TN Department of Education | College, Career and Technical Education

Program of Study Justifications for Advanced Manufacturing

TN Department of Education | College, Career and Technical Education

Electromechanical Technology

2016-17 Program of Study	Level 1	Level 2	Level 3	Level 4
Electromechanical Technology	Principles of Manufacturing (5922)	Introduction to Electromechanical (6091)	Advanced Electromechanical Technology (6090)	Manufacturing Practicum (5926)

Description

The *Electromechanical Technology* program of study is designed to provide students with the knowledge and skills to effectively perform basic industrial maintenance procedures in an advanced manufacturing facility. This program of study is designed for students that are interested in becoming: a general maintenance and repair worker, industrial machinery mechanic, master mechanic, electromechanical technician, mechanical engineer, or an electromechanical engineer. Course content focuses on the electromechanical domains, including: fundamental safety practices in electromechanical technology, shielded metal arc welding (SMAW), basic metal inert gas (MIG) welding, electrical systems, AC and DC motors, calibrating instruments, drive systems, pipe fabrication, hydraulic systems, pumps, digital electronics, programmable logic controllers (PLC), and troubleshooting procedures. Upon completion of this POS, proficient students will be prepared to pursue postsecondary electromechanical technology programs and entry-level industrial maintenance technology careers in the advanced manufacturing industry.

Job Outlook

Back in 2011, Governor Bill Haslam announced six target clusters for which Tennessee had a competitive advantage and would focus its recruitment efforts to bring more businesses to the state.[1] One of those target clusters was Advanced Manufacturing and Energy Technologies, and after several consecutive years of strong job gains, the demand for skilled workers shows no sign of slowing. Among these careers was Machinist.[2] Machinist fall under the manufacturing subcategory of Production. Compared to the national rate of 8.7 percent, job creation in Tennessee is soaring in manufacturing fields, accounting for 27.1 percent of all new jobs.[3] In

2015, Tennessee ranked first in the nation in automotive manufacturing strength.[4] With its attractive business climate and strategic location, Tennessee is home to a strong base of manufacturers representing many diverse industries, led by the state's automotive sector, which in recent years has

[1] TN.gov, Newsroom & Media Center. Retrieved from: http://www.tn.gov/news/category/governor-haslam/P720
[2] Tennessee Department of Labor and Workforce Development. (2014). *Tennessee's Hot Careers to 2020,* on the Internet at https://www.tn.gov/assets/entities/labor/attachments/statewide_2020outlooks.pdf (visited March 16, 2016)
[3] Tennessee Department of Economic & Community Development (2014). Retrieved from: http://www.tnecd.com/industries/advanced-manufacturing/. (visited March 16,2016)
[4] Tennessee Department of Economic & Community Development (2015). Retrieved from: http://www.tn.gov/ecd/news/16577 (visited March 16, 2016)

converted into a regional and national powerhouse.[5] In industries such as these, employers like Alcoa, Eastman Chemical, and Bridgestone are in need of skilled technicians and engineers who can design, maintain, and operate complex production systems.

Moreover, the Tennessee Department of Labor and Workforce Development listed four manufacturing jobs on the list of Hot Careers in 2020. Among these careers were Maintenance and Repair Workers (general) and Industrial Machinery Mechanics.[3] Maintenance and Repair Workers (general) and Industrial Machinery Mechanics fall under the manufacturing subcategory of Installation, Maintenance, and Repair. According to the National Bureau of Labor Statistics, Installation, Maintenance, and Repair occupations are expected to increase at a rate of 6.4 percent through the year 2024.[6]

Electromechanical Technology is the study of the combination of knowledge of mechanical technology systems with the knowledge of electronic circuits. Technologists will install, repair, and troubleshoot electronic and computer-controlled mechanical systems. Examples include working on robotic assembly machines, mobile robots and manipulator arms that operate on assembly lines.[7] In order for them to function properly, however, successful professionals in this field must be able to problem solve and troubleshoot by applying mathematics, design, and systems thinking, while also documenting highly technical processes in a manner that can be replicated by others.[8]

Figure 1. Employment Statistics for Electromechanical Occupations in Tennessee[9]

Occupation	Employment 2012	Employment 2022	Percent Change	National Annual Median Wage (2014)	State Annual Mean Wage (2014)
Mechanical Engineers	4,430	4,570	+3%	$83,060	$84,890
Electrical Engineers	2,440	2,660	+9%	$91,410	$85,800
Electromechanical Technicians	240	290	+25%	$63,070	$62,590

[5] Muro, M., Andes, S., Fikri, K., Ross, M., Lee, J., Ruiz, N., & Marchio, N. (2013). Drive! Moving Tennessee's Automotive Sector up the Value Chain. Brookings Institution. Retrieved from: http://www.brookings.edu/research/reports/2013/10/04-tennessee-automotive. (visited March 16, 2016)

[6] Bureau of Labor Statistics, U.S. Department of Labor, *National Occupational Data*, *December 2015*, Table 1.1. (visited March 16, 2016)

[7] Bureau of Labor Statistics, U.S. Department of Labor, *Occupational Outlook Handbook*. (2014) Retrieved from: http://www.bls.gov/ooh/architecture-and-engineering/electro-mechanical-technicians.htm#tab-2 (visited march 16, 2016)

[8] O*Net OnLine (2015). http://www.onetonline.org/link/summary/17-3024.00 (visited March 16, 2016)

[9] O*Net OnLine (2015). http://www.onetonline.org/link/summary(visited March 16, 2016)

Current Secondary Landscape

In the 2014-15 school year, 14 schools in Tennessee responded to the demand to grow local talent in emerging manufacturing fields and instituted special programs of study in Electromechanical Technology. District data from school year 2015-16 suggests that 25 schools will implement Electromechanical Technology at the beginning of the new school year. These figures demonstrate that there is an appetite among schools and students to explore electromechanical technology at the high school level, which bodes well for the growing number of postsecondary institutions to offer mechatronics-related programs.

