Scott), Parker Hannifin (Overton), PML (Henry), Eaton Aeroquip (Dyer), and Teknor Apex (Haywood). These companies' products are used by a variety of industries. HBD Industries produces industrial hoses, conveyor and power transmission belting, industrial rubber bands, and other rubber products. Eaton's hoses have industrial, aerospace, and automotive applications. Parker Hannifin manufactures rubber hose and tubing as components for its medical devices, welding apparatuses, and aerospace technologies. PML and Fluid Routing Solutions' rubber products are primarily fuel hoses for vehicles. Teknor Apex, which employs more than 600 workers in Haywood County, creates hoses using synthetic rubber compounds. This company was recently awarded a Safety Performance Award by the Vinyl Institute due to zero OSHA-recordable incidents at its Brownsville facility in 2016.[21]

This industry employs 2,128 Tennesseans, nearly one-fifth of all regional employment.[22] Tennessee ranks first in the Southeast and fourth in the nation for employment. Industry employment in Tennessee grew 8.1% since 2012. This job creation was particularly impressive given that total employment decreased at the regional and national level. The largest gains were made by Henry County, which added 121 jobs. Overton County, an at-risk county, added 87 jobs. Dyer County added 66 jobs, doubling its 2012 employment. Net job losses occurred exclusively in at-risk counties. Employment in Henderson County decreased from 508 to 318. Carroll County lost 52 jobs, which was more than half of its industry jobs. Analysts anticipate Tennessee's growth rate to begin cooling off. Total employment will likely return to its 2012 level within a few years.



Tennessee currently has 19 hose and belting manufacturers, the seventh highest in the nation and third highest behind North Carolina and Florida. Since 2012, Tennessee has added seven new manufacturers. Illinois and Tennessee tied for the largest net increase in manufacturers during this time period. Henry County, the epicenter of Tennessee's hose and belting manufacturing, increased its number of businesses from three to five. Shelby County added its first two businesses in this industry. Sullivan, Robertson, and Knox Counties each added one. No county in Tennessee lost industry presence during this time. Tennessee's hose and belting manufacturing operations are on average smaller than some regional

[21] Teknor Apex. (2017). *Three Teknor Apex Facilities Receive Vinyl Institute Awards for Worker Safety and Environmental Excellence*. https://www.teknorapex.com/three-teknor-apex-facilities-receive-vinyl-institute-awards-for-worker-safety-and-environmental-excellence

[22] EMSI's employment estimate was adjusted to account for the 600+ workers at Teknor Apex (Haywood). Rankings are based on EMSI's original estimate.

competitors. Arkansas manufacturers employ an average of 157 workers per location, while Tennessee businesses have 82 employees on average.

Tennessee's location quotient in this industry increased from 3.04 in 2012 to 3.27 today. In employment concentration, Tennessee ranks eighth nationally and fourth in the region behind Arkansas, Kentucky, and South Carolina. Five of the top ten states for location quotient are located in the Southeast. Louisiana's employment concentration is expected to increase in coming years, narrowly surpassing Tennessee's score by 2022.

Average industry wages in Tennessee ($61,031) are higher than both the regional and national average, when adjusting for cost-of-living differences between the states. Hose and belting manufacturers in Tennessee generated $93.8 million in earnings in 2016, which accounted for 18% of all industry profit in the region. Sales by Tennessee manufacturers totaled $275.7 million in 2016. Revenue may increase through 2022, but only marginally. Domestic oil and natural gas exploration is expected to grow. Hose and belt manufacturers will enjoy greater demand as a result of new hydrocarbon mining operations. Reduced manufacturing output from China and growing exports to Mexico will also help the industry. Demand will decrease in U.S. automotive markets. Because of short-term interest rate increases, consumers will lack the credit needed for new automobile purchases. Auto makers will purchase fewer brake line hoses and transmission belts. The number of industry establishments is expected to remain the same, as new manufacturers will likely pop up at the same rate as mergers and acquisitions. These small establishments will be most successful in targeting niche, industrial machinery markets rather than entering highly-saturated automotive component markets. Wages and employment are also expected to increase due to new market entrants. Manufacturers in Tennessee will continue to benefit from close proximity to major manufacturing operations, particularly automotive.[23]

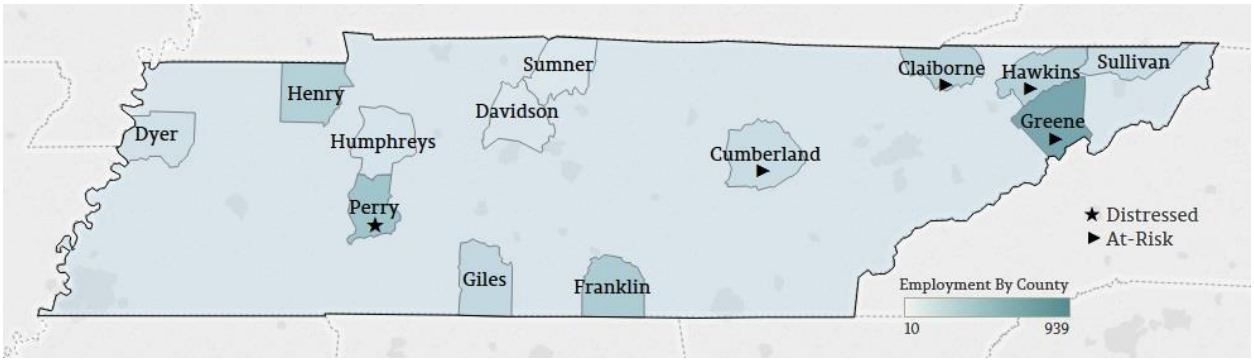
Rubber Product Manufacturing for Mechanical Use

This industry is tied with tire manufacturing for the most substantial source of employment in the advanced materials cluster. Manufacturers in this industry use techniques like molding, extruding, and lathe-cutting to create rubber products with mechanical applications. Most industry products are components used in motor vehicles or industrial machinery. The major manufacturers are SumiRiko Tennessee Inc. (Greene, Claiborne), Saargummi Tennessee LLC (Giles), Microporous LLC (Sullivan), Tepro Inc. (Knox), Durable Products Inc. (Cumberland), and Hutchinson Sealing Systems Inc. (Hawkins). Like hose and belt manufacturers, these companies offer products with a wide range of applications. Durable Products creates molded rubber with industrial purposes. Microporous LLC produce rubber battery separators. Saargummi Tennessee, Tepro, and Hutchinson Sealing Systems manufacture rubber products primarily for the automotive industry. Saargummi Tennessee announced an expansion project in 2015, in partnership with TNECD and the Giles County Economic Development Board.[24]

