Advanced Manufacturing

Comprehensive Career Cluster Review (C3R)

College, Career & Technical Education | Spring 2024

TN Department of Education

Comprehensive Career Cluster Review (C3R)

The comprehensive career cluster review (C3R) is the intentional review of career and technical education (CTE) programs and the course standards within each program to ensure students have up-to-date course standards aligned to postsecondary and career needs. Each career cluster is reviewed annually with input from the state-wide advisory councils comprised of postsecondary partners, industry partners, and secondary CTE teachers. Advisory council meetings allow the stakeholders to engage in dialogue and discuss current needs, emerging trends, and necessary course revisions to course standards. Advisory council input could potentially lead to new or retired programs of study, new courses or retired courses, or revised course standards within existing courses, if necessary. The collaborative engagement ensures students receive instruction on the most up-to-date and relevant course standards, so they are prepared for postsecondary and the workforce.

Advanced Manufacturing

Advanced Manufacturing is the integration of cutting-edge technologies and innovative processes to enhance productivity, efficiency, and quality in the manufacturing industries. This includes techniques such as automation, robotics, additive manufacturing, etc. to streamline production processes and create more customized products. Advanced Manufacturing is a critical sector of Tennessee's economy. After several consecutive years of positive employment growth, the demand for skilled manufacturing workers shows no sign of slowing. This career cluster contains four programs of study (POS): Industrial Maintenance Technology, Machining Technology, Mechatronics, and Welding. Concentrators (the number of CTE participating students who earn credit in at least two sequenced courses in a single, approved CTE program of study) continue to increase in the Advanced Manufacturing career cluster as indicated below.

School Year	Advanced Manufacturing Concentrators
2020-21	4,563
2021-22	4,642
2022-23	5,574

Industrial Maintenance Technology

2023-24 Program of Study	Year 1	Year 2	Year 3	Year 4
Industrial Maintenance Technology	Principles of Manufacturing (C13H05)	Introduction to Industrial Maintenance (C13H28)	Advanced Industrial Maintenance (C13H29) -or- **Dual Enrollment** Industrial Maintenance Technology I (C13H30) -or- **Dual Enrollment** Industrial Maintenance Technology II (C13H31)	Manufacturing Practicum (C13H08) -or- **Dual Enrollment** Industrial Maintenance Technology III (C13H32) -or- **Dual Enrollment** Industrial Maintenance Technology IV (C13H33) -or- **WBL** Industrial Maintenance Technology Career Practicum (C13H40)

Description

Industrial Maintenance Technology is a wide-ranging field that includes maintaining and repairing mechanical systems, electrical systems, computer systems, and electronic circuits. Technicians install, repair, and troubleshoot mechanical, electrical, electronic, and computer-controlled systems. 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. Engineers plan and design the infrastructure within the manufacturing facilities.

The Industrial Maintenance Technology POS is designed to provide students with the knowledge and skills to effectively perform basic industrial maintenance procedures in an advanced manufacturing facility. This POS is designed for students interested in becoming general maintenance and repair workers, industrial machinery mechanics, master mechanics, electromechanical technicians, mechanical engineers, or electromechanical engineers. 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 industrial maintenance technology programs and entry-level industrial maintenance technology careers in the advanced manufacturing industry.

This program is aligned with SkillsUSA and Technology Student Association (TSA) career and technical student organizations (CTSOs).

Job Outlook

Job demand for industrial maintenance technicians is strong. Industrial Maintenance Technology provides these critical employees with the knowledge and skills needed at every manufacturing facility. There are many opportunities for career advancement. Tennessee is home to a strong base of manufacturers representing many diverse industries, led by the state's automotive sector, which has become a regional and national powerhouse. The continual growth of manufacturing combined with the number of workers retiring ensures that industrial maintenance technicians remain a high-demand occupation.

As seen in Figure 1, the demand for all occupations related to Industrial Maintenance continues to grow. According to the Bureau of Labor Statistics, jobs for Industrial Machinery Mechanics in Tennessee are projected to grow 38 percent from 2020 to 2030[1], much faster than the average for all occupations. The Supply and Demand Report lists Maintenance and Repair Workers as an occupation in demand in eight (8) of the state's regions[2]. Career One Stop designates Industrial Machinery Mechanics as one of the fastest-growing occupations in the United States[3]. Demand for Maintenance and Repair Workers is projected to grow 17 percent from 2020 to 2030[4]. Over 3,000 openings for First-Line Supervisors in Industrial

[1] Bureau of Labor Statistics, U.S. Department of Labor, O*NET Online, Retrieved February 1, 2024, from https://www.onetonline.org/link/summary/47-2031.00

[2] Tennessee Higher Education Commission, Supply and Demand Report, Retrieved March 1, 2024, from https://www.tn.gov/thec/research/supply-and-demand.html

[3] Career One Stop, U.S. Department of Labor, Fastest-Growing Careers, Retrieved February 12, 2024, from https://www.careeronestop.org/Toolkit/Careers/fastest-growing-careers.aspx

[4] Bureau of Labor Statistics, U.S. Department of Labor, O*NET Online, Retrieved February 1, 2024, from https://www.onetonline.org/link/summary/47-2031.00

Maintenance areas are projected each year through 2030[5]. Many of these openings are expected due to the need to replace workers who retire from the workforce.