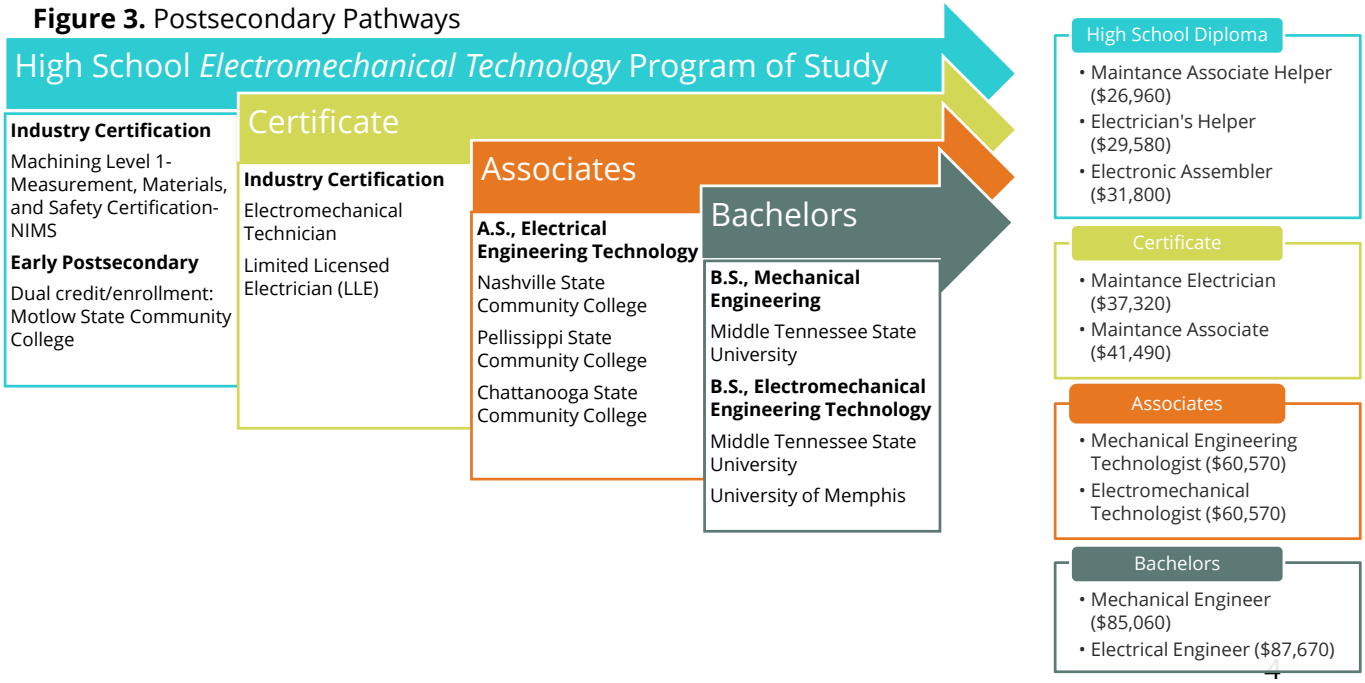
Figure 2. Open Enrollment Analysis

	Electromechanical Technology
2014-15	14
2015-16	25
	Increase

Postsecondary Pathways

What kinds of careers can students expect to pursue upon completion of the Electromechanical Technology POS in Tennessee? In many ways, Electromechanical represents a great example of the department's emphasis on creating pathways linked to local labor market needs, composed of stackable credentials at discrete levels of postsecondary. The figure below illustrates what one such pathway might look like for a student graduating from a Tennessee Electromechanical Technology program in high school. Annual median wages are based on Bureau of Labor Statistics Occupational Employment Statistics (OES) estimates for Tennessee, unless otherwise indicated.

Figure 3. Postsecondary Pathways



Electromechanical technology pathways offer opportunities to funnel into careers at a variety of education levels. Pursuing just an additional year or two of study can yield great returns for students. Among Tennessee graduates from public two-year colleges who completed programs in electrical Engineering Technology, median wages for their first year out of school was $60,570 which is higher than the state average for all Associate's holders. This, coupled with advanced training at the Bachelor's level, will open even more doors for students moving their employment prospects to the higher-wage engineering and production management occupations. As the following table demonstrates, compared to Associate's degree holders employed as electromechanical technicians, the payoff for earning a Bachelor's of Science in industrial or electrical engineering is complimented by the favorable ratio of available candidates to job openings. Due to this shift, the need to encourage more students to pursue early postsecondary opportunities at the high school level and ultimately complete certificate programs at the state's network of TCATs, in order to swiftly gain the credentials to compete for these openings is essential.[10]

Recommendation

No recommendations for changes at this time.

2017-18 Program of Study	Level 1	Level 2	Level 3	Level 4
Electromechanical Technology	Principles of Manufacturing (5922)	Introduction to Electromechanical (6091)	Advanced Electromechanical Technology (6090) -or- **Dual Enrollment** Electromechanical Technology (4061)	Manufacturing Practicum (5926) -or- **Dual Enrollment** Electromechanical Technology (4061)
	Industry Certification: Machining Level I - Measurement, Materials, and Safety Certification (NIMS)			

[10] Bureau of Labor Statistics, Employment Projections (2014). Retrieved from: http://www.bls.gov/emp/.

References

TN.gov, Newsroom & Media Center. Retrieved from: http://www.tn.gov/news/category/governor-haslam/P720

Tennessee Department of Labor and Workforce Development. (2014). *Tennessee's Hot Careers to 2020.* Retrieved from: https://www.tn.gov/assets/entities/labor/attachments/statewide_2020outlooks.pdf

Tennessee Department of Economic & Community Development (2014). Retrieved from: http://www.tnecd.com/industries/advanced-manufacturing/

Tennessee Department of Economic & Community Development (2015). Retrieved from: http://www.tn.gov/ecd/news/16577

Muro, M., Andes, S., Fikri, K., Ross, M., Lee, J., Ruiz, N., & Marchio, N. (2013). Drive! Moving Tennessee's Automotive Sector up the Value Chain. Brookings Institution. Retrieved from: http://www.brookings.edu/research/reports/2013/10/04-tennessee-automotive.

Bureau of Labor Statistics, U.S. Department of Labor, *National Occupational Data*, *December 2015*, Table 1.1.

Bureau of Labor Statistics, U.S. Department of Labor, *Occupational Outlook Handbook*. (2014) Retrieved from: http://www.bls.gov/ooh/architecture-and-engineering/electro-mechanical-technicians.htm#tab-2

O*Net OnLine (2015). http://www.onetonline.org/link/summary/17-3024.00

Bureau of Labor Statistics, Employment Projections (2014). Retrieved from: http://www.bls.gov/emp/.

O*Net OnLine (2015). http://www.onetonline.org/link/summary

TN Department of Education | College, Career and Technical Education

Machining Technology

2016-17 Program of Study	Level 1	Level 2	Level 3	Level 4
Machining Technology	Principles of Manufacturing (5922)	Principles of Machining I (5929)	Principles of Machining II (5923)	Manufacturing Practicum (5926)

Description

The *Machining Technology* program of study is designed for students interested in becoming a Computer-Controlled Machine Tool Operator, a CNC Machining Tool Programmer, or a Machinist. Course content focuses on safety practices concerning: machining technology; proper measurement and layout techniques; reading and interpreting specification drawings and blueprints; production design processes; quality control procedures; machine parts to specifications using both manual and computer-controlled machine tools; and measuring, examining, and testing completed products to check for defects and conformance to specifications. Upon completion of this POS, proficient students will be prepared to pursue industry certification at a technology college or more advanced coursework at a two-year or four-year postsecondary institution.

Job Outlook

Back in 2011, Governor Bill Haslam announced six target clusters for which Tennessee had a competitive advantage and would focus its recruitment efforts to bring more businesses to the state.[11] One of those target clusters was Advanced Manufacturing and Energy Technologies, and after several consecutive years of strong job gains, the demand for skilled workers shows no sign of slowing. Among these careers was Machinist.[12] Machinist fall under the manufacturing subcategory of Production. Compared to the national rate of 8.7 percent, job creation in Tennessee is soaring in manufacturing fields, accounting for 27.1 percent of all new jobs.[13] In 2015, Tennessee ranked first in the nation in automotive manufacturing strength.[14] With its attractive business climate and strategic location, Tennessee is home to a strong base of manufacturers representing many diverse industries, led by the state's automotive sector, which in recent years has converted into a regional and national powerhouse.[15] In industries such as these, employers like Alcoa, Eastman Chemical,

[11] TN.gov, Newsroom & Media Center. Retrieved from: http://www.tn.gov/news/category/governor-haslam/P720
[12] Tennessee Department of Labor and Workforce Development. (2014). *Tennessee's Hot Careers to 2020,* on the Internet at https://www.tn.gov/assets/entities/labor/attachments/statewide_2020outlooks.pdf (visited March 16, 2016)
[13] Tennessee Department of Economic & Community Development (2014). Retrieved from: http://www.tnecd.com/industries/advanced-manufacturing/. (visited March 16,2016)
[14] Tennessee Department of Economic & Community Development (2015). Retrieved from: http://www.tn.gov/ecd/news/16577 (visited March 16, 2016)
[15] Muro, M., Andes, S., Fikri, K., Ross, M., Lee, J., Ruiz, N., & Marchio, N. (2013). Drive! Moving Tennessee's Automotive Sector up the Value Chain. Brookings Institution. Retrieved from: http://www.brookings.edu/research/reports/2013/10/04-tennessee-automotive. (visited March 16, 2016)

and Bridgestone are in need of skilled technicians and engineers who can design, maintain, and operate complex production systems.