Manufacturers of rubber products for mechanical use employ 3,360 Tennesseans.[25] Unlike tire manufacturing, this industry has been growing in Tennessee and at a rate that greatly outpaces most states. Employment in Tennessee increased 27.3% since 2012, as compared with 16.6% regionally and 9.3% nationally. Tennessee ranks first in the Southeast and second in the nation behind Ohio for total employment. Distressed and at-risk counties experienced the most substantial growth during this time. Employment in at-risk Claiborne County increased from 40 to 266, a 565.8% rate of growth. Greene and Hawkins Counties, also at-risk, added more than 100 jobs each. Perry County, the only distressed county

[23] IBISWorld. (2017). *Belted Out: Due to Low New Car Sales and Oil Production, Industry Revenue is Declining*.
[24] TNECD. (2015). *Governor Haslam, Commissioner Boyd Announce Saargummi Tennessee, Inc. to Expand Giles County Operations*. http://www.tnecd.com/news/244/governor-haslam-commissioner-boyd-announce-saargummi-tennessee-inc-to-expand-giles-county-operations/
[25] This employment estimate includes data for Bates Rubber (Perry), which could also be classified as a manufacturer of rubber belt and hoses.

with this type of industry, added 108 jobs. Every distressed and at-risk county enjoyed job creation, and only three counties in Tennessee experienced net job losses.



The gap between Tennessee and other states in the region is substantial. Tennessee, which contributes 43.0% to regional employment, employs three times as many workers as second-ranked North Carolina. Moreover, Tennessee's employment is roughly equal to the combined employment of all Southeastern states, excluding North Carolina. Employment may contract slightly by 2022, but Tennessee's share of total regional employment will only continue to grow.

True to prediction, manufacturers of rubber products have been consolidating into larger operations. In 2012, Tennessee had 18 manufacturers of this kind, as compared with 17 today. Businesses are growing in size without expanding into other counties. Greene was the only county in Tennessee to augment its industry presence. Even so, Greene had the lowest growth rate among counties with net job growth, despite increasing its total number of businesses. The trend towards consolidation has been more pronounced in Tennessee than other states in the region. Tennessee manufacturers only comprise 17.9% of total businesses in the Southeast, despite contributing 43.0% to regional employment. Tennessee's average number of workers per business location (194) is the highest of any state in the U.S. for this type of manufacturing. Florida, which has the most industry establishments for Southeastern states, employs on average 22 workers per facility.

Tennessee's location quotient (5.52) ranks first in the nation. In 2012, Tennessee trailed Ohio in the national rankings, but Ohio's location quotient declined from 5.07 to 4.97. Tennessee is predicted to widen its lead in the next few years as Ohio continues to lose employment concentration in this industry. By 2022, analysts predict Tennessee's location quotient to grow to 5.68. Moreover, Tennessee's employment concentration has been growing faster than nearly every other state. Between 2012 and 2017, Tennessee's location quotient grew by 0.71, second only to New Hampshire for the largest increase during this time.

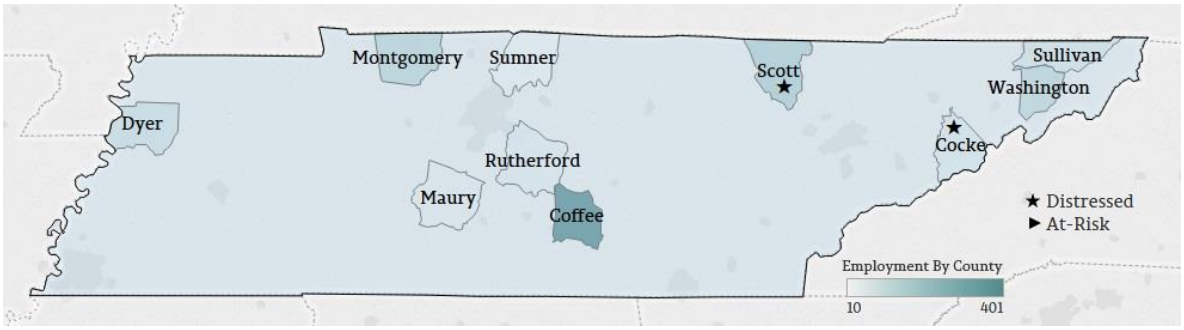
Average wages in this industry are $54,635, with $45,487 in salaries and $9,147 in supplements. These wages are roughly equal to the regional and national averages. In 2016, manufacturers in Tennessee brought in $177.8 million in earnings, which was 40% of all industry earnings in the region. Tennessee businesses completed sales worth $852.0 million, $92.3 million of which were in-region. Revenue in this industry will likely grow through 2022. Manufacturers will have an opportunity to charge higher prices for their products due to increasing upstream costs. Prices for industry inputs– latex for natural rubber production and styrene-butadiene rubber, nitrile and neoprene-based plastics for synthetic rubber– declined by double digits between 2012 and 2015, constricting manufacturers' ability to raise prices. The costs of these inputs are expected to increase. Earnings will vary greatly based on the type of product. Manufacturers of rubber automotive components will be negatively impacted by fewer automobile sales. However, higher fuel costs and environmental concerns create new demand for rubber components that maximize fuel efficiency. Revenue will be more substantial for manufacturers of rubber components used in the construction industry. Residential and commercial construction projects are on the rise, leading to more sales of industrial machinery components. Foreign rubber product manufacturers

have become more competitive in recent years, prompting many changes to domestic industry. Many U.S. companies are either offshoring their operations or merging with other businesses to achieve economies of scale. Fortunately, downstream markets in the U.S. seem to favor American-made rubber products, undermining the advantage of importers. The strategy of many domestic manufacturers has been to switch their focus toward high-quality, precision-made rubber products. This adjustment has resulted in higher industry wages due to greater emphasis on R&D. High-skilled jobs will account for much of the employment growth in this industry.[26]

All Other Rubber Product Manufacturing

Rubber manufacturers produce many types of products beyond tires, belts, and hoses. Other products include footwear parts, balloons, hair curlers and pins, latex foam, pacifiers, spatulas, rafts, condoms, birth control devices, roofing, erasers, and doormats. This industry has steadily grown in Tennessee in the last decade, and the state now ranks nationally on several metrics. Major employers include Hexpol Compounding (Washington), Wearwell Inc. (Rutherford), JDS Technologies (Scott), and Preferred Compounding (Carroll). Hexpol Compounding and Preferred Compounding produce natural rubber compounds in sponge, sheet, slab, and strip form. These compounds are used to manufacture everything from high-performance tires to diaphragms. JDS Technologies offers engineered rubber products like gaskets, seals, O-rings, as well as hoses. Wearwell's rubber flooring and matting are used in medical and industrial work settings. Medegen Medical Products, a medical device manufacturer that employs hundreds in Gallaway, creates a variety of fabricated rubber products including rubber trays. This company is included in the medical devices cluster rather than advanced materials.