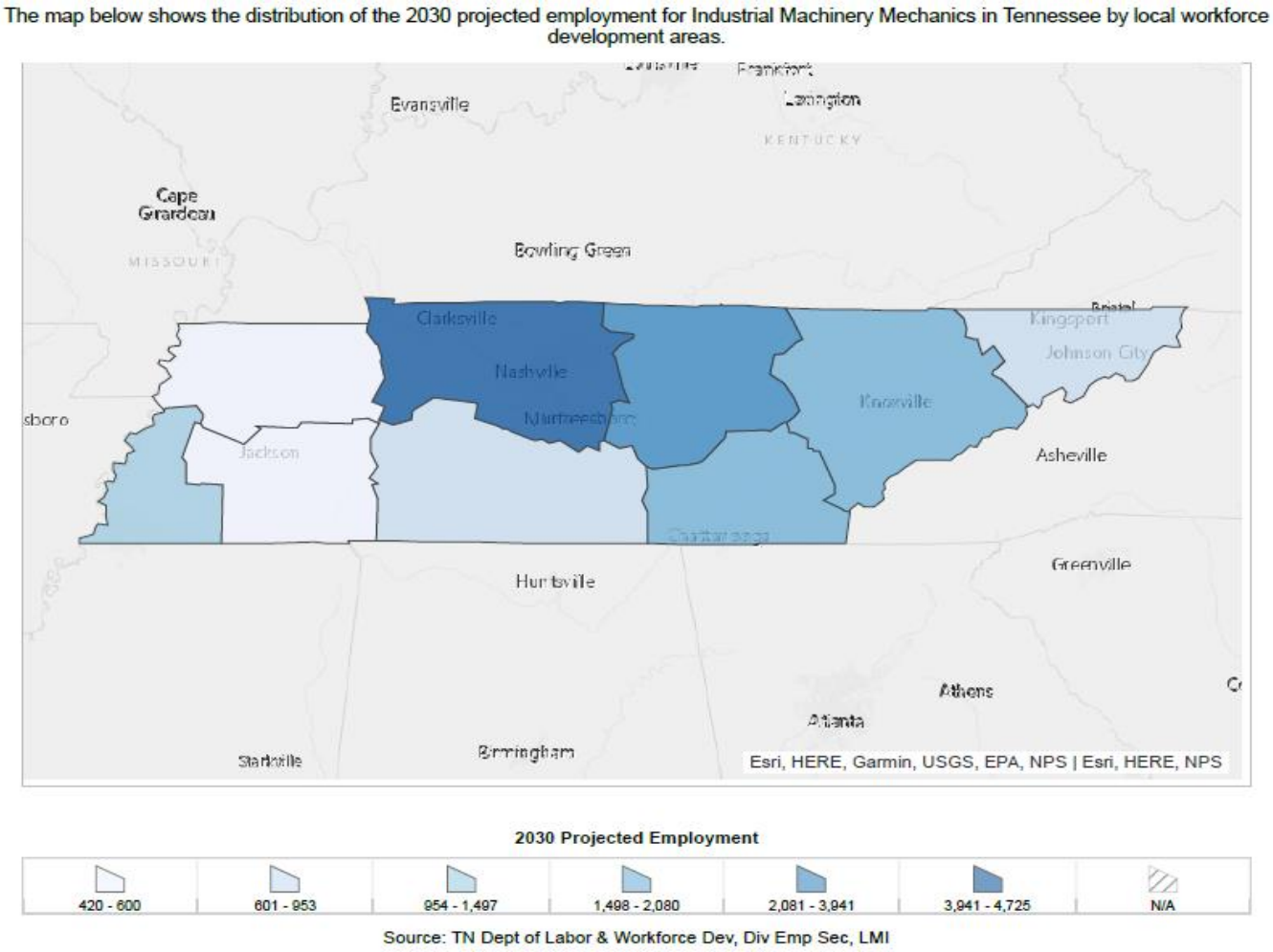
Figure 1. Tennessee employment projections for Industrial Maintenance Technology-related occupations with positive job openings projected for 2020-2030 according to the Tennessee Higher Education Commission, Supply and Demand Report.[2]

Occupation	SOC Code	Employment (2020)	Projected Employment (2030)	Projected Growth (2020-2030)	Projected Annual Job Openings (2020-2030)
Industrial Machinery Mechanics	49-9041	9,511	13,154	38%	1,324
First-Line Supervisors of Mechanics, Installers, and Repairers	49-1011	9,410	10,720	14%	1,020
General and Operations Managers	11-1021	46,120	56,270	22%	5,210
Maintenance and Repair Workers	49-9071	28,240	33,130	17%	3,360
Multiple Machine Tool Setters, Operators, and Tenders	51-4081	9,080	13,580	50%	1,590
First-Line Supervisors of Production and Operating Workers	51-1011	18,620	21,500	16%	2,240
Laborers and Freight, Stock, and Material Movers, Hand	53-7062	93,790	116,920	25%	16.090
Production Workers	51-9199	18,210	22,280	22%	5,210

[5] Bureau of Labor Statistics, U.S. Department of Labor, O*NET Online, Retrieved February 1, 2024, from https://www.onetonline.org/link/summary/47-2031.00

Occupation	SOC Code	Employment (2020)	Projected Employment (2030)	Projected Growth (2020-2030)	Projected Annual Job Openings (2020-2030)
Packers and Packagers, Hand	53-7064	17,950	21,610	20%	3,100
Shipping, Receiving, and Inventory Clerks	43-5071	19,260	20,250	5%	1,980

Figure 2. 2030 projected employment for Industrial Machinery Mechanics in Tennessee.[6]



[6] Jobs4Tn.gov. Occupation Profile. Retrieved (February 1, 2024), from https://jobs4tnwfs.tn.gov/vosnet/Default.aspx

Program of Study Level

The Tennessee Investment in Student Achievement (TISA) provides direct funding for student participation in career and technical education (CTE) programs to drive college and career readiness outcomes. Pursuant to Tenn. Code Ann. § 49-3-105(c)(2), a direct allocation amount will be generated for each student membership in a CTE program based on the rule:

1. The level of the program
    - Programs shall be designated into one (1) of three (3) levels.
    - Programs will be classified into three (3) levels based on alignment to wage-earning potential indicators and additional resources required to support the program if aligned to wage-earning potential occupational pathways.
2. The student progression in coursework through the program

*The state budget keeps all programs funded at $5,000 for 2024-25 school year funding. See the CTE TISA Programs of Study Leveling Guide 2024-25 for the TISA funding formula for program of study levels.

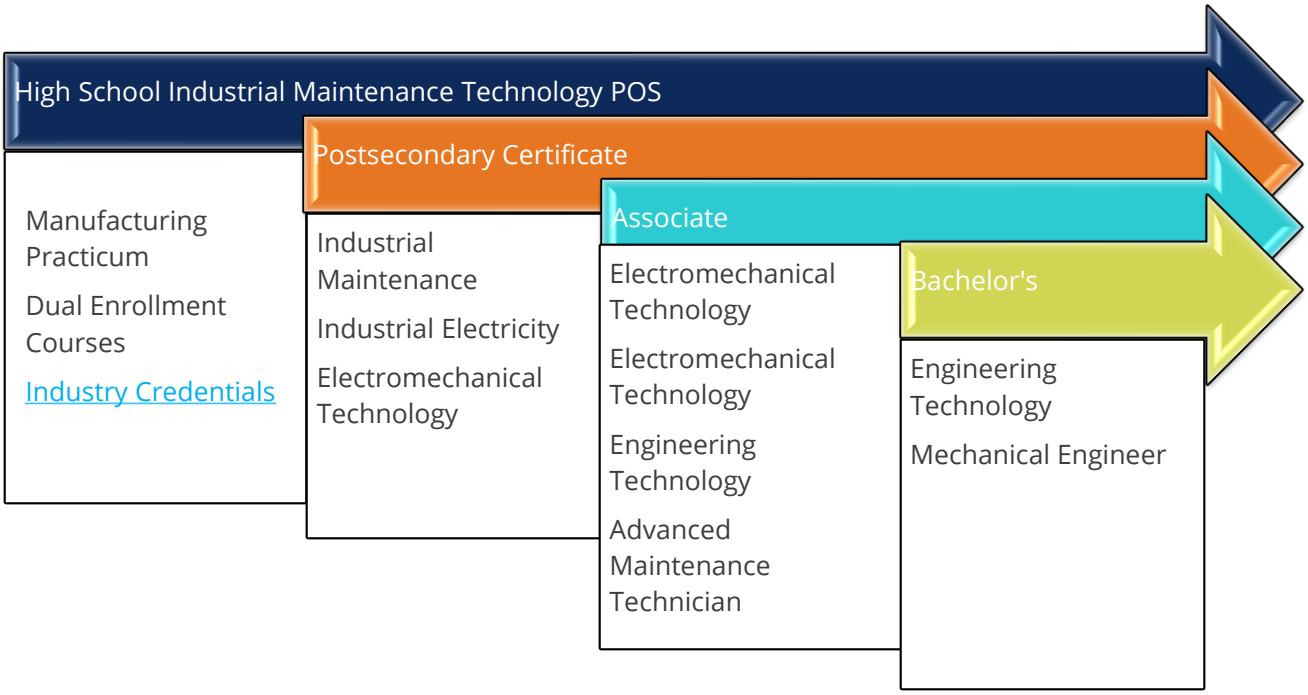
Industrial Maintenance Technology Program: Level 2