Machining Technology is the investigation of utilizing distinctive complex machining applications and procedures to help in more astute, more effective item plan and improvement. Engineers will set up and work a mixture of CNC controlled and mechanically-controlled machine apparatuses to deliver accurate metal parts, instruments, and devices. CNC machines control the cutting apparatus speed that intricately cut each section. The mechanic decides the cutting path, the velocity of the cut, and the feed rate by programming directions into the CNC machine. Mechanical engineers must have the capacity to utilize both manual and computer controlled apparatus in their occupations. [16]

Since the innovation of machining is evolving quickly, machinists must figure out how to work an extensive variety of machines. Some more up to date assembling procedures use lasers, water jets, electrical release machines (EDM), and energized wires. Albeit a portion of the computer controls are like those of other machine instruments, machinists must comprehend the one of a kind capacity of distinctive machines. As they create new sorts of machine devices, machinists must continuously learn new machining properties and systems.[17]

According to Jobs4TN.gov, the rate of employment is expected to grow in these occupations (See Figure 1 for details).[18] Although these occupations are all related to Machine Technology, they each have different roles and responsibilities. Machinists operate computer-controlled and mechanically-controlled machine tools to produce precision metal parts, instruments, and tools.[19] On the other hand, Computer Numerically controlled machine Tool Programmers (metal and plastic) develop the programs to control machining and processing of metal or plastic parts by automatic machine tools, equipment, or systems.[20] Finally, Computer-Controlled Machine Tool Operators (metal and plastic) operate computer-controlled machines or robots to perform one or more machine functions on metal or plastic work pieces.[21]

---

[16] Bureau of Labor Statistics, U.S. Department of Labor, *Occupational Outlook Handbook, 2014-15 Edition*, Machinists and Tool and Die Makers, http://www.bls.gov/ooh/production/machinists-and-tool-and-die-makers.htm (visited *March 16, 2016*).

[17] Bureau of Labor Statistics, U.S. Department of Labor, *Occupational Outlook Handbook, 2014-15 Edition*, Machinists and Tool and Die Makers, http://www.bls.gov/ooh/production/machinists-and-tool-and-die-makers.htm (visited *March 16, 2016*).

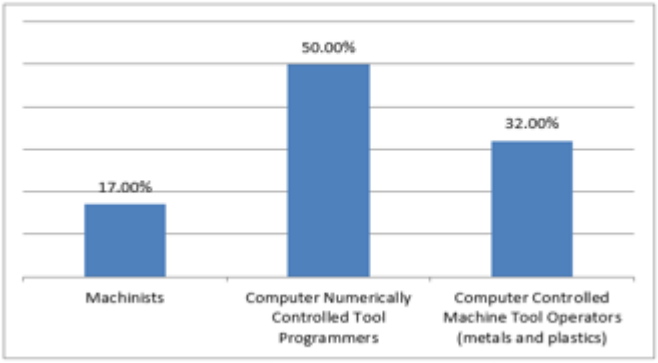
[18] Tennessee Department of Labor and Workforce Development. (2014). Supply and Demand Data: Occupation Employment and Projections (Long Term), on the Internet at www.jobs4tn.gov (visited March 16, 2016).

[19] Bureau of Labor Statistics, U.S. Department of Labor, *Occupational Outlook Handbook, 2014-15 Edition*, Machinists and Tool and Die Makers, http://www.bls.gov/ooh/production/machinists-and-tool-and-die-makers.htm (visited March 16, 2016).

[20] O*Net Online, Computer Numerically Controlled Machine Tool Programmers (metal and plastic), on the Internet at http://www.onetonline.org/link/summary/51-4012.00 (visited March 16, 2016).

[21] O*Net Online, Computer-Controlled Machine Tool Operators (metal and plastic), on the Internet at http://www.onetonline.org/link/summary/51-4011.00 (visited March 16, 2016).

Figure 1: Employment Projection of Machining Technology Occupations in Tennessee (2012 – 2022)



Current Secondary Landscape

In the 2014-2015 school year, forty-nine schools in Tennessee responded to the demand to grow local talent in emerging manufacturing fields and instituted special programs of study in Machining Technology. District data from SY 15-16 suggest that 56 schools will implement Machining Technology at the beginning of the SY.[22] These figures demonstrate that there is an appetite among schools—and students—to explore machining technology at the high school level, which bodes well for the growing number of postsecondary institutions to offer mechatronics-related programs.

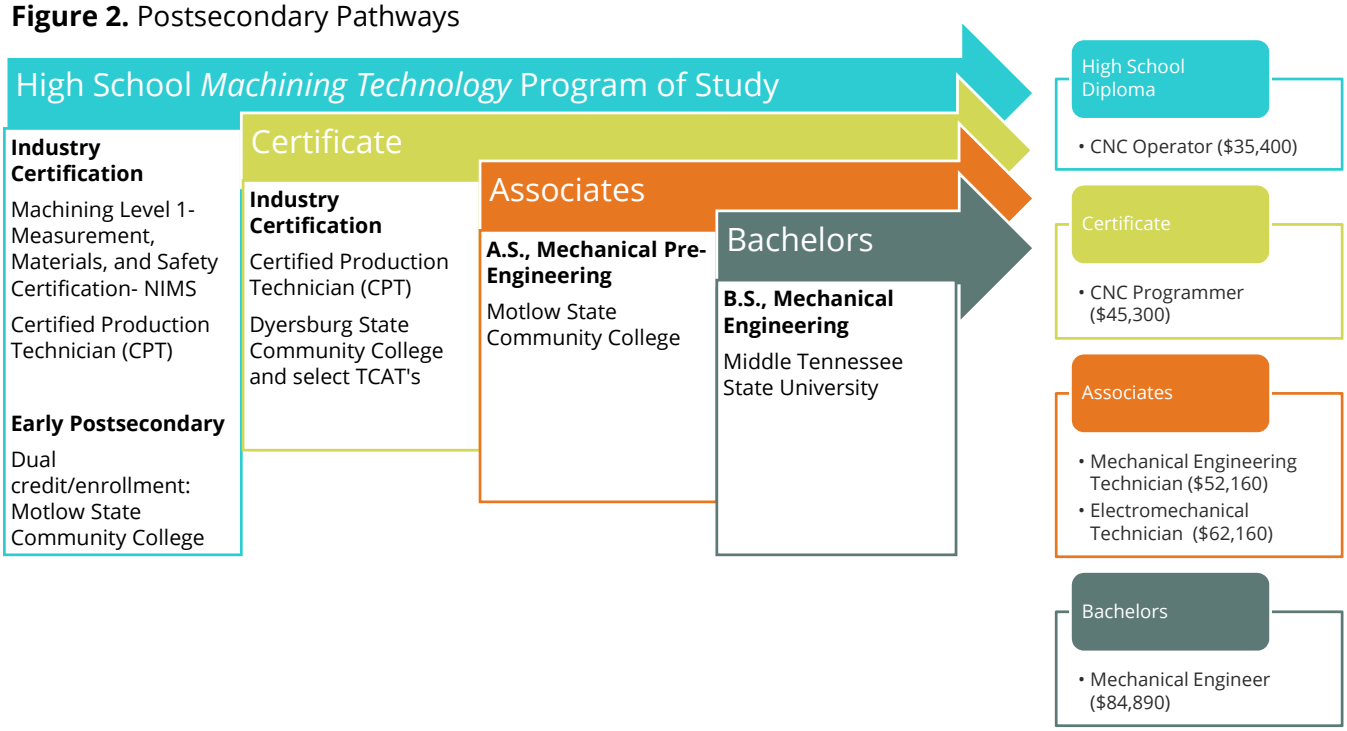
	Machining Technology
2014-15	49
2015-16	56
	Increase

Postsecondary Pathways

What kinds of careers can students expect to pursue upon completion of the Machining Technology POS in Tennessee? In many ways, Machining Technology represents one of the best examples of the department's emphasis on creating pathways linked to local labor market needs, composed of stackable credentials at discrete levels of postsecondary. The figure below illustrates what one such pathway might look like for a student graduating from a Tennessee Machining Technology program in high school. Annual median wages are based on Bureau of Labor Statistics Occupational Employment Statistics (OES) estimates for Tennessee and O*Net online.