Manufacturers of miscellaneous rubber products employ 962 Tennesseans.[27] Tennessee's share of regional and national employment is smaller for this industry than other parts of the sub-cluster. Tennessee contributes only 12.1% to industry jobs in the Southeast and 3.8% nationally. However, this industry is growing rapidly. The growth rate in Tennessee was 9.7%, compared to -0.6% regionally. Tennessee now ranks third in the region for employment, surpassing Florida which experienced a net job loss. By 2022, Tennessee will replace North Carolina as the second-biggest employer in the region. The same trend is occurring on the national stage. Tennessee now ranks in the top ten for the first time, due to declining employment in Texas, Minnesota, and Florida. Most counties in Tennessee actually experienced job losses in the last few years. Employment in Dyer County decreased from 211 to 64. Rutherford County lost 58 of its 89 total jobs. Exceptional job growth in Coffee County, as well as modest gains of 50 or less jobs in Montgomery, Washington, Sullivan, and Scott Counties, resulted in a net increase in Tennessee.



Trends in miscellaneous rubber production do not mirror what has been happening in the overall cluster. Unlike most advanced materials industries, this industry had a net increase in employment and

[26] IBISWorld. (2017). *Breaking the Mold: Growth Will Be Hindered by Limited Demand from Key Downstream Markets*.
[27] Employment is likely higher, as EMSI's estimate includes Preferred Compounding (Carroll) in the rubber hose and belt manufacturing industry.

business locations. Tennessee now has 15 establishments, as compared with 13 in 2012. Gains in Rutherford and McMinn Counties offset the loss of White County's only manufacturer. The lack of consolidation is likely due to the inherent lack of competition within this industry. Since manufacturers produce a wide range of products, companies have an easier time carving out niche markets. For most advanced materials industries, manufacturers are declining in number, and the labor intensity of remaining manufacturers is increasing. In the case of miscellaneous rubber production, most Tennessee counties lost jobs without losing businesses. Excluding Coffee County, the average number of workers per business location declined from 58 to 50 in the last five years. However, this trend only held true for medium- to small-scale manufacturers. The range of operational size increased in recent years. Because of these expansions, Tennessee now ranks fifth in the nation for average labor intensity in this industry.

Tennessee's location quotient (1.87) is the ninth highest in the U.S. and fifth highest in the region. Like most types of rubber production, the Southeast is a hotspot for this industry. More than a quarter of all industry establishments are located in the region. Five Southeastern states (Arkansas, Georgia, Kentucky, West Virginia, and Tennessee) rank in the top ten for location quotient. Employment concentration will continue growing in Tennessee. The predicted location quotient for 2022 (1.98) will be the seventh highest in the nation. Vermont and West Virginia are expected to lose employment concentration in the years ahead.

Average wages in Tennessee are $64,998 for this industry, with $54,115 in salaries and an additional $10,883 in supplements. The regional average is almost $10,000 lower, when factoring in cost of living differences. Average compensation in Tennessee is the eighth highest in the nation and second to West Virginia in the Southeast. In 2016, Tennessee businesses brought in $62.2 million in total earnings. Of the $297.8 million in sales, $49.0 million were in-region. Like rubber products with mechanical applications, miscellaneous rubber products range in profit potential. Manufacturers of rubber roofing, tubing, and insulation will benefit from a booming construction industry. Rubber flooring and mats also have applications in the housing industry. Other manufacturers in this industry are threatened by growth in the plastics industry. Plastic is becoming increasingly viable as a substitute to rubber. For example, polyethylene foam performs many of the same applications as rubber foam at a lower cost.[28]

Clay Industries

The clay sub-cluster includes five industries: pottery, ceramics, and plumbing fixture manufacturing, clay building material and refractories manufacturing, ground or treated mineral and earth manufacturing, kaolin and ball clay mining, and clay and ceramic and refractory mineral manufacturing. Tennessee's employment in this sub-cluster (2,918) ranks sixth in the nation.

Recently, the clay industries have contended with stronger competition from foreign companies in both domestic and export markets. For ceramic products, Mexico has emerged as a major producer of low-cost products, while Chinese manufacturers have focused their operations on high-quality goods. Ball clay miners in Tennessee are most insulated from foreign competition due to an abundance of local deposits. The future of the clay industries will hinge on the recovery of the real estate market. Revenue for ceramics, clay material, refractories, and ball clay will grow as sales to the construction industry increases. Tennessee businesses have the unique advantage of being located in the Southeast, where the real estate market is growing much faster than in other parts of the country.

The clay sub-cluster has the most diverse set of industry purchases. Manufacturers of ceramics and clay building materials rely on bituminous coal and lignite, 85% of which is purchased from out-of-region suppliers. For mineral and earth manufacturing, intra-industry sales account for the most significant purchase. 100% of these sales are made in-region. Mineral and earth manufacturers also

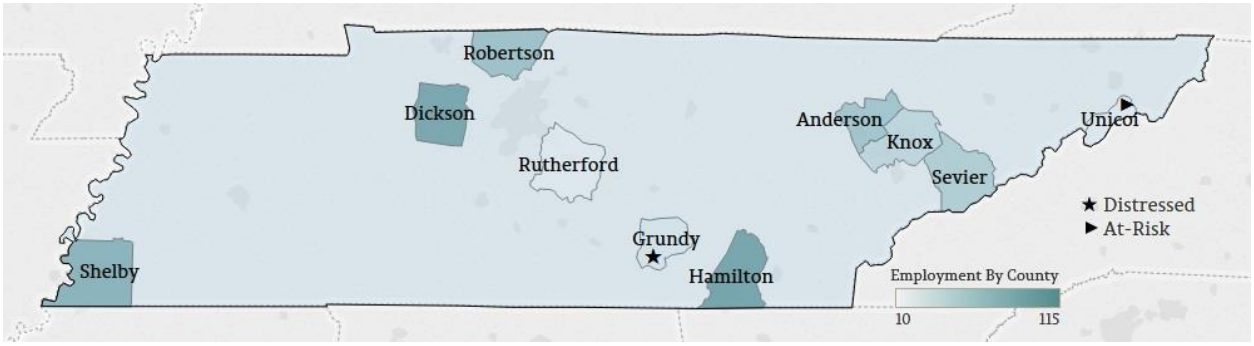
[28] IBISWorld. (2017). *Breaking the Mold: Growth Will Be Hindered by Limited Demand from Key Downstream Markets*.

require crushed and broken limestone, copper, nickel, lead, and zinc. More than 70% of these materials are obtained from regional suppliers. Kaolin and clay ball mining involves significant purchases of petroleum, natural gas, and engineering, legal, and banking services. Manufacturers of clay building materials purchase roughly three-quarters of sand and gravel from regional suppliers, while the rest of the industries in the cluster obtain only one-third of their supply from companies in the Southeast.