Postsecondary Opportunities

The Industrial Maintenance Technology pathway offers opportunities to funnel students into careers at various education levels. Industry credentials earned in high school and work experience through practicum courses can lead to employment immediately after high school. There are early postsecondary opportunities at the high school level that lead to certificate programs at the state's network of Tennessee Colleges for Advanced Technology (TCATs). As shown in the figure below, the wage level increase with a certificate from a TCAT is significant. Community colleges in Tennessee offer various associate-level degrees that continue to increase wage-earning potential. Chattanooga State, Nashville State, Pellissippi State, and Walters State offer associate-level degrees for this program. Advanced training at the bachelor's level increases opportunities for students as better prospects for higher-wage engineering and production management occupations. Middle Tennessee State University (MTSU), East Tennessee State, and the University of Tennessee at Knoxville offer bachelor's degrees for this program.

Figure 3 illustrates whicht opportunities are available for a student graduating from a Tennessee Machining Technology program in high school. The figure outlines some of the related postsecondary certificates and degrees, career opportunities, and salaries available to students in the pathway. Students may acquire hours transferable to a postsecondary institution for the completion of certificates and degrees.

Figure 3. Outlines the related career opportunities and training necessary for each program of study. Students may acquire hours transferable to a postsecondary institution for the completion of a degree.



Additional opportunities are offered at multiple postsecondary institutions as indicated in the Tennessee Department of Labor and Workforce Dashboard.

High School Diploma	Certificate	Associate	Bachelor's
• Production Workers **($30,550)**	• Industrial Engineering Technicians **($52,833)**	• Mechnical Engineering Technicians **($60,132)**	• Mechanical Engineers **($93,649)**
• Maintenance and Repair Workers **($28,310)**	• Industrial Machinery Mechanics **($59,795)**	• Electrical and Electronic Engineering Technicians **($66,390)**	• General and Operations Managers **($99,600)**

Current Secondary Landscape

Over the past three years, the number of schools offering Industrial Maintenance Technology has increased from 21 to 28. In 2022-23, 6,549 students were enrolled in Industrial Maintenance Technology courses, an

increase from previous years. This program may not be appropriate for schools that do not have supporting labor market data. The figures below show the open enrollment analysis for the 2020-21 through the 2022-23 school year and the course enrollment in the Industrial Maintenance Technology program.

Figure 4. Open Enrollment Analysis

School Year	Schools Offering Industrial Maintenance Technology
2020-21	21
2021-22	26
2022-23	28

Figure 5. Student Enrollment by Course

School Year	Principles of Manufacturing	Introduction to Industrial Maintenance	Advanced Industrial Maintenance	Manufacturing Practicum	Dual Enrollment Courses
2020-21	4,498	180	112	193	361
2021-22	5,104	199	77	241	490
2022-23	5,377	245	100	316	511

Machining Technology

2023-24 Program of Study	Year 1	Year 2	Year 3	Year 4
Machining Technology	Principles of Manufacturing (C13H05)	Principles of Machining I (C13H09)	Principles of Machining II (C13H06) -or- **Dual Enrollment** Machining Technology I (C13H01) -or- **Dual Enrollment** Machining Technology II (C13H20)	Manufacturing Practicum (C13H08) -or- **Dual Enrollment** Machining Technology III (C13H34) -or- **Dual Enrollment** Machining Technology IV (C13H35) -or- **WBL** Machining Technology Career Practicum (C13H41)

Description

Machining Technology is the heart of manufacturing things. Machinists, Computer Numerical Controlled (CNC) Machine Tool Operators and Programmers, and Manufacturing Production Technicians set up and operate a variety of machine tools to produce precision parts and instruments. Technicians may also fabricate and modify parts to make or repair machine tools or maintain machines, applying knowledge of mechanics, mathematics, metal properties, layout, and machining procedures. Mechanical engineers plan and design the tools and equipment used in machining.

The Machining Technology POS is designed for students interested in becoming a CNC 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.

This program is aligned with the SkillsUSA and TSA CTSOs.

Job Outlook

Job demand for machinists is strong. Machining technology, using lathes, milling machines, and grinders, is a critical occupation in every manufacturing facility ensuring many opportunities for career advancement in manufacturing industries. Tennessee is home to a strong base of manufacturers representing many diverse industries, led by the state's automotive sector, which has become a regional and national powerhouse. The continual growth of manufacturing combined with the number of workers retiring ensures that machinists remain a high-demand occupation in Tennessee.

As seen in Figure 1, the demand for all occupations related to Machining Technology continues to grow. According to the Bureau of Labor Statistics, jobs for Machinists in Tennessee are projected to grow 17 percent from 2020 to 2030[7], much faster than the average for all occupations. The Supply and Demand Report lists Production Workers as an occupation in demand in eight of the state's regions[8]. Career One Stop designates Industrial Machinery Mechanics as one of the fastest-growing occupations in the United States[9]. Demand for Production Workers is projected to grow 22 percent from 2020 to 2030[10]. Over 3000 openings for First-Line Supervisors in Machining areas are projected each year through 2030[11]. Many of these openings are expected as a result of the need to replace workers who retire from the workforce.

[7] Bureau of Labor Statistics, U.S. Department of Labor, O*NET Online, Retrieved February 1, 2024, from https://www.onetonline.org/link/summary/47-2031.00

[8] Tennessee Higher Education Commission, Supply and Demand Report, Retrieved March 1, 2024, from https://www.tn.gov/thec/research/supply-and-demand.html

[9] Career One Stop, U.S. Department of Labor, Fastest-Growing Careers, Retrieved February 12, 2024, from https://www.careeronestop.org/Toolkit/Careers/fastest-growing-careers.aspx