[22] Author's calculation of student enrollment data received from the Tennessee Department of Education, 2015.

Figure 2. Postsecondary Pathways



As shown in the graphic above, machining technology pathways offer opportunities to funnel into careers at a variety of education levels. Moreover, demand is high for students who can complete with a certificate or related credential from a Tennessee College of Applied Technology (TCAT). The Tennessee Department of Labor and Workforce Development, in its statewide supply and demand analysis for the 16 national career clusters, forecasts that the Production Design, Precision Production, and Operations and Maintenance programs—all of which are aligned to advanced manufacturing-related careers—will produce shortages of qualified labor if the current rate of Tennessee postsecondary completers holds steady. Production Design, in particular, was identified as a high-skill, high-wage, and in-demand pathway that is not producing enough completers to match employer demand.[23] For example, CNC programmer is an occupation projected to experience high growth through 2024 (50 percent in Tennessee, 19 percent nationally), underscoring the need to encourage more students to pursue early postsecondary opportunities at the high school level and ultimately complete certificate programs at the state's network of TCATs, in order to swiftly gain the credentials to compete for these openings.[24]

[23] Hedges, K., and Wettemann, M. (2012). Tennessee Statewide Supply and Demand Analysis for the 16 Education Clusters. Tennessee Department of Labor and Workforce Development. Retrieved from: http://www.doleta.gov/performance/results/AnnualReports/2011_economic_reports/tn_supplyand_demand.pdf (visited March 16, 2016)

[24] Bureau of Labor Statistics, Employment Projections (2014). Retrieved from: http://www.bls.gov/emp/ (visited March 16, 2016)

Recommendation

No recommendations for changes at this time.

2017-18 Program of Study	Level 1	Level 2	Level 3	Level 4
Machining Technology	Principles of Manufacturing (5922)	Principles of Machining I (5929)	Principles of Machining II (5923) -or- **Dual Enrollment** Machining Technology (4060)	Manufacturing Practicum (5926) -or- **Dual Enrollment** Machining Technology (4060)
	Industry Certification: Machining Level I - Measurement, Materials, and Safety Certification (NIMS)	**Industry Certification:** Certified Production Technician (CPT) Safety Module	**Industry Certification:** Certified Production Technician (CPT) Quality Practices and Measurement Module	**Industry Certification:** Certified Production Technician (CPT) Manufacturing Processes and Production Module and Maintenance Awareness Module

References

TN.gov, Newsroom & Media Center. Retrieved from: http://www.tn.gov/news/category/governor-haslam/P720

Tennessee Department of Labor and Workforce Development. (2014). *Tennessee's Hot Careers to 2020.* Retrieved from: https://www.tn.gov/assets/entities/labor/attachments/statewide_2020outlooks.pdf

Tennessee Department of Economic & Community Development (2014). Retrieved from: http://www.tnecd.com/industries/advanced-manufacturing/

Tennessee Department of Economic & Community Development (2015). Retrieved from: http://www.tn.gov/ecd/news/16577

Muro, M., Andes, S., Fikri, K., Ross, M., Lee, J., Ruiz, N., & Marchio, N. (2013). Drive! Moving Tennessee's Automotive Sector up the Value Chain. Brookings Institution. Retrieved from: http://www.brookings.edu/research/reports/2013/10/04-tennessee-automotive

Bureau of Labor Statistics, U.S. Department of Labor, *Occupational Outlook Handbook, 2014-15 Edition*, Machinists and Tool and Die Makers, http://www.bls.gov/ooh/production/machinists-and-tool-and-die-makers.htm

Bureau of Labor Statistics, U.S. Department of Labor, *Occupational Outlook Handbook, 2014-15 Edition*, Machinists and Tool and Die Makers, http://www.bls.gov/ooh/production/machinists-and-tool-and-die-makers.htm

Tennessee Department of Labor and Workforce Development. (2014). Supply and Demand Data: Occupation Employment and Projections (Long Term), on the Internet at www.jobs4tn.gov

Bureau of Labor Statistics, U.S. Department of Labor, *Occupational Outlook Handbook, 2014-15 Edition*, Machinists and Tool and Die Makers, http://www.bls.gov/ooh/production/machinists-and-tool-and-die-makers.htm

O*Net Online, Computer Numerically Controlled Machine Tool Programmers (metal and plastic). Retrieved from: http://www.onetonline.org/link/summary/51-4012.00

O*Net Online, Computer-Controlled Machine Tool Operators (metal and plastic). Retrieved from: http://www.onetonline.org/link/summary/51-4011.00

Hedges, K., and Wettemann, M. (2012). Tennessee Statewide Supply and Demand Analysis for the 16 Education Clusters. Tennessee Department of Labor and Workforce Development. Retrieved from:http://www.doleta.gov/performance/results/AnnualReports/2011_economic_reports/tnsupplyand_demand.pdf

Bureau of Labor Statistics, Employment Projections (2014). Retrieved from: http://www.bls.gov/emp/

Mechatronics

2016-17 Program of Study	Level 1	Level 2	Level 3	Level 4
Mechatronics	Principles of Manufacturing (5922)	Digital Electronics (5925)	Mechatronics I (6156)	Mechatronics II (6157) -or- Manufacturing Practicum (5926)

Description

The *Mechatronics* program of study is designed for students interested in becoming a mechatronics technician, electrical technician, mechanical engineering technician, robotics technician, or mechatronics engineer. Course content focuses on the components of manufacturing systems, collection and analysis of quality data, electronics, mechanics, fluid power systems, computers and control systems, and technical documentation and troubleshooting. Upon completion of this POS, proficient students will be prepared to pursue industry certification at a technology college or more advanced coursework at a two-year or four-year postsecondary institution.

Job Outlook

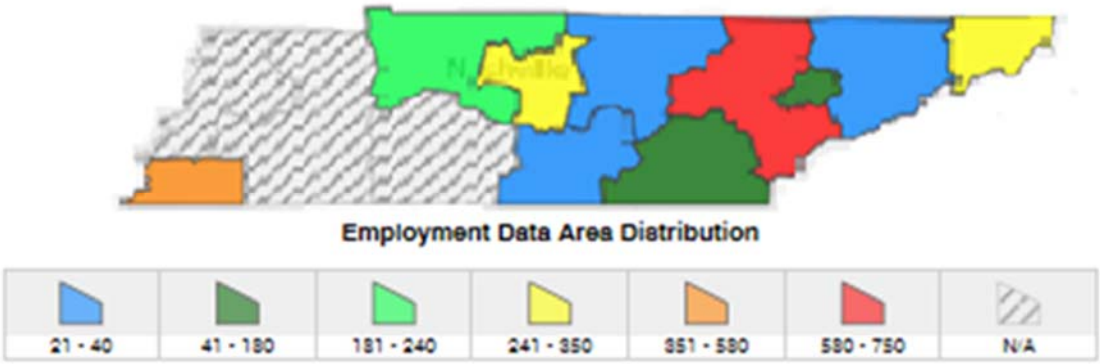
Back in 2011, Governor Bill Haslam announced six target clusters for which Tennessee had a competitive advantage and would focus its recruitment efforts to bring more businesses to the state.[25] One of those target clusters was Advanced Manufacturing and Energy Technologies, and after several consecutive years of strong job gains, the demand for skilled workers shows no sign of slowing. Compared to the national rate of 8.1 percent, job creation in Tennessee is soaring in manufacturing fields, accounting for 30.3 percent of all new jobs.[26] Tennessee believes in the power of manufacturing. Over the last three years, Tennessee has posted the second largest percentage increase in the Southeast in manufacturing GDP, which reached $48.1 billion in 2014. That's 16 percent of the state's total GDP.[27] With its attractive business climate and strategic location, Tennessee is home to a strong base of manufacturers representing many diverse industries, led by the state's automotive sector, which in recent years has converted into a regional and national powerhouse.[28] In industries such as these, employers like Alcoa, Eastman Chemical, Bridgestone, and Nissan are in need of engineers who can design, maintain, and operate complex production systems. Mechatronics, with its emphasis on applied mathematics and engineering design, offers a wealth of opportunities for career advancement in today's cutting-edge advanced manufacturing