Pottery, Ceramics, and Plumbing Fixture Manufacturing

Tennessee achieved significant gains in this industry in recent years. Since 2012, businesses have grown in size and overall number. The rate of growth in Tennessee eclipsed other states in the U.S. by nearly all measures. Manufacturers in this sector produce clay and ceramic products through processes like molding, glazing, shaping, and firing. Common industry products include kitchenware and bathware, garden pottery, chemical stoneware, insulators, and various kinds of plumbing fixtures. The major companies in Tennessee include Mohawk Industries (Dickson), Coors Technical Ceramics (Anderson), Wonder Porcelain (Wilson), and Saint-Gobain Ceramics & Plastics (Hamilton).

Employment in this industry increased from 308 in 2012 to 558 today. This net increase in jobs was the largest of any state besides Texas. In 2012, Tennessee ranked sixteenth in the U.S. for total employment. By 2022, Tennessee is expected to rank ninth, due to declining industry in states like California and New Jersey. Moreover, Tennessee managed to add jobs in this industry while the region and country as a whole experienced net job losses. Tennessee's share of regional employment rose from 7.5% to 13.9% during this time. Like most industries in the cluster, job growth occurred unevenly across the state. Six counties had a positive growth rate. Employment in Dickson County increased by over 1,000% because of the new Mohawk Industries plant. The company plans to open a second facility that will employ 245 new workers.[29] Wilson County made the second largest gains. In 2017, Wonder Porcelain LLC opened a tile manufacturing plant in Lebanon, creating more than 200 new jobs.[30] (Employment data for this industry does not account for Wonder Porcelain's Lebanon facility.) An equal number of counties lost jobs, however. Briggs Industries in Knoxville, which manufactured ceramic bathtubs, closed in mid-2012.



Tennessee now has 17 manufacturers, a net increase of three business establishments since 2012. This increase was the largest of any state during this time. The U.S. as a whole lost 119 businesses. Only 11 states were able to add businesses. Six Southeastern states (Tennessee, Mississippi, West Virginia, South Carolina, Louisiana, and Kentucky) were among the few states that brought in new businesses. Most manufacturers in this industry are located in the Southeast, due to the region's easy access to Atlantic Ocean ports, proximity to major export markets like Mexico, and high population density that provides

[29] TNECD. (2017). *Governor Haslam, Commissioner Rolfe Announce Mohawk Industries to Expand Operations in Dickson*. https://www.tnecd.com/news/420/governor-haslam-commissioner-rolfe-announce-mohawk-industries-to-expand-operations-in-dickson/

[30] American Wonder Porcelain. (2017). *New State-of-the-Art Tile Manufacturing Plant Opens in Lebanon*. https://www.wonderporcelain.com/new-state-art-tile-manufacturing-plant-opens-lebanon/

consistent demand and labor supply.[31] Despite the gains made by Tennessee and other states, the Southeast region lost 19 business establishments. Florida and North Carolina each lost 11 manufacturers.

Ceramics manufacturing has followed the same trends as miscellaneous rubber product manufacturing. Employment and total businesses are increasing, but medium- to small-size manufacturers require less labor than in previous years. Sevier County, which has the most ceramics manufacturers of any Tennessee county, lost jobs despite adding a fifth manufacturer. Hamilton County secured a fourth ceramics manufacturer while experiencing net job losses. Small establishments are downsizing while the big are only getting bigger. In 2012, Coors Technical Ceramics in Anderson County was Tennessee's largest employer. Today, Mohawk Industries in Dickson employs nearly twice as many workers as Coors Technical did in 2012.

Tennessee's location quotient (1.74) is the seventh highest in the nation and third highest in the region behind West Virginia and South Carolina. In 2012, Tennessee's location quotient was 0.99, which ranked seventeenth in the nation and sixth in the region. The increase in employment concentration since 2012 was the largest of any U.S. state. By 2022, Tennessee is expected to replace South Carolina as the second largest employer in the region and sixth largest nationally.

Average wages for this industry ($55,502) are the third highest in the Southeast and tenth highest in the nation. Major occupations for ceramics manufacturing in Tennessee include furnace and kettle operators and tenders, molders, shapers, and casters, team assemblers, first-line supervisors of production and operating workers, and extruding, forming, pressing, and compacting machine setters, operators, and tenders. This industry generates sizable earnings despite employing less than 600 Tennesseans. In 2016, ceramics businesses in Tennessee made $29.4 million in profit, with $77.7 million in sales. Almost half of these sales were in-region.

Manufacturers in this industry have become less profitable in recent years. Earnings are expected to decline by 3.6% in 2018 alone. Revenue for this industry collapsed early in the decade due to an influx of imports from Mexico and China. Manufacturers in Mexico, most of which compete with U.S. companies on the basis of price, specialize in cheap ceramics like toilets. Chinese producers are focused on advanced ceramics, which are highly-durable and corrosion-resistant products used in healthcare, aerospace, and general electronics. Italy. Increases in consumer spending in the U.S. will largely benefit foreign producers, as 79.1% of consumer demand will be satisfied by imports. Italian imports have also siphoned off a substantial share of the market from domestic companies. To make matters worse, semiconductors and other electrical devices are becoming less expensive, further undercutting margins for producers of ceramic components. Many U.S. companies are now outsourcing operations to remain competitive. Other manufacturers have turned to the high-tech market of advanced ceramics, hoping to outperform Chinese rivals with superior craftsmanship.