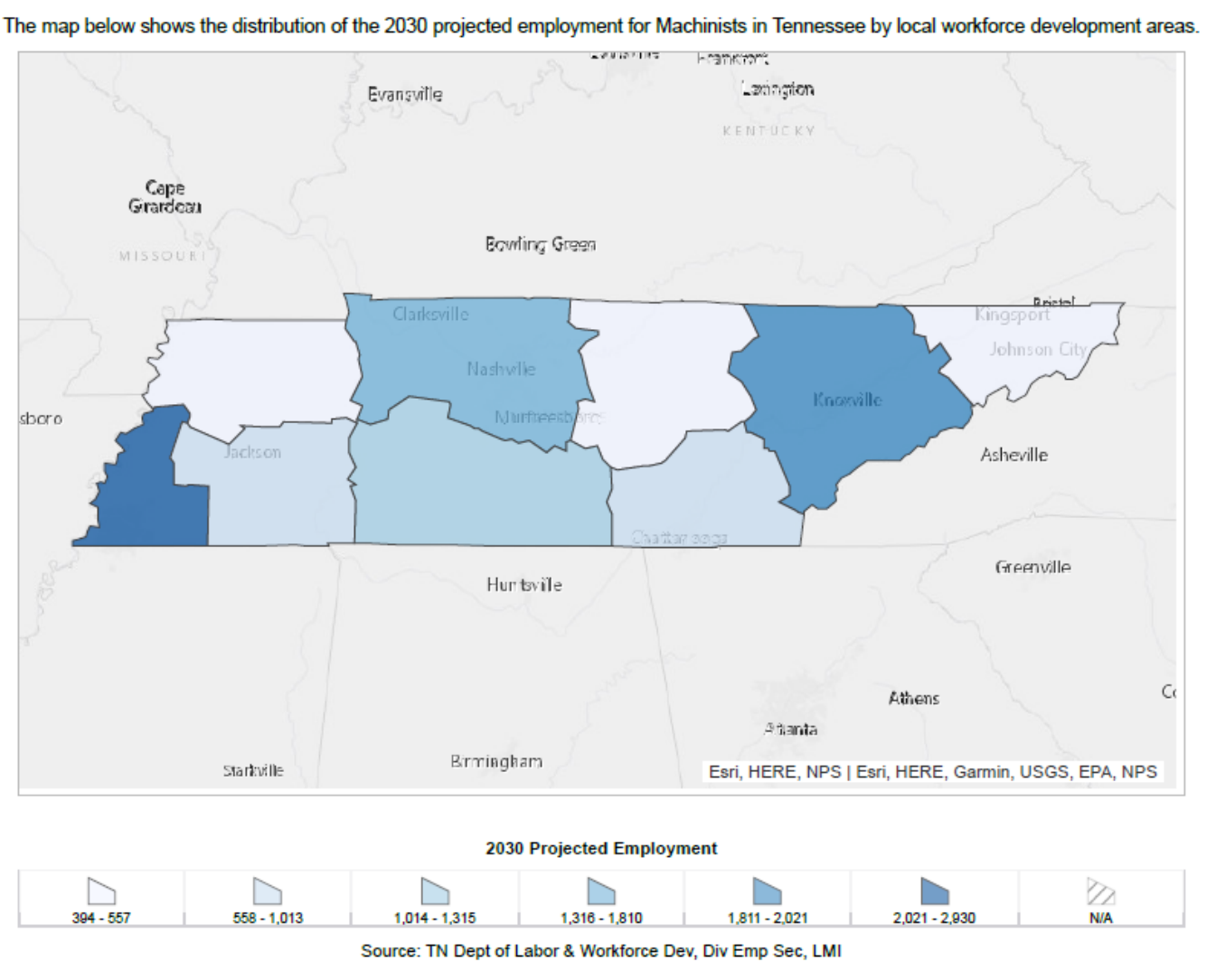
[10] Bureau of Labor Statistics, U.S. Department of Labor, O*NET Online, Retrieved February 1, 2024, from https://www.onetonline.org/link/summary/47-2031.00

[11] Bureau of Labor Statistics, U.S. Department of Labor, O*NET Online, Retrieved February 1, 2024, from https://www.onetonline.org/link/summary/47-2031.00

Figure 1. Tennessee employment projections for Machining Technology related occupations with positive job openings projected for 2020-2030 according to the Tennessee Higher Education Commission, Supply and Demand Report.[2]

Occupation	SOC Code	Employment (2020)	Projected Employment (2030)	Projected Growth (2020-2030)	Projected Annual Job Openings (2020-2030)
Multiple Machine Tool Setters, Operators, and Tenders	51-4081	9,080	13,580	50%	1,590
Production Workers	51-9199	18,210	22,280	22%	2,600
Industrial Machinery Mechanics	49-9041	9,510	13,150	38%	1,320
Laborers and Freight, Stock, and Material Movers, Hand	53-7062	93,790	116,920	25%	16,090
First-Line Supervisors of Mechanics, Installers, and Repairers	49-1011	9,410	10,720	14%	1,020
General and Operations Managers	11-1021	46,120	56,270	22%	5,210
Maintenance and Repair Workers	49-9071	28,240	33,130	17%	3,360
First-Line Supervisors of Production and Operating Workers	51-1011	18,620	21,500	16%	2,240
Packers and Packagers, Hand	53-7064	17,950	21,610	20%	3,100
Shipping, Receiving, and Inventory Clerks	43-5071	19,260	20,250	5%	1,980

Figure 2. 2030 projected employment for Machinists in Tennessee.[6]



Program of Study Level

TISA provides direct funding for student participation in CTE programs to drive college and career readiness outcomes. Pursuant to T.C.A. § 49-3-105(c)(2), a direct allocation amount will be generated for each student membership in a CTE program based on the rule:

1. The level of the program
    - Programs shall be designated into one (1) of three (3) levels.
    - Programs will be classified into three (3) levels based on alignment to wage-earning potential indicators and additional resources required to support the program if aligned to wage-earning potential occupational pathways.
    2. The student progression in coursework through the program.

The state budget keeps all programs funded at $5,000 for the 2024-25 school year funding. See the CTE TISA Programs of Study Leveling Guide 2024-25 for the TISA funding formula for program of study levels.