[25] TN.gov, Newsroom & Media Center. Retrieved from: http://www.tn.gov/news/category/governor-haslam/P720
[26] Tennessee Department of Economic & Community Development (2014). Retrieved from: http://www.tnecd.com/industries/advanced-manufacturing/. (visited March 17, 2016)
[27] Tennessee Department of Economic & Community Development (2014). Retrieved from: http://www.tnecd.com/industries/advanced-manufacturing/ (visited March 17, 2016)
[28] Muro, M., Andes, S., Fikri, K., Ross, M., Lee, J., Ruiz, N., & Marchio, N. (2013). Drive! Moving Tennessee's Automotive Sector Up the Value Chain. Brookings Institution. Retrieved from: http://www.brookings.edu/research/reports/2013/10/04-tennessee-automotive. (visited March 17, 2016)

industries.[29] Bridgestone has recently partnered with Motlow State Community College to develop a mechatronics program based on the Siemens Mechatronics Systems approach to advanced manufacturing. It's the only program in the U.S. to offer a three-step pathway for advanced manufacturing education.[30]

Mechatronics is the study of complex systems and processes to aid in smarter, more efficient product design and development, particularly within manufacturing environments. Mechatronics systems combine mechanical, electrical, computer, and control systems into a unified process, drawing on principles of industrial engineering and related disciplines to optimize results and minimize defects.[31] Examples of classic mechatronics systems within automotive manufacturing environments include the mobile robots and manipulator arms that operate on assembly lines.[32] In order for them to function properly, however, successful professionals in this field must be able to problem solve and troubleshoot by applying mathematics, design, and systems thinking, while also documenting highly technical processes in a manner that can be replicated by others.[33]

Figure 1. Employment area



State and National Trends

United States	Employment		Percent Change	Projected Annual Job Openings [1]
	2014	2024		
Engineers, All Other	136,900	142,300	+4%	3,300
Tennessee	**Employment**		**Percent Change**	**Projected Annual Job Openings [1]**
	2012	2022		
Engineers, All Other	2,910	3,080	+6%	70

[1]Projected Annual Job Openings refers to the average annual job openings due to growth and net replacement.
Note: The data for the State Employment Trends and the National Employment Trends are not directly comparable.
The projections period for state data is 2012-2022, while the projections period for national data is 2014-2024.

[29] O*Net OnLine (2015). 17-2199.05 - Mechatronics Engineers. Retrieved from: http://www.onetonline.org/link/summary/17-2199.05. (visited March 17, 2016)
[30] Tennessee Department of Economic & Community Development (2015). Retrieved from: http://www.tnecd.com/advantages/workforce-education/ (visited on March 17, 2016)
[31] North Carolina State University (2012). What is Mechatronics? NC State University-UNC Asheville. Retrieved from: http://www.engr.ncsu.edu/mechatronics/what-mech.php. (visited March 17, 2016)
[32] Sharif, L. (2012). Examples of Mechatronic Systems. Retrieved from: http://www.saylor.org/site/wp-content/uploads/2012/11/ME302-subunit-1.2-Examples-of-Mechatronic-Systems-FINAL.pdf. (visited March 17, 2016)
[33] O*Net OnLine (2015). Retrieved from: http://www.onetonline.org/link/summary/17-2199.05 (visited March 17, 2016)

Current Secondary Landscape

In the 2014-15 school year, 12 schools in Tennessee responded to the demand to grow local talent in emerging manufacturing fields and instituted special programs of study in Mechatronics. Student enrollment data from SY 15-16 suggest that 34 schools are implementing Mechatronics.[34] These figures demonstrate that there is an appetite among schools—and students—to explore the science of mechatronics at the high school level, which bodes well for the growing number of postsecondary institutions to offer mechatronics-related programs.

Figure 2. Open Enrollment Analysis

	Mechatronics
2014-15	12
2015-16	34
	Increase

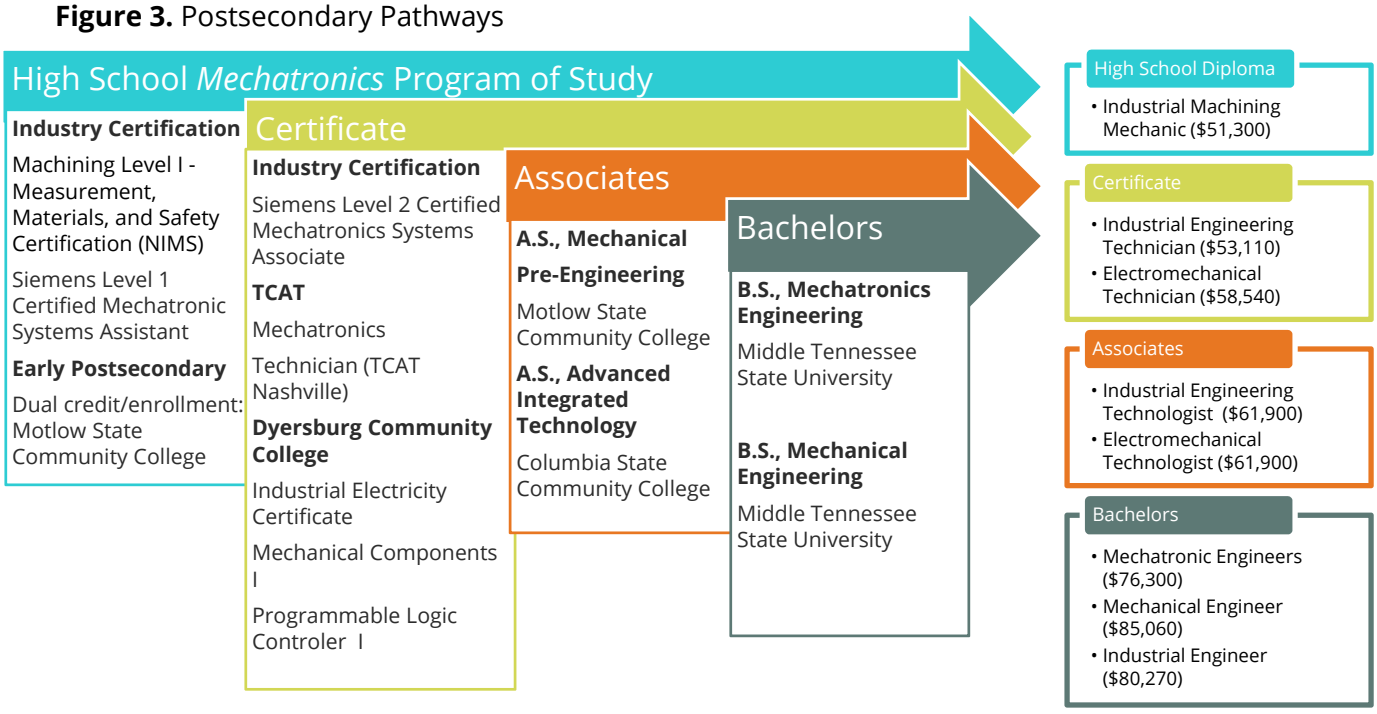
Postsecondary Pathways

What kinds of careers can students expect to pursue upon completion of the Mechatronics POS in Tennessee? In many ways, Mechatronics represents a great example of the department's emphasis on creating pathways linked to local labor market needs, composed of stackable credentials at discrete levels of postsecondary. The figure below illustrates what one such pathway might look like for a student graduating from a Tennessee Mechatronics program in high school. Annual median wages are based on Bureau of Labor Statistics Occupational Employment Statistics (OES) estimates for Tennessee, unless otherwise indicated.