Overall, the nationwide trend in this industry has been a consolidation in business, due to companies merging or going out of business altogether. The net increase in business locations in Tennessee defied this trend, as did growing employment in Tennessee at a time when industry jobs were disappearing across the country. The primary revenue opportunity for this industry will be a recovery of the residential construction market, which will boost ceramics demand. Employment and average wages will likely decrease due to cost pressures that manufacturers are facing. However, the number of high-paying jobs in this industry is growing. Manufacturers are investing more heavily in R&D due to advanced ceramics' growing market share and consumer demand for bath products that use less water.[32]

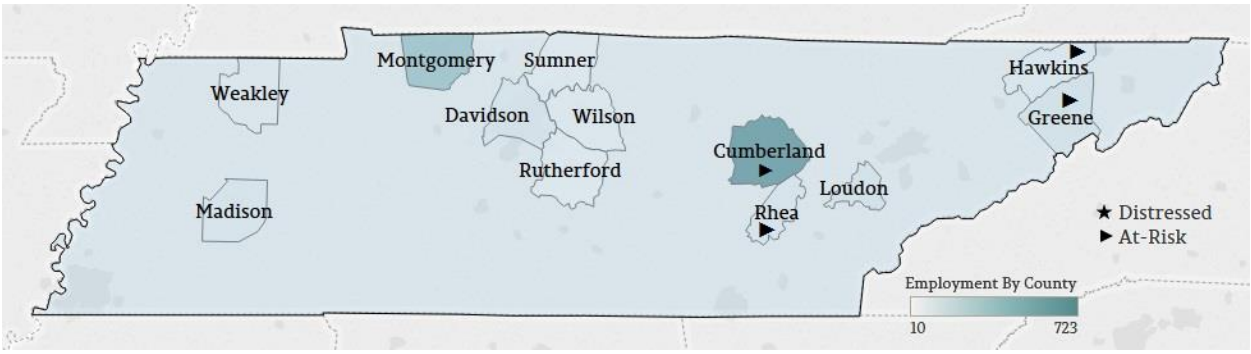
[31] IBISWorld. (Feb. 2018). *Easily breakable: Industry revenue will decline as more domestic demand is met by imports*.
[32] IBISWorld. (Feb. 2018). *Easily breakable: Industry revenue will decline as more domestic demand is met by imports*.

Clay Building Material and Refractories Manufacturing

This industry accounts for nearly half of all clay industry employment in Tennessee. This industry produces structural clay materials, such as bricks and ceramic tiles, as well as nonclay refractories used by steel, iron, and glass manufacturers. Tennessee's major employers are Crossville Tile (Cumberland), Florim USA (Montgomery), and Del Conca USA (Loudon).

Manufacturers of clay building material and refractories employ 1,406 Tennesseans, an increase of 199 jobs since 2012. This net increase in jobs was the largest in the country behind Texas. Tennessee now ranks first in the region and fourth in the nation for industry employment. Analysts expect Tennessee to maintain this position through at least 2022. The Southeast had remarkable employment growth compared to the rest of the nation. The regional growth rate since 2012 has been 9.0%, compared to 0.4% nationally.

In Tennessee, this industry is spread out among 13 counties, including five at-risk counties (Cumberland, Rhea, Weakley, Hawkins, and Greene). The largest job growth occurred in Cumberland County, in which industry jobs increased from 613 to 723 today. Cumberland, where StonePeaks Ceramics opened a facility in 2017, is also home to leading manufacturer Crossville Tile. Montgomery, Loudon, and Rhea Counties each added roughly 50 jobs.



Industry presence shifted in recent years. In 2012, Tennessee had 16 counties with manufacturers of this kind. Seven counties, including at-risk Pickett and Gibson Counties, lost all employment in this industry. Tennessee now has 19 manufacturers, as compared with 17 in 2012. Cumberland County and Montgomery Counties, both of which have three manufacturers, lead Tennessee for the most number of business establishments. Loudon, Wilson, and Rutherford Counties each have two manufacturers despite having zero among them in 2012. Del Conca USA, a major tile manufacturer headquartered in Italy, opened its Loudon facility in 2014 and recently expanded production.[33] Across the U.S., only eight states were able to add new businesses during this time.

Tennessee's location quotient (2.85) ranks fourth nationally and second in the region behind Alabama. Employment concentration has grown in recent years and is predicted to continue growing. By 2022, Tennessee will overtake Oklahoma for third in location quotient, while Alabama will surpass Ohio for first nationally. Like other clay industries, manufacturing operations for clay building material and refractories are more labor-intensive on average in Tennessee than in other states. Manufacturers in Tennessee employ on average 74 workers per business location, the third highest in the nation behind West Virginia (94) and Massachusetts (82).

Average wages in this industry are $59,743, with $49,974 in salaries and $9,759 in supplemental benefits. These wages are roughly equal to the regional and national averages. Common occupations for this industry are furnace and kettle operators and tenders, molders, shapers, and casters, machine setters, operators, and tenders, team assemblers, and first-line supervisors of production and operating workers. In 2016, businesses in Tennessee earned $84.2 million after completing $222.7 in sales. Revenue will grow

[33] TNECD. (2016). *Del Conca USA to expand in Loudon*.

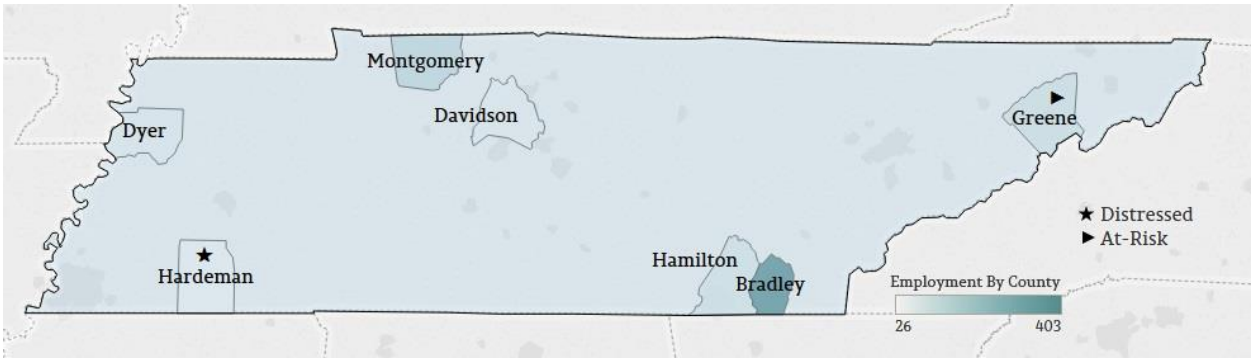
slightly through 2022. Like glass manufacturing, this industry benefits from an expanding real estate sector. The construction industry is in greater demand for clay bricks for residential houses and ceramic tile for office buildings. A slowdown in housing construction led to a hiring freeze in this industry. Manufacturers will begin adding more jobs as the construction market picks back up. However, the glass sub-cluster has emerged as a unique challenge to this industry. Glass now has some of the same applications as clay for residential housing, undermining revenue for manufacturers of clay building materials. Increased sales of refractory materials to glass manufacturers will offset some of these losses. However, refractories manufacturers are struggling with poor performance in other downstream markets. A decline in the price of steel, coupled with reduced international demand for steel and nonferrous metals, has reduced the profitability of refractories manufacturers.[34]

Ground or Treated Mineral and Earth Manufacturing

For many years, Tennessee has been among the top five states for employment, business locations, and location quotient in this industry. Manufacturers use mined clays, refractories, and other nonmetallic minerals to create processed substances like barite, magnesite, and graphite.