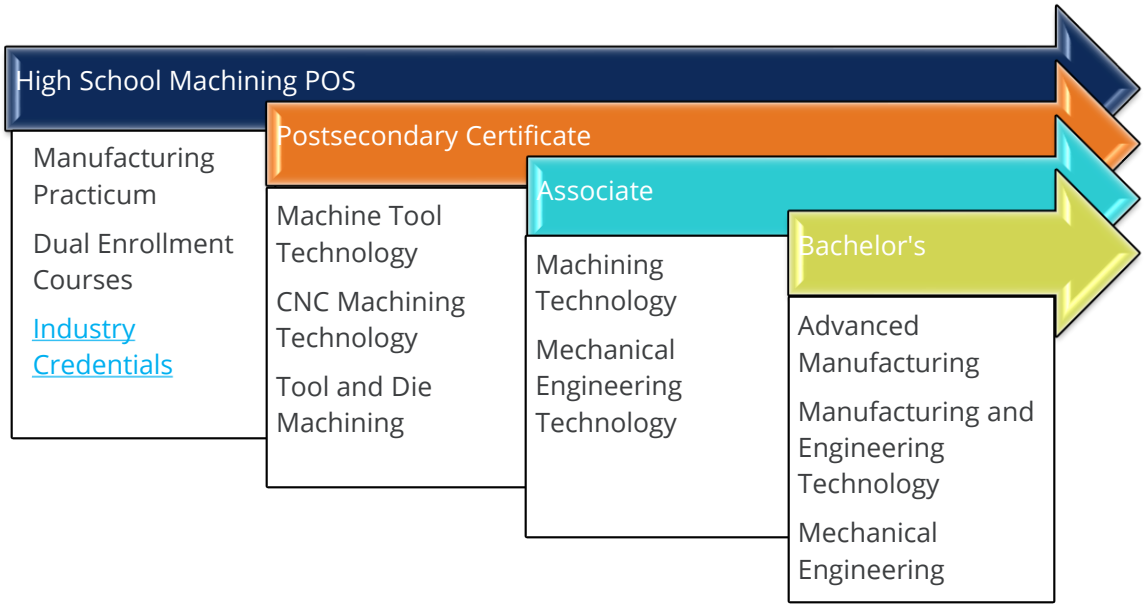
Machining Technology Program: Level 2

Postsecondary Opportunities

The Machining Technology pathway offers opportunities to funnel students into careers at a variety of education levels. Industry credentials earned in high school and work experience, through practicum courses, can lead to employment immediately after high school. There are early postsecondary opportunities at the high school level that lead to certificate programs at the state's network of Tennessee Colleges for Advanced Technology (TCATs). As shown in the table below, the wage level increase with a certificate from a TCAT is significant. Community colleges in Tennessee offer a variety of associate-level degrees that continue to increase wage-earning potential. Colombia State and Nashville State offer associate-level degrees for this program. Advanced training at the bachelor's level increases opportunities for students as better prospects for higher-wage engineering and production management occupations. Middle Tennessee State University (MTSU), East Tennessee State, and the University of Tennessee at Knoxville offer bachelor's degrees for this program.

Figure 3 illustrates which opportunities are available for a student graduating from a Tennessee Machining Technology program in high school. The figure outlines some of the related postsecondary certificates and degrees, career opportunities, and salaries available to students in the pathway. Students may acquire hours transferable to a postsecondary institution for the completion of certificates and degrees.

Figure 3. Outlines the related career opportunities and training necessary for each program of study. Students may acquire hours transferable to a postsecondary institution for the completion of a degree.



Additional opportunities are offered at multiple postsecondary institutions as indicated in the Tennessee Department of Labor and Workforce Dashboard.

High School Diploma	Certificate	Associate	Bachelor's
• Production Workers **($30,550)**	• Industrial Engineering Technicians **($52,833)**	• Mechnical Engineering Technicians **($60,132)**	• Mechanical Engineers **($93,649)**
• Maintenance and Repair Workers **($28,310)**	• Industrial Machinery Mechanics **($59,795)**	• Millwrights **($60,930)**	• General and Operations Manager **($99,600)**

Current Secondary Landscape

Over the past three years, the number of schools offering Machining Technology has not changed significantly. In 2022-23, 7,779 students were enrolled in Machining Technology courses which was an increase from previous years. This program may not be appropriate for schools that do not have supporting labor market data. The figures below show the open enrollment analysis for the 2020-21 through the 2022-23 school year and the course enrollment in the Machining Technology program.

Figure 4. Open Enrollment Analysis

School Year	Schools Offering Machining Technology
2020-21	58
2021-22	51
2022-23	57

Figure 5. Student Enrollment by Course

School Year	Principles of Manufacturing	Principles of Machining I	Principles of Machining II	Manufacturing Practicum	Dual Enrollment Courses
2020-21	4,498	826	368	193	633
2021-22	5,104	811	394	241	762
2022-23	5,377	702	402	316	982

Mechatronics

2023-24 Program of Study	Year 1	Year 2	Year 3	Year 4
Mechatronics	Principles of Manufacturing (C13H05)	Digital Electronics (C13H07)	Mechatronics I (C13H16) -or- Robotics & Automated Systems (C13H15) -or- **Dual Enrollment** Mechatronics I (C13H04) -or- **Dual Enrollment** Mechatronics II (C13H21)	Mechatronics II (C13H17) -or- Manufacturing Practicum (C13H08) -or- **Dual Enrollment** Mechatronics III (C13H36) -or- **Dual Enrollment** Mechatronics IV (C13H37) -or- **WBL** Mechatronics Career Practicum (C13H42)

Description

Mechatronics is an interdisciplinary field that includes manufacturing production technicians, industrial engineer technicians, robot technicians, mechanical engineering technicians, and mechatronics engineers. Technicians work wherever mechanical systems are used, including the integration of digital electronics, robotics, human-machine interfaces, and information processing. Troubleshooting is a particularly important skill. Mechatronics systems combine mechanical, electrical, computer, and control systems into a unified process to optimize results and minimize defects.

The Mechatronics POS 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 certifications at a technology college or more advanced coursework at a two-year or four-year postsecondary institution.

This program is aligned with the SkillsUSA and TSA CTSOs.

Job Outlook

Job demand for mechatronics technicians and engineers is strong. Mechatronics, with its emphasis on ensuring machines and processes work well, offers many opportunities for career advancement in advanced manufacturing industries. Tennessee is home to a strong base of manufacturers representing many diverse industries, led by the state's automotive sector, which has become a regional and national powerhouse. The continual growth of manufacturing, combined with the number of workers retiring, ensures that mechatronics is a high-demand occupation in Tennessee.

As seen in Figure 1, the demand for all occupations related to Mechatronics continues to grow. According to the Bureau of Labor Statistics, jobs for Multiple Machine Tool Setters, Operators, and Tenders in Tennessee are projected to grow 50 percent from 2020 to 2030[12], much faster than the average for all occupations. The Supply and Demand Report lists Maintenance and Repair Workers as an occupation in demand in eight of the state's regions[13]. Career One Stop designates Industrial Machinery Mechanics as one of the fastest-growing occupations in the United States[14]. Demand for Industrial Engineering Technicians is projected to grow 14 percent from 2020 to 2030[15]. Over 3,000 openings for First-Line Supervisors in Mechatronics areas are projected each year through 2030[16]. Many of these openings are expected as a result of the need to replace workers who retire from the workforce.

[12] Bureau of Labor Statistics, U.S. Department of Labor, O*NET Online, Retrieved February 1, 2024, from https://www.onetonline.org/link/summary/47-2031.00

[13] Tennessee Higher Education Commission, Supply and Demand Report, Retrieved March 1, 2024, from https://www.tn.gov/thec/research/supply-and-demand.html

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[15] Bureau of Labor Statistics, U.S. Department of Labor, O*NET Online, Retrieved February 1, 2024, from https://www.onetonline.org/link/summary/47-2031.00

[16] Bureau of Labor Statistics, U.S. Department of Labor, O*NET Online, Retrieved February 1, 2024, from https://www.onetonline.org/link/summary/47-2031.00

Figure 1. Tennessee employment projections for Mechatronics related occupations with positive job openings projected for 2020-2030 according to the Tennessee Higher Education Commission, Supply and Demand Report.[2]