Pursuing just an additional year or two of study, however, can yield great returns for students. Among Tennessee graduates from public two-year colleges who completed programs in Mechanical Pre-Engineering or Advanced Integrated Technology, median wages for their first year out of school was $53,110 and $58,540 respectively. Both of these are higher than the state average for all Associate's holders. Beyond that, advanced training at the Bachelor's level will open even more doors for students, moving their employment prospects to the higher-wage engineering and production management occupations.

[34] Author's calculation of student enrollment data received from the Tennessee Department of Education, 2015.

Figure 3. Postsecondary Pathways



Mechatronics pathways offer opportunities to funnel into careers at a variety of education levels. Moreover, demand is high for students who can complete with a certificate or related credential from a Tennessee College of Applied Technology (TCAT). The Tennessee Department of Labor and Workforce Development, in its statewide supply and demand analysis for the 16 national career clusters, forecasts that the Production Design, Precision Production, and Operations and Maintenance programs—all of which are aligned to mechatronics-related careers—will produce shortages of qualified labor if the current rate of Tennessee postsecondary completers holds steady. Production Design, in particular, was identified as a high-skill, high-wage, and in-demand pathway that is not producing enough completers to match employer demand.[35]

[35] Hedges, K., and Wettemann, M. (2012). Tennessee Statewide Supply and Demand Analysis for the 16 Education Clusters. Tennessee Department of Labor and Workforce Development. (viewed March 17, 2016)

Recommendation

No recommendations for changes at this time.

2017-18 Program of Study	Level 1	Level 2	Level 3	Level 4
Mechatronics	Principles of Manufacturing (5922)	Digital Electronics (5925) Or Robotics & Automated Systems (6143) Or Project Lead the Way (PLTW) Computer Integrated Manufacturing (6055)	Mechatronics I[1] (6156) -or- **Dual Enrollment** Mechatronics (4063)	Mechatronics II[1] (6157) -or- Manufacturing Practicum (5926) -or- **Dual Enrollment** Mechatronics (4063)
	Industry Certification: Machining Level I - Measurement, Materials, and Safety Certification (NIMS)			**Industry Certification:** Level 1 Siemens Certified Mechatronic Systems Assistant

References:

TN.gov, Newsroom & Media Center. Retrieved from: http://www.tn.gov/news/category/governorhaslam/P720

Tennessee Department of Economic & Community Development (2014). Retrieved from: http://www.tnecd.com/industries/advanced-manufacturing/

Tennessee Department of Economic & Community Development (2014). Retrieved from: http://www.tnecd.com/industries/advanced-manufacturing/

Muro, M., Andes, S., Fikri, K., Ross, M., Lee, J., Ruiz, N., & Marchio, N. (2013). Drive! Moving Tennessee's Automotive Sector Up the Value Chain. Brookings Institution. Retrieved from: http://www.brookings.edu/research/reports/2013/10/04-tennessee-automotive

O*Net OnLine (2015). 17-2199.05 - Mechatronics Engineers. Retrieved from: http://www.onetonline.org/link/summary/17-2199.05

Tennessee Department of Economic & Community Development (2015). Retrieved from: http://www.tnecd.com/advantages/workforce-education/

North Carolina State University (2012). What is Mechatronics? NC State University-UNC Asheville. Retrieved from: http://www.engr.ncsu.edu/mechatronics/what-mech.php

Sharif, L. (2012). Examples of Mechatronic Systems. Retrieved from: http://www.saylor.org/site/wpcontent/uploads/2012/11/ME302-subunit-1.2-Examples-of-Mechatronic-Systems-FINAL.pdf.

O*Net OnLine (2015). Retrieved from: http://www.onetonline.org/link/summary/17-2199.05

Hedges, K., and Wettemann, M. (2012). Tennessee Statewide Supply and Demand Analysis for the 16 Education Clusters. Tennessee Department of Labor and Workforce Development.

Welding

2016-17 Program of Study	Level 1	Level 2	Level 3	Level 4
Welding	Principles of Manufacturing (5922)	Welding I (6078)	Welding II (6033)	Manufacturing Practicum (5926)

Description

The *Welding* program of study is designed to prepare and certify students as entry-level welders. Students will learn safe practices, career exploration, leadership development, and basic arc welding and thermal cuttings skills. Basic arc welding and thermal cutting skills are developed over a series of two courses which will prepare students for an *American Welding Society* certification.

Job Outlook

Back in 2011, Governor Bill Haslam announced six target clusters for which Tennessee had a competitive advantage and would focus its recruitment efforts to bring more businesses to the state.[36] One of those target clusters was Advanced Manufacturing and Energy Technologies, and after several consecutive years of strong job gains, the demand for skilled workers shows no sign of slowing. Compared to the national rate of 8.1 percent, job creation in Tennessee is soaring in manufacturing fields, accounting for 30.3 percent of all new jobs.[37] Tennessee believes in the power of manufacturing. Over the last three years, Tennessee has posted the second largest percentage increase in the Southeast in manufacturing GDP, which reached $48.1 billion in 2014. That's 16 percent of the state's total GDP[38] With its attractive business climate and strategic location, Tennessee is home to a strong base of manufacturers representing many diverse industries, led by the state's automotive sector, which in recent years has converted into a regional and national powerhouse.[39] In industries such as these, employers like Alcoa, Eastman Chemical, Bridgestone, and Nissan are in need of engineers who can design, maintain, and operate complex production systems.

The Occupational Outlook Handbook developed by the Bureau of Labor Statistics lists the following occupations and related occupations for welders: Industrial maintenance mechanics, welding engineers, materials engineers, sculptors, welding inspectors, assemblers and fabricators, boilermakers, jewelers and precious stone metal workers, machinists and tool and die makers, metal and plastic machine workers, plumbers, pipefitters, streamfitters, and sheet metal workers.[40]

---

[36] TN.gov, Newsroom & Media Center. Retrieved from: http://www.tn.gov/news/category/governor-haslam/P720
[37] Tennessee Department of Economic & Community Development (2014). Retrieved from: http://www.tnecd.com/industries/advanced-manufacturing/. (visited March 17, 2016)
[38] Tennessee Department of Economic & Community Development (2014). Retrieved from: http://www.tnecd.com/industries/advanced-manufacturing/ (visited March 17, 2016)
[39] Muro, M., Andes, S., Fikri, K., Ross, M., Lee, J., Ruiz, N., & Marchio, N. (2013). Drive! Moving Tennessee's Automotive Sector Up the Value Chain. Brookings Institution. Retrieved from: http://www.brookings.edu/research/reports/2013/10/04-tennessee-automotive. (visited March 17, 2016)

Welding courses are considered necessary by some pipefitter and steamfitter apprenticeship programs.[41]

The nation's aging infrastructure will require the expertise of welders, cutters, solderers, and brazers to help rebuild bridges, highways, and buildings. The construction of new power generation facilities and, specifically, pipelines transporting natural gas and oil will also result in new jobs. National employment of welders, cutters, solderers, and brazers is projected to grow 4 percent from 2014 to 2024.[42] Employment growth reflects the need for welders in manufacturing because of the importance and versatility of welding as a manufacturing process. The basic skills of welding are similar across industries, so welders can easily shift from one industry to another, depending on where they are needed most. Overall job prospects will vary with the worker's skill level. Job prospects should be good for welders trained in the latest technologies. Welding schools report that graduates have little difficulty finding work, and many employers report difficulty finding properly skilled welders. However, welders who do not have up-to-date training may face strong competition for jobs.