Currently, mineral and earth manufacturers in Tennessee employ 752 Tennesseans, a net decrease of 121 jobs since 2012. Industry employment has been shrinking across the country. The Southeast region lost nearly a quarter of employment. Employment in the U.S. decreased by 17%. Tennessee now accounts for 45.8% of regional employment, as compared with 39.2% in 2012. Roughly one-eighth of U.S. employment in this industry is located in Tennessee alone. Michigan is the only state to employ more workers in this industry than Tennessee. Employment in Tennessee is expected to grow in coming years. By 2022, employment will likely reach 950 jobs, nearly tying Michigan's predicted employment. Manufacturers in Tennessee will soon contribute more than half of all jobs in the region.

Most counties in Tennessee experienced a net decrease in industry jobs. Montgomery County, where employment decreased from 421 to 108 jobs, saw the closing of Hemlock Semiconductor in Clarksville after several months of downsizing. At-risk Greene County lost 86 of its 160 jobs. Bradley County was the major success story during this time. Employment increased from 150 to 403 as a result of an expansion at Wacker Chemical. The company, which is currently building a new production plant next to the existing polysilicon operation in Charleston, has invested more in Tennessee than any company in history ($2.5 billion since 2005).[35] The new plant will open in mid-2019 and bring more than 50 new jobs to Bradley County. Hamilton, Dyer, and Hardeman Counties also added jobs, but not enough to offset downsizing in Montgomery County.



Tennessee currently has 8 mineral and earth manufacturers, the fifth highest number of business establishments among all states. The U.S. only has 158 manufacturers in this industry, 41 of which are in the Southeast. Since 2012, Tennessee has had a net decrease of two manufacturers. Knox, Shelby, and

[34] IBISWorld. (2017). *Break the Mold: Operators Will Combat Competitive Import Pressures with Greater Consolidation*.
[35] WCTV. (2016). *Wacker Chemie AG to build new pyrogenic silica plant in Charleston, 50 new jobs*.

Decatur Counties each lost their only manufacturer. Hardeman County brought in its first business. On average, manufacturers in Tennessee employ 97 workers per location. This average is the highest in the region and third highest nationally. Businesses in Michigan and Montana are more labor-intensive on average than anywhere else in the country. The average number of workers per location is well over 200 for both of these states.

Tennessee's location quotient is currently 6.07, as compared with 5.93 in 2012. Tennessee currently ranks third in the nation and first in the region. In 2012, Tennessee ranked second in the nation, but explosive industry growth in New Mexico pushed Tennessee down in the rankings. New Mexico is unlikely to sustain this level of growth. By 2022, Tennessee will retake its position as second nationally with a score of 7.15.

Average wages in Tennessee are $87,667 per year. When adjusting for cost of living, Tennesseans employed in this industry earn almost $10,000 more than their regional counterparts. Like other clay industries, common occupations include machine setters, operators, and tenders, production workers, team assemblers, first-line supervisors of operating workers, and molders, shapers, and casters. In 2016, mineral and earth manufacturers in Tennessee earned $64.3 million, with $489.1 million in sales and $98.6 million in regional sales specifically. Tennessee businesses generated nearly half of total regional profit. Revenue for this industry is expected to grow, in part from increased housing starts. The construction industry, which relies on mineral products for building insulation, is the primary downstream market for mineral manufacturers. Energy-efficient insulation systems are in particularly high demand now for environmental and cost-saving reasons. Manufacturers in Tennessee stand to benefit from explosive real estate growth in the Southeast region. Moreover, treated mineral products have a variety of other applications, including electrical equipment, medical devices, computers, jewelry, and sports equipment and apparel. This diversity in downstream markets ensures steady revenue for the industry even when property development has stagnated.[36]

Kaolin and Ball Clay Mining

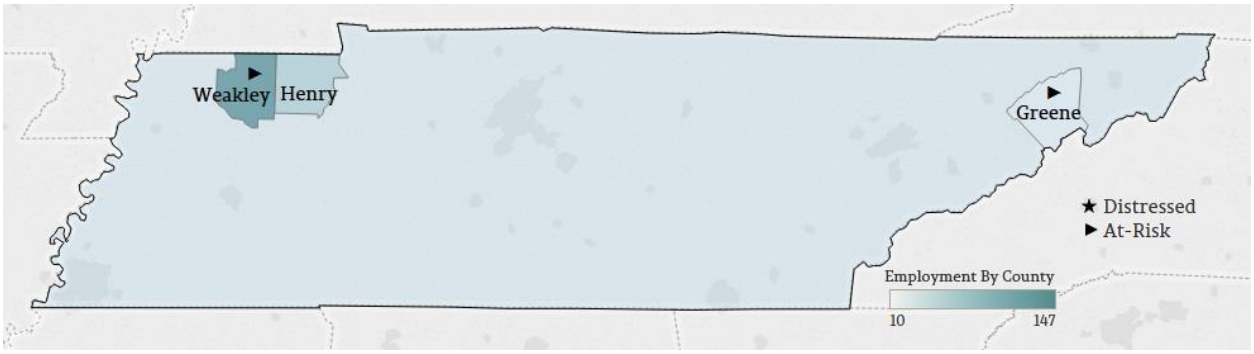
Proximity to ball clay deposits has enabled Tennessee to thrive in this type of mining. Tennessee leads the nation in ball clay mining and accounts for 63% of all U.S. production.[37] Ball clay is primarily used in ceramic flooring and wall tiling. Other uses include the manufacture of bricks, electrical porcelain, and china tableware. Mining has been a key part of Tennessee's economy. By the end of the twentieth century, Tennessee had nonfuel mineral mining in 80 counties, four of which mined ball clay specifically.[38] Major Tennessee businesses in this industry include H.C. Spinks Clay Company (Henry), Kentucky-Tennessee Clay of Imerys Ceramics (Weakley), and Old Hickory Clay (Weakley).

Currently, kaolin and ball clay mining companies in Tennessee employ 223 Tennesseans, a decrease of roughly 20 jobs since 2012. Job losses in Henry County, Tennessee's primary area for industry employment behind at-risk Weakley County, resulted in a net decrease. Tennessee's negative growth rate (-9.4%) pales in comparison to net job losses in the Southeast region (-45.1%). Across the United States, the growth rate has been -35.4%. Researchers expect employment to contract at a similar rate in coming years, although less significantly in Tennessee than in other states.