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Production Workers	51-9199	18,210	22,280	22%	2,600
Maintenance and Repair Workers	49-9071	28,240	33,130	17%	3,360
Production, Planning, and Expediting Clerks	43-5061	8,740	10,540	21%	1,150
First-Line Supervisors of Production and Operating Workers	51-1011	18,620	21,500	16%	2,240
Multiple Machine Tool Setters, Operators, and Tenders	51-4081	9,080	13,580	50%	1,590
Laborers and Freight, Stock, and Material Movers, Hand	53-7062	93,790	116,920	25%	16.090
General and Operations Managers	11-1021	46,120	56,270	22%	5,210
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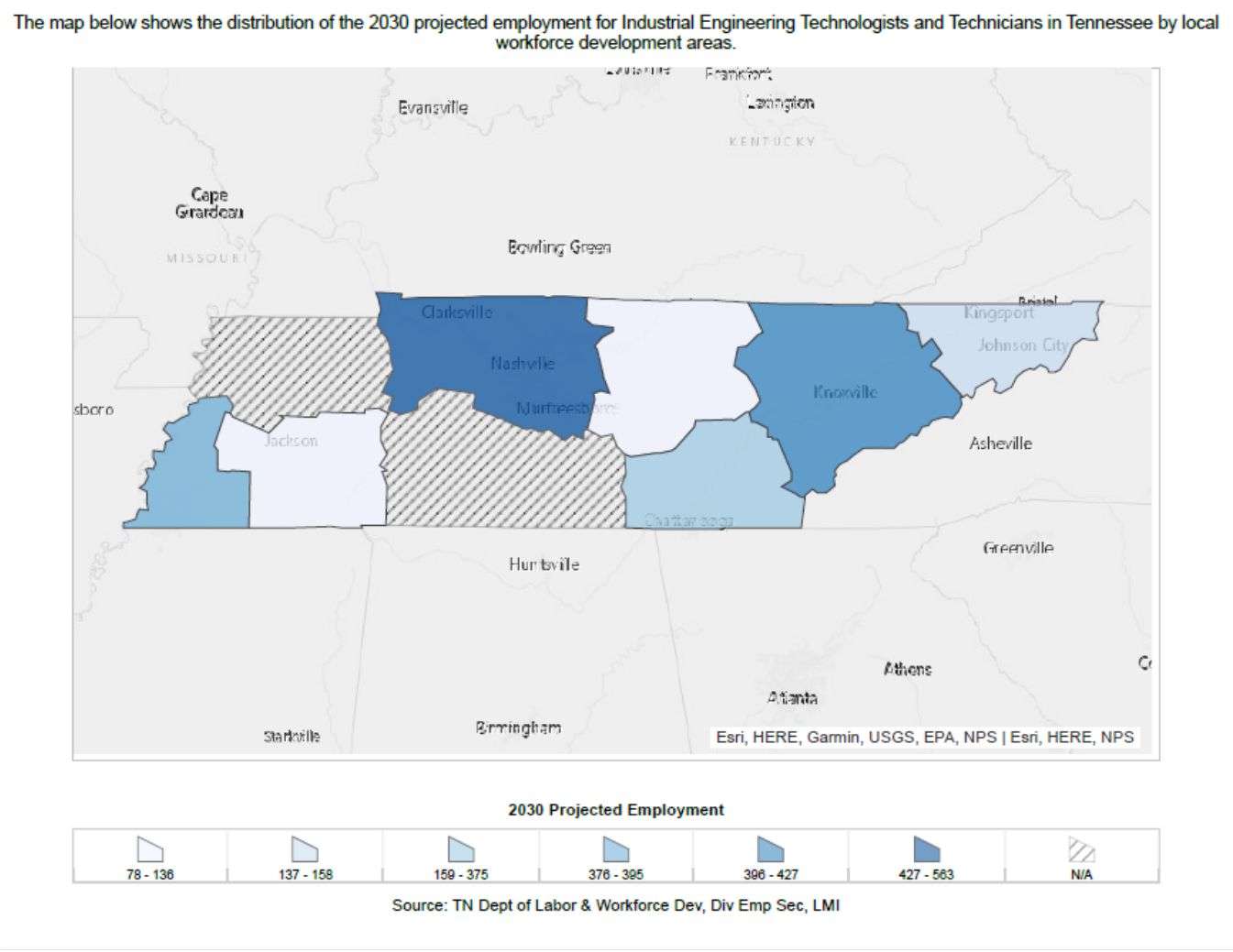
Figure 2. 2030 projected employment for Industrial Engineering Technicians in Tennessee.[6]



Program of Study Level

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2. The student progression in coursework through the program

The state budget keeps all programs funded at $5,000 for the 2024-25 school year funding. See the CTE TISA Programs of Study Leveling Guide 2024-25 for the TISA funding formula for program of study levels.

Mechatronics Program: Level 2

Postsecondary Opportunities

The Mechatronics pathway offers opportunities to funnel students into careers at a variety of education levels. Industry credentials earned in high school and work experience through practicum courses can lead to employment immediately after high school. There are early postsecondary opportunities at the high school level that lead to certificate programs at the state's network of Tennessee Colleges for Advanced Technology (TCATs). As shown in the table below, the wage level increases with a certificate from a TCAT. TCAT Memphis and Motlow State Community College offer certificates in Mechatronics. Community colleges in Tennessee offer a variety of associate-level degrees that continue to increase wage-earning potential. Chattanooga State and Nashville State offer associate-level degrees for this program. Advanced training at the bachelor's level opens even more doors for students for better prospects in higher-wage engineering and production management occupations. Tennessee Tech, Middle Tennessee State University (MTSU), and the University of Tennessee at Knoxville offer bachelor's degrees for this program.

Figure 3 illustrates which opportunities are available for a student graduating from a Tennessee Mechatronics program in high school. The figure outlines some of the related postsecondary certificates and degrees, career opportunities, and salaries available to students in the pathway. Students may acquire hours transferable to a postsecondary institution for the completion of certificates and degrees.

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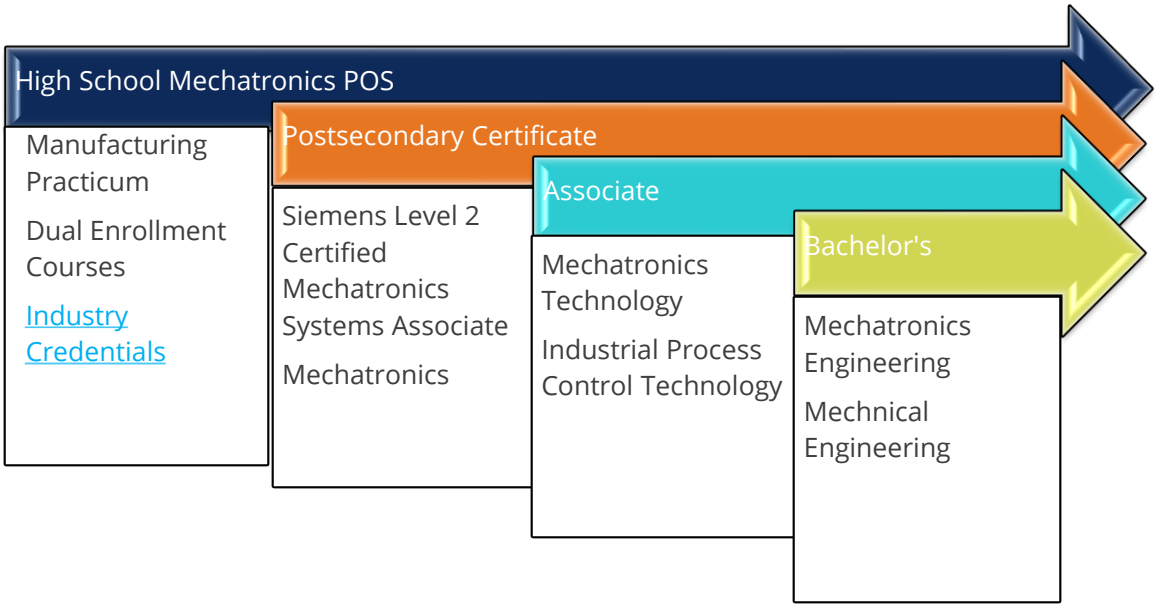


Additional opportunities are offered at multiple postsecondary institutions as indicated in the Tennessee Department of Labor and Workforce Dashboard.