Nationally, demand for welders will create over 128,500 job openings through 2024, the vast majority of which will arise from replacement needs as the current welding workforce approaches retirement.[43] Despite this seemingly positive outlook, however, employers frequently report that they cannot find the skilled labor to fill available positions, which has held back the growth of domestic manufacturing even as it has recovered faster than other industries.[44] This much-discussed "skills gap" seems to have disproportionately affected manufacturing: as much as 82 percent of U.S. manufacturers report moderate to serious shortages of skilled labor according to a

Deloitte survey, and the U.S. Bureau of Economic Analysis estimates that the shortage could grow to 875,000 machinists, welders, industrial mechanics, and similar welding-related occupations if the supply of qualified labor does not keep pace.[45] Given the current and projected industry needs, it is imperative to train the next generation of skilled welders to fill these positions and help drive the revitalization of U.S. manufacturing. It will be the job of welders and their machinist peers to manufacture the new products and perform the required maintenance in order for this much-needed upgrade to be realized in the coming years.[46]

The TN Department of Labor and Workforce Development projects 1500 openings for welders, cutters, solderers, and brazers from 2012 to 2022 with and a total of 9,740 employed in TN in 2020.

---

[40] Bureau of Labor Statistics, U.S. Department of Labor, Occupational Outlook Handbook (2015). Retrieved from: http://www.bls.gov/ooh/production/welders-cutters-solderers-and-brazers.htm (visited March 17, 2016)
[41] United States Department of Labor, Bureau of Labor Statistics (2015). Retrieved from: http://www.bls.gov/ooh/production/welders-cutters-solderers-and-brazers.htm (visited March 17, 2016)
[42] Bureau of Labor Statistics, U.S. Department of Labor, May 2014 State Occupational Employment and Wage Estimates for Tennessee. Retrieved from: http://www.bls.gov/oes/current/oes_tn.htm (visited March 17, 2016)
[43] O*NET Online: Welders, cutters, Solderers, and Brazers 51-4121.00 on the Internet at http://www.onetonline.org/link/summary/51-4121.00 (2014). (visited March 17, 2016)
[44] ManpowerGroup. (2013) Retrieved from http://www.manpowergroup.com/wps/wcm/connect/587d2b45-c47a-4647-a7c1-e7a74f68fb85/2013_Talent_Shortage_Survey_Results_US_high+res.pdf?MOD=AJPERES (visited March 17, 2016)
[45] SHRM Foundation. Current Issues in HR. Closing the Manufacturing Skills Gap. (2013) Retrieved from: http://www.shrm.org/about/foundation/products/documents/4-13%20skills%20gap%20briefing.pdf (visited March 17, 2016)
[46] Bureau of Labor Statistics, U.S. Department of Labor, Occupational Outlook Handbook (2015). Retrieved from: http://www.bls.gov/oes/ (visited March 17, 2016)

This includes a state growth rate of 18.0 percent for welders, cutters, solderers, and brazers (51-4121) and 37 percent for welding machine setters and operators (51-4122).[47] In northern middle TN counties in particular, welders, solders, and brazers occupations are listed as a hot job. Tennessee is one of the top five states with the highest concentration of setters and operators in this field. Welders work in a variety of industries and with their skill sets they can easily transition among different industries.[48]

In Tennessee, the production and refinement of metals, in particular, occupies an important sector of the economy. In 2012, there were 85 primary metal manufacturers and 1,000 fabricated metal product manufacturers operating in the state—both of which industry "clusters" were proportionally greater than the concentration of such manufacturers nationally.[49] Meanwhile, Tennessee employees in primary metal manufacturing were represented at 1.43 times the national proportion. Additionally, Tennessee employees in this cluster enjoy a larger share of total annual wages compared with their peers elsewhere in the country, with a wage location quotient of 1.61.[50] As previously stated, Tennessee demand for welders, cutters, solderers, and brazers is expected to grow 18 percent through 2022 (faster than the state average), resulting in approximately 350 annual openings.[51]

Figure 1.

State and National Trends

United States	Employment		Percent Change	Projected Annual Job Openings [1]
	2014	2024		
Welders, Cutters, Solderers, and Brazers	397,900	412,300	+4%	12,850
Tennessee	**Employment**		**Percent Change**	**Projected Annual Job Openings [1]**
	2012	2022		
Welders, Cutters, Solderers, and Brazers	8,240	9,740	+18%	350

[1]Projected Annual Job Openings refers to the average annual job openings due to growth and net replacement.
Note: The data for the State Employment Trends and the National Employment Trends are not directly comparable. The projections period for state data is 2012-2022, while the projections period for national data is 2014-2024.

[47] TN Department of Labor and Workforce Development. (2015). Employment Security Division, *Employment Figures.* Retrieved from:https://www.jobs4tn.gov/vosnet/lmi/occ/occsummary.aspx?category=EMPLOYMENT&ff_occprofile_section_controls=1&session=occspecewd&geo=4701000000&section=outlook&geotype=&city=&zip=&radius=&onetcode=51412106 (visited March 17, 2016)

[48] Bureau of Labor Statistics, U.S. Department of Labor, Occupational Outlook Handbook (2015). Retrieved from: http://www.bls.gov/oes/ (visited March 17, 2016)

[49] Innovation in American Regions. (2012). Retrieved from: http://www.statsamerica.org/innovation/ (visited March 17, 2016)

[50] Innovation in American Regions. (2012). Retrieved from: http://www.statsamerica.org/innovation/ (visited March 17, 2016)

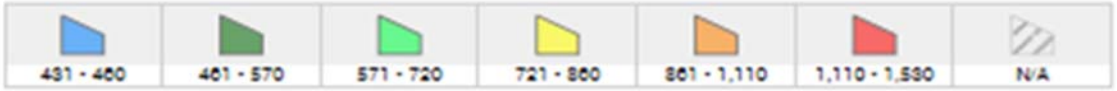
[51] O*NET (2014). Retrieved from: http://www.onetonline.org/ (visited March 17, 2016)

State and National Trends

United States	Employment		Percent Change	Projected Annual Job Openings [1]
	2014	2024		
Welding, Soldering, and Brazing Machine Setters, Operators, and Tenders	59,500	48,800	-18%	1,710
Tennessee	**Employment**		**Percent Change**	**Projected Annual Job Openings [1]**
	2012	2022		
Welding, Soldering, and Brazing Machine Setters, Operators, and Tenders	1,740	2,380	+37%	110

[1]Projected Annual Job Openings refers to the average annual job openings due to growth and net replacement.
Note: The data for the State Employment Trends and the National Employment Trends are not directly comparable. The projections period for state data is 2012-2022, while the projections period for national data is 2014-2024.

Employment Data Area Distribution



Current Secondary Landscape

Student enrollment data from the 2014-2015 school year suggest that 68 schools offered welding. For the SY15-16, it is projected that 74 schools will offer the welding POS.[52] This indicates a 10% increase of schools implementing welding for the first time in the SY15-16.[53] These figures demonstrate that there is an appetite among schools—and students—to explore welding at the high school level, which bodes well for the growing number of postsecondary institutions to offering welding certifications and degrees.

[52] Author's calculation of student enrollment data received from the Tennessee Department of Education, 2015.
[53] Tennessee Department of Education (2014). Student Success POS Open Enrollment Analysis. Internal report.