Tennessee ranks third nationally and second in the Southeast behind Georgia for employment in this industry. Georgia leads the nation in production of kaolin, a rare type of clay used in paper production due to its white color and glossy texture. Georgia, which employed 1,873 workers in kaolin and ball clay mining in 2012, lost 991 jobs in the last few years. Because of these losses, Tennessee's share of industry jobs in the region grew considerably. In 2012, businesses in Tennessee contributed only 9.7% to

[36] IBISWorld. (2017). *Rock Solid: Strong Growth in Construction Markets Will Continue to Drive Industry Demand*.
[37] United States Geological Survey. (2017). *2014 Minerals Yearbook: Clay and Shale [Advance Release]*.
[38] United States Geological Survey. (2017). *2012-2013 Minerals Yearbook: Tennessee [Advance Release]*.

regional employment and 8.5% of U.S. jobs. Today, Tennessee accounts for 16% of regional jobs and 12% nationally.



Tennessee now has seven mining companies in this industry. Weakley County added an additional mining company in the last few years for a total of four. Henry County has two mining companies. Greene County, which now employs roughly 10 workers in this industry, added its first business in this industry, resulting in a net increase in business locations for the state. Tennessee is now tied with South Carolina for the third most kaolin and ball clay mining operations in the nation. Only four states in the U.S. have increased total mining operations since 2012.

The location quotient for this industry increased from 4.33 in 2012 to 5.99 today. By 2022, Tennessee's employment concentration score is predicted to rise to 6.55. Employment concentration for this industry is second in the nation behind Georgia. The location quotient for Georgia, which declined from 24.58 in 2012 to 17.45, will continue to decrease. However, since kaolin mining accounts for more employment than ball clay mining, Tennessee is unlikely to surpass Georgia in this industry ranking.

Average wages in this industry ($84,064) are strong, especially given the concentration of this industry in at-risk counties. This industry has the most unique set of occupations for the clay sub-cluster. Common occupations include excavating and loading machine and dragline operators, heavy and tractor-trailer truck drivers, operating engineers and other construction equipment operators, plant and system operators, and industrial engineers. In 2016, Tennessee companies generated $15.2 million in earnings with $54.7 million in sales. Only 3% of sales were in-region, a testament to the strength of this export market.

The future of kaolin and ball clay mining depends on numerous factors. The discovery of kaolin deposits in Brazil's Amazon Basin, as well as decreasing demand for paper due to electronic information exchange, has negatively impacted the U.S. kaolin mining industry.[39] 97% of kaolin imports into the U.S. are from Brazil. Demand for ball clay, while greatly dependent on general manufacturing activity, has been much steadier. Sales of ball clay for construction purposes continue to increase.[40] Deposits of these minerals are highly concentrated in the U.S. compared to other nations, keeping this industry mostly insulated from foreign competition. Exports of clay products outnumber imports by 20 tons to one.[41] Imports of ball clay increased four-fold from 2014 to 2015 (551 to 2,220 tons), but occasional fluctuations in imports are common in this industry. For example, between 2002 and 2003, imports of ball clay increased from 407 to 13,300 tons then dropped to 520 tons in 2004. Exports of ball clay have remained rather static in the last decade (~48,000 tons) but are only one-third of the average tonnage of exports prior to 2006. The unit value of ball clay has decreased by 200% in the last 30 years. Imports and exports have been much steadier. In 2015, imports of kaolin were at their lowest level since 2010. Exports remained roughly the same between 2008 and 2015 (~2,500,000 tons). In recent years, the value of kaolin

[39] Kogel, J. (2006). *Industrial Minerals & Rocks: 7th Edition*. Society for Mining, Metallurgy, and Exploration, Inc.: Littleton, CO.
[40] United States Geological Survey. (2017). *2014 Minerals Yearbook: Clay and Shale [Advance Release]*.
[41] IBISWorld. (2017). *Sand castle: Recovery in the construction markets will benefit industry performance*.

has been at its highest in several decades.[42] Revenue for ball clay is expected to increase in the near future as residential and commercial construction in the U.S. ramps back up. Kaolin mining, which will also benefit from construction sales, will have declining revenue due to declining paper usage and less ceramics demand in the oil and gas industry.[43]

Clay and Ceramic and Refractory Minerals Mining

Tennessee does not currently have operations in this industry. Across the U.S., this type of mining employs only 3,838 workers, of which 2,123 are located in the Southeast. Industry employment grew at a rate of 15.5% nationally and 60.5% in the region. Most of this regional job creation occurred in Georgia, where industry employment increased from 275 jobs in 2012 to 1,228 today. Tennessee is the only state in the Southeast not to have employment in this industry. Analysts expect this industry to expand through 2022, although at a much slower rate. Revenue will grow due to increased construction activity. Manufacturers in the U.S. will find new opportunities in export markets like China and Mexico. Average wages for this industry are $85,254.

[42] Kelly, T., & Matos, G. (2014). *Historical Statistics for Mineral and Material Commodities in the United States*.
[43] United States Geological Survey. (2017). *2014 Minerals Yearbook: Clay and Shale [Advance Release]*.

Recent Projects

The Haslam Administration has made advanced materials a key component of Tennessee's economic development strategy. Since 2011, the Department of Economic and Community Development has received 43 project commitments to create 6,383 jobs. Total capital investment exceeds $2.5 billion.

Company	New Job Commitments	Capital Investment ($)	County	Date
Hankook Tire Co.	1,800	$800,000,000	Montgomery	October 2013
SaarGummi Tennessee	416	$24,623,973	Giles	October 2015
Nokian Tyres	400	$360,000,000	Rhea	May 2017
Mohawk Industries	320	$180,000,000	Dickson	March 2014
Mohawk Industries	245	$142,000,000	Dickson	June 2017
Heritage Glass	237	$10,000,000	Sullivan	April 2014
American Wonder Porcelain	220	$150,000,000	Wilson	November 2015
Landmark Ceramics	180	$85,000,000	Maury	March 2015
Ceramica Del Conca	178	$70,000,000	Loudon	December 2012
Gemtron Corporation	107	$530,200	Monroe	April 2012

During Governor Haslam's administration, Tennessee has also attracted capital investment from automotive companies to open new advanced materials operations in the state.[44] These operations include FICOSA North America's rearview mirror plant in Putnam County (550 jobs and $57.9 million in capital investment) and HP Pelzer's automotive components facility in McMinn County (200 new jobs and a $28 million investment).[45]