High School Diploma	Certificate	Associate	Bachelor's
• Production Worker **($30,550)**	• Industrial Engineering Technician **($52,833)**	• Mechnical Engineering Technicians **($60,132)**	• Mechatronics Engineers **($89,710)**
• Maintenance and Repair Worker **($28,310)**	• Industrial Machinery Mechanic **($59,795)**	• Electrical and Electronic Engineering Technicians **($66,390)**	• General and Operations Managers **($99,600)**

Current Secondary Landscape

Over the past three years, the number of schools offering Mechatronics has increased from 43 to 59. In 2022-23, 8,765 students were enrolled in Mechatronics courses which was an increase from previous years. This program may not be appropriate for schools that do not have the supporting labor market data. The figures below show the open enrollment analysis for the 2020-21 through the 2022-23 school year and the course enrollment in the Mechatronics program.

Figure 4. Open Enrollment Analysis

School Year	Schools Offering Mechatronics
2020-21	43
2021-22	44
2022-23	59

Figure 5. Student Enrollment by Course

School Year	Principles of Manufacturing	Digital Electronics	Mechatronics I	Robotics & Automated Systems	Mechatronics II	Dual Enrollment Courses
2020-21	4,498	845	376	951	165	850
2021-22	5,104	807	360	923	159	1,075
2022-23	5,377	755	369	1,062	160	1,042

Welding

2023-24 Program of Study	Year 1	Year 2	Year 3	Year 4
Welding	Principles of Manufacturing (C13H05)	Welding I (13H12)	Welding II (C13H10) -or- **Dual Enrollment** Welding I (C13H03) -or- **Dual Enrollment** Welding II (C13H18)	Manufacturing Practicum (C13H08) -or- **Dual Enrollment** Welding III (C13H38) -or- **Dual Enrollment** Welding IV (C13H39) -or- **WBL** Welding Career Practicum (C13H43)

Description

Welding careers are an integral part of Advanced Manufacturing. Welders, cutters, solderers, and brazers use hand-held or remotely controlled equipment to join, repair, or cut metal parts and products. They may work outdoors, often in inclement weather, or indoors, sometimes in a confined area. They may work on a scaffold, high off the ground, and they occasionally must lift heavy objects and work in awkward positions. Some welders go on to earn their bachelor's degrees as material engineers.

The Welding POS 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 cutting skills. Basic welding and thermal cutting skills are developed over a series of two welding courses, which will prepare students for an American Welding Society certification.

This program is aligned with SkillsUSA and http://www.tntsa.org/ TSA CTSOs.

Job Outlook

Job demand for welders is strong in both construction and manufacturing. Welders are needed in manufacturing because of the importance and versatility of welding. The nation's aging infrastructure will require the expertise of welders, cutters, solderers, and brazers to help rebuild bridges, highways, and buildings. There are many job openings to replace retiring workers. The basic skills of welding are similar

across multiple industries, so welders can easily shift from one industry to another, depending on where they are needed most.

As seen in Figure 1, the demand for all occupations related to Welding continues to grow. According to the Bureau of Labor Statistics, jobs for Welders, Cutters, Solderers, and Brazers in Tennessee are projected to grow 15 percent from 2020 to 2030[17], much faster than the average for all occupations. The Supply and Demand Report lists Welders, Cutters, Solderers, and Brazers as an occupation in demand in nine of the state's regions[18]. Demand for Production Workers is projected to grow 22 percent from 2020 to 2030[19]. Demand for Machinists is projected to grow 17 percent from 2020 to 2030[20]. Over 3,000 openings for First-Line Supervisors in Welding areas are projected each year through 2030[21]. Many of these openings are expected as a result of the need to replace workers who retire from the workforce.

[17] Bureau of Labor Statistics, U.S. Department of Labor, O*NET Online, Retrieved February 1, 2024, from https://www.onetonline.org/link/summary/47-2031.00

[18] Tennessee Higher Education Commission, Supply and Demand Report, Retrieved March 1, 2024, from https://www.tn.gov/thec/research/supply-and-demand.html

[19] Bureau of Labor Statistics, U.S. Department of Labor, O*NET Online, Retrieved February 1, 2024, from https://www.onetonline.org/link/summary/47-2031.00

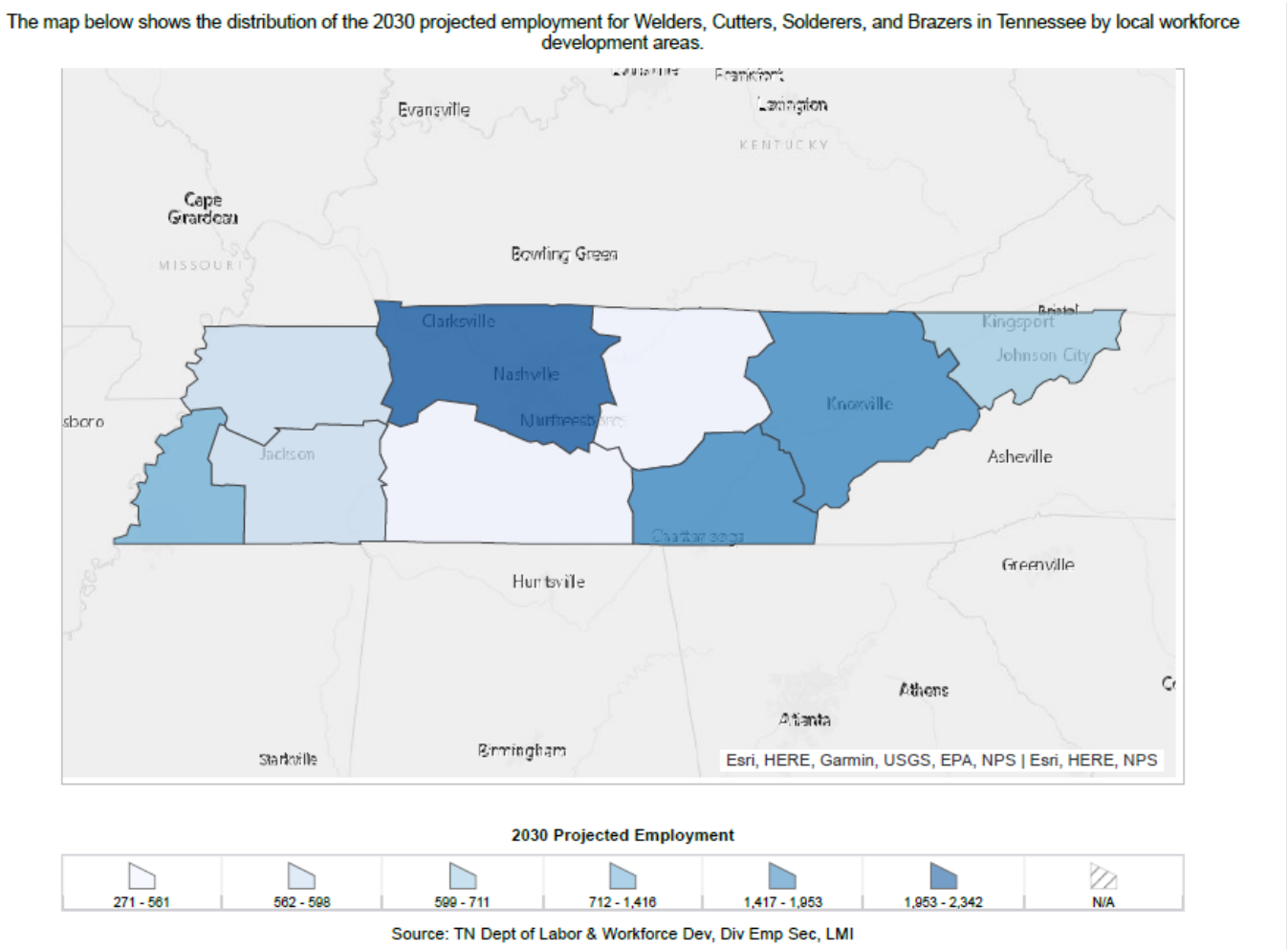
[20] Bureau of Labor Statistics, U.S. Department of Labor, O*NET Online, Retrieved February 1, 2024, from https://www.onetonline.org/link/summary/47-2031.00

[21] Bureau of Labor Statistics, U.S. Department of Labor, O*NET Online, Retrieved February 1, 2024, from https://www.onetonline.org/link/summary/47-2031.00

Figure 1. Tennessee employment projections for Welding related occupations with positive job openings projected for 2020-2030 according to the Tennessee Higher Education Commission, Supply and Demand Report.[2]

Occupation	SOC Code	Employment (2020)	Projected Employment (2030)	Projected Growth (2020-2030)	Projected Annual Job Openings (2020-2030)
Welders, Cutters, Solderers, and Brazers	51-4121	10,180	11,740	15%	1,310
Machinists	51-4041	9,050	10,540	17%	1,140
Maintenance and Repair Workers	49-9071	28,240	33,130	17%	3,360
Cutting, Punching, and Press Machine Setters, Operators, and Tenders	51-4031	6,970	7,120	2%	720
Production Workers	51-9199	18,210	22,280	22%	2,600
First-Line Supervisors of Production and Operating Workers	51-1011	18,620	21,500	16%	2,240
Laborers and Freight, Stock, and Material Movers, Hand	53-7062	93,790	116,920	25%	16,090
Industrial Production Managers	11-3051	4,660	5,450	17%	420
Installation, Maintenance, and Repair Workers	49-9099	7,100	8,290	17%	900
Helpers - Production Workers	51-9198	7,660	8,110	6%	1,160

Figure 2. 2030 projected employment for Welders in Tennessee.[6]



Program of Study Level

TISA provides direct funding for student participation in CTE programs to drive college and career readiness outcomes. Pursuant to T.C.A. § 49-3-105(c)(2), a direct allocation amount will be generated for each student membership in a CTE program based on the rule:

1. The level of the program
    - Programs shall be designated into one (1) of three (3) levels.
    - Programs will be classified into three (3) levels based on alignment to wage-earning potential indicators and additional resources required to support the program if aligned to wage-earning potential occupational pathways.
2. The student progression in coursework through the program

The state budget keeps all programs funded at $5,000 for the 2024-25 school year funding. See the CTE TISA Programs of Study Leveling Guide 2024-25 for the TISA funding formula for program of study levels.

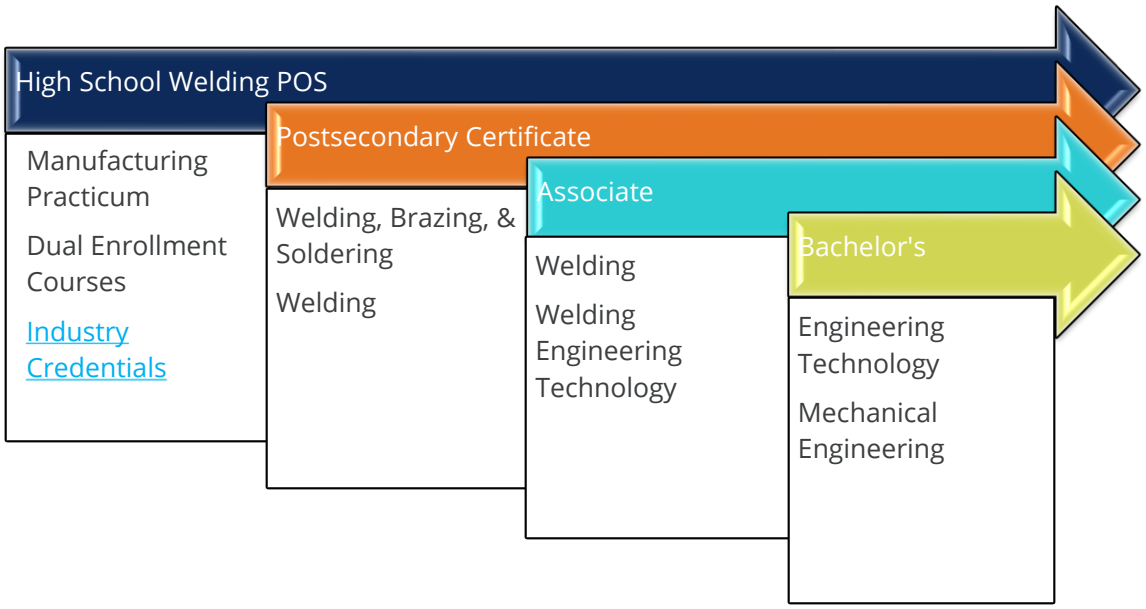
Welding Program: Level 2

Postsecondary Opportunities

The Welding pathway offers opportunities to funnel students into careers at a variety of education levels. Industry credentials earned in high school and work experience through practicum courses can lead to employment immediately after high school. There are early postsecondary opportunities at the high school level that lead to certificate programs at the state's network of Tennessee Colleges for Advanced Technology (TCATs). As shown in the table below, the wage level increase with a certificate from a TCAT is significant. Private and community colleges in Tennessee offer a variety of associate-level degrees that continue to increase wage-earning potential. Moore Tech and Pellissippi State offer associate-level degrees for this program. Advanced training at the bachelor's level opens even more doors for students for better prospects in higher-wage engineering and production management occupations. Middle Tennessee State University (MTSU), East Tennessee State, and the University of Tennessee at Knoxville offer bachelor's degrees for this program.

Figure 3 illustrates which opportunities are available for a student graduating from a Tennessee Welding program in high school. The figure outlines some of the related postsecondary certificates and degrees, career opportunities, and salaries available to students in the pathway. Students may acquire hours transferable to a postsecondary institution for the completion of certificates and degrees.

Figure 3. Outlines the related career opportunities and