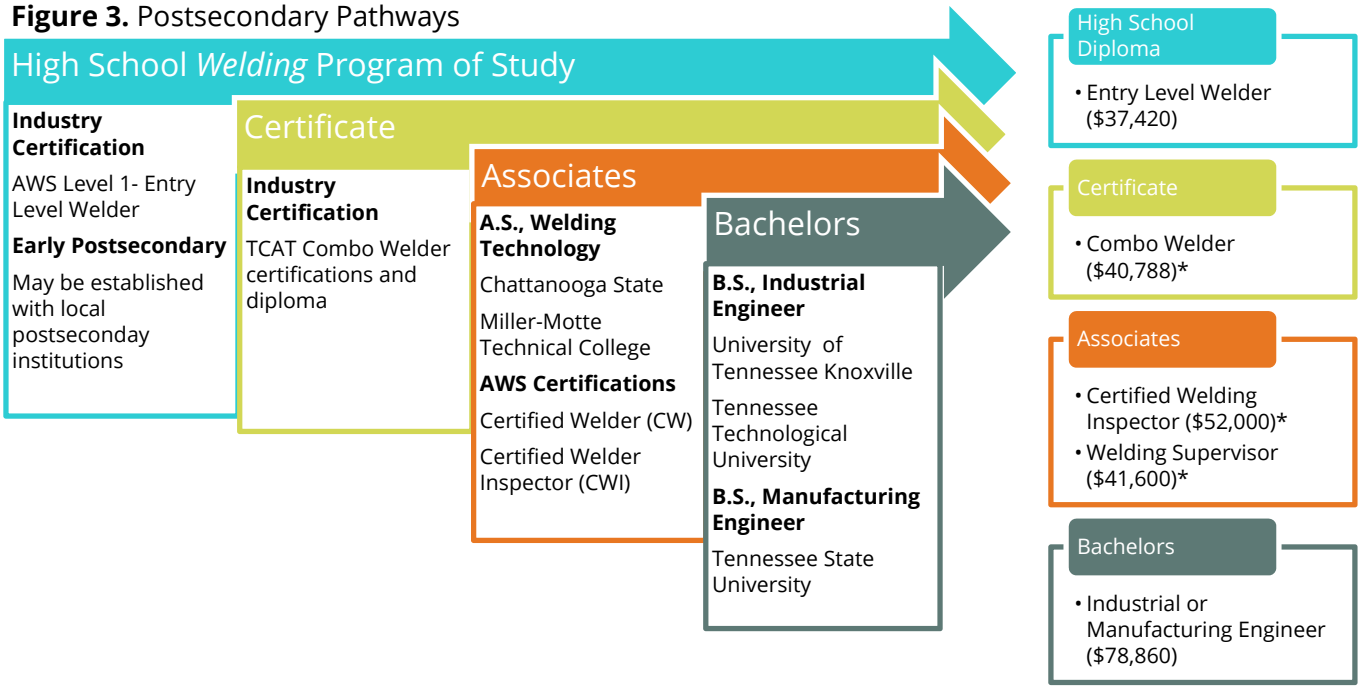
Figure 2. Open Enrollment Analysis

	Welding
2014-15	68
2015-16	74
	Increase

Postsecondary Pathways

What kinds of careers can students expect to pursue upon completion of the Welding POS in Tennessee? In many ways, Welding represents a great example of the department's emphasis on creating pathways linked to local labor market needs, composed of stackable credentials at discrete levels of postsecondary. The figure below illustrates what one such pathway might look like for a student graduating from a Tennessee Welding program in high school. Annual median wages are based on Bureau of Labor Statistics Occupational Employment Statistics (OES) estimates for Tennessee[54], unless it is proceeded by an (*) signifying annual median wages are found at PayScale, Inc.[55]

Figure 3. Postsecondary Pathways



[54] Bureau of Labor Statistics, U.S. Department of Labor, Occupational Outlook Handbook (2014). Retrieved from: http://www.bls.gov/oes/ (visited (visited March 17, 2016)

[55] PayScale (2015). Retrieved from : http://www.payscale.com/research/US/Skill=Welding/Hourly_Rate (visited March 17, 2016)

Welding pathways offer opportunities to funnel into careers at a variety of education levels. Moreover, demand is high for students who can complete with a certificate or related credential from a Tennessee College of Applied Technology (TCAT). In northern middle TN counties in particular, welders, solders, and brazers occupations are listed as a hot job. Tennessee is one of the top five states with the highest concentration of setters and operators in this field. Welders work in a variety of industries and with their skill sets they can easily transition among different industries. Pursuing just an additional year or two of study, however, can yield great returns for students. Among Tennessee graduates from public two-year colleges who completed programs in Welding Technology, median wages for their first year out of school was $41,600 and $52,000 respectively (higher than the state average for all Associate's holders). Beyond that, advanced training at the Bachelor's level will open even more doors for students, moving their employment prospects to the higher-wage engineering occupations.

Recommendation

No recommendations for changes at this time.

2017-18 Program of Study	Level 1	Level 2	Level 3	Level 4
Welding	Principles of Manufacturing (5922)	Welding I (6078)	Welding II[2] (6033) -or- **Dual Enrollment** Welding (4062)	Manufacturing Practicum (5926) -or- **Dual Enrollment** Welding (4062)
	Industry Certification: Machining Level I - Measurement, Materials, and Safety Certification (NIMS)	**Industry Certification:** AWS SENSE Entry Level Welder	**Industry Certification:** AWS SENSE Advanced Level Welder or American Welding Society Certified Welder	

References

TN.gov, Newsroom & Media Center. Retrieved from: http://www.tn.gov/news/category/governorhaslam/P720

Tennessee Department of Economic & Community Development (2014). Retrieved from: http://www.tnecd.com/industries/advanced-manufacturing/

Tennessee Department of Economic & Community Development (2014). Retrieved from: http://www.tnecd.com/industries/advanced-manufacturing/

Muro, M., Andes, S., Fikri, K., Ross, M., Lee, J., Ruiz, N., & Marchio, N. (2013). Drive! Moving Tennessee's Automotive Sector Up the Value Chain. Brookings Institution. Retrieved from: http://www.brookings.edu/research/reports/2013/10/04-tennessee-automotive

Bureau of Labor Statistics, U.S. Department of Labor, Occupational Outlook Handbook (2015). Retrieved from: http://www.bls.gov/ooh/production/welders-cutters-solderers-and-brazers.htm

United States Department of Labor, Bureau of Labor Statistics (2015). Retrieved from: http://www.bls.gov/ooh/production/welders-cutters-solderers-and-brazers.htm

Bureau of Labor Statistics, U.S. Department of Labor, May 2014 State Occupational Employment and Wage Estimates for Tennessee. Retrieved from: http://www.bls.gov/oes/current/oes_tn.htm

O*NET Online: Welders, cutters, Solderers, and Brazers 51-4121.00 on the Internet at http://www.onetonline.org/link/summary/51-4121.00 (2014)

ManpowerGroup. (2013) Retrieved from: http://www.manpowergroup.com/wps/wcm/connect/587d2b45-c47a-4647-a7c1-e7a74f68fb85/2013_Talent_Shortage_Survey_Results_US_high+res.pdf?MOD=AJPERES

SHRM Foundation. Current Issues in HR. Closing the Manufacturing Skills Gap. (2013) Retrieved from: http://www.shrm.org/about/foundation/products/documents/4-13%20skills%20gap%20briefing.pdf

Bureau of Labor Statistics, U.S. Department of Labor, Occupational Outlook Handbook (2015). Retrieved from: http://www.bls.gov/oes/

TN Department of Labor and Workforce Development. (2015). Employment Security Division, *Employment Figures.* Retrieved from: https://www.jobs4tn.gov/vosnet/lmi/occ/occsummary.aspx?category=EMPLOYMENT&ff_occprofile_section_controls=1&session=occspecewd&geo=4701000000&section=outlook&geotype=&city=&zip=&radius=&onetcode=51412106

Bureau of Labor Statistics, U.S. Department of Labor, Occupational Outlook Handbook (2015). Retrieved from: http://www.bls.gov/oes/

Innovation in American Regions. (2012). Retrieved from: http://www.statsamerica.org/innovation/

O*NET (2014). Retrieved from: http://www.onetonline.org/

Bureau of Labor Statistics, U.S. Department of Labor, Occupational Outlook Handbook (2014). Retrieved from: http://www.bls.gov/oes/

PayScale (2015). Retrieved from: http://www.payscale.com/research/US/Skill=Welding/Hourly_Rate