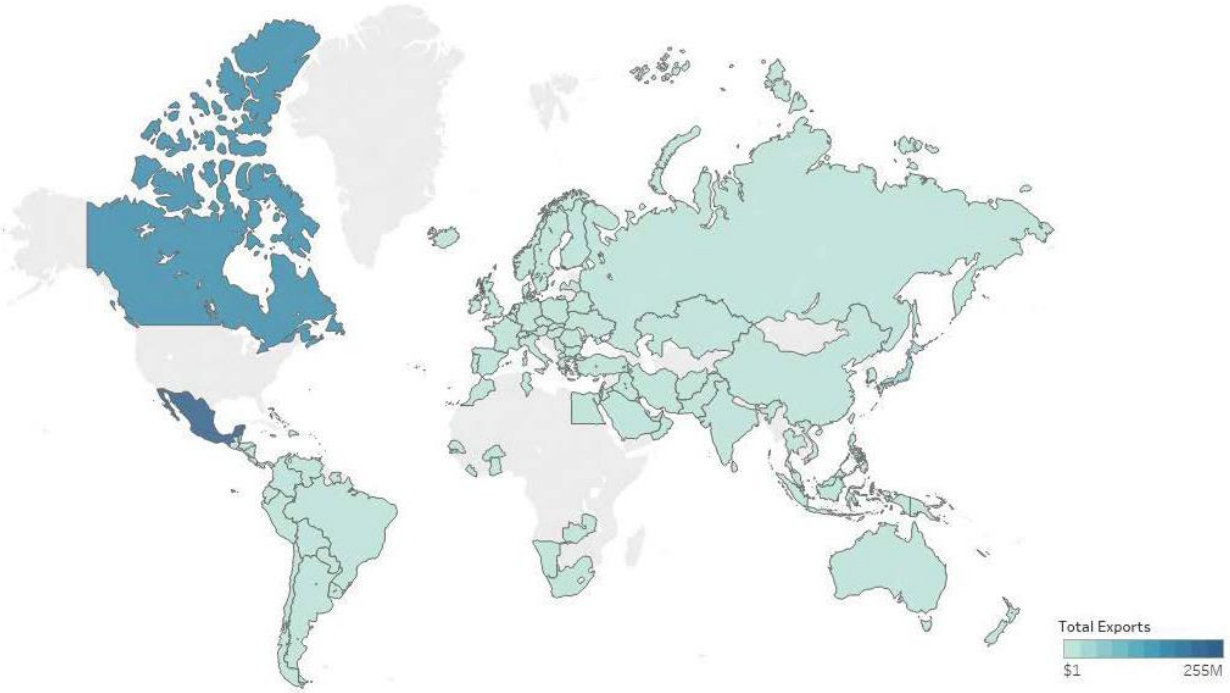
[44] TNECD. (2015). *Governor Haslam, Commissioner Boyd Announce FICOSA North America to Build New Facility in Putnam County*. http://www.tnecd.com/news/186/governor-haslam-commissioner-boyd-announce-ficosa-north-america-to-build-new-facility-in-putnam-county/

[45] TNECD. (2013). *Governor Haslam, Commissioner Hagerty Announce HP Pelzer to Locate New Manufacturing Facility in McMinn County*. https://www.tn.gov/governor/news/2013/4/15/governor-haslam-commissioner-hagerty-announce-hp-pelzer-to-locate-new-manuf.html

Exports

Major Markets

In 2017, exports from Tennessee's advanced materials companies totaled $597.7 million in value. The primary export markets are Mexico ($255.4 million), Canada ($167.2 million), Japan ($41.6 million), China ($15.8 million), and Germany ($12.5 million). Exports to these countries accounted for 82% of total exports for these industries.[46]

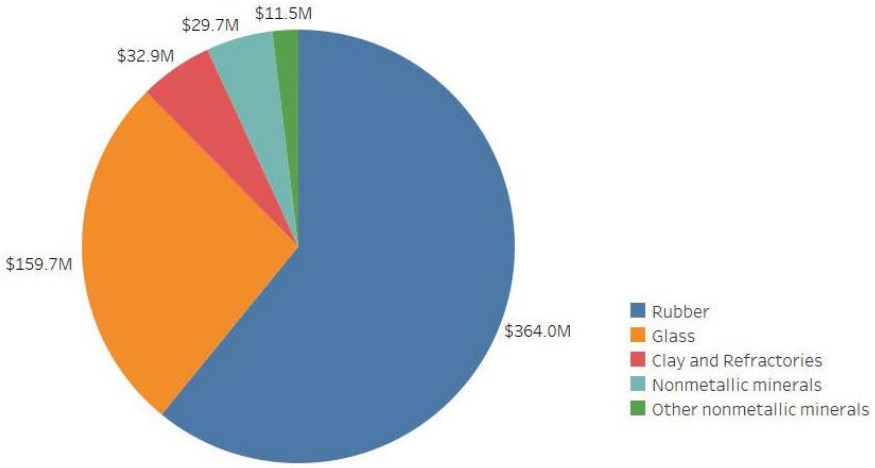


Exports by Industry

Rubber products are the most substantial source of export revenue for Tennessee companies in this cluster. In 2017, the value of rubber exports from Tennessee was $364.0 million, more than 60% of all export revenue for these industries. Rubber exports rebounded in 2017 after a sharp decline in 2016. The primary markets are Mexico ($194.7 million) and Canada ($95.0 million). Mexico imports nearly 25 times as much rubber as China, which is Tennessee's third largest export market for this material.

Tennessee's glass industries exported $159.7 million in product in 2017, roughly one-quarter of all cluster exports. Canada is the primary buyer for these products ($58.0 million), followed by Mexico ($33.2 million) and Japan ($32.9 million). Exports grew substantially in recent years, increasing 30.4% since 2012. Most of this growth occurred due to increased exports to Germany, the United Kingdom, Thailand, and Singapore. Exports to Mexico have also increased in recent years. The value of rubber exports to Canada have rebounded in recent years, after experiencing a $10 million decline between 2012 and 2013.

[46] U.S. Census Bureau, USA Trade Online. (2018).



Tennessee companies exported $32.9 million in clay building material and refractories last year. Nearly one-third of these exports went to Canada ($10.4 million). Another key market is Singapore ($5.1 million). Exports of clay and refractory materials have increased 44.4% since 2012. Tennessee companies have doubled and in some cases tripled their exports to numerous markets around the world, such as Singapore, Germany, Mexico, China, the United Arab Emirates, Bahrain, Russia, Turkey, India, and the Cayman Islands.

Exports of nonmetallic minerals, including ball clay and kaolin, totaled $29.7 million in 2017. The primary market for these products is Mexico ($23.4 million). Exports to Mexico have nearly doubled since 2012. China is the second largest importer of Tennessee nonmetallic minerals ($1.0 million), although sales dropped significantly after 2014. Tennessee companies recently made a splash into the Kazakh market. Exports to Kazakhstan were $0.8 million in 2017. Exports of miscellaneous nonmetallic minerals, including mineral and earth products, account for the smallest share of cluster exports. In 2017, Tennessee exports of these products were valued at $11.5 million. Canada is the primary market ($3.3 million). Other markets include El Salvador ($1.8 million) and the Dominican Republic ($1.1 million). Exports to the Dominican Republic have increased 5,720% since 2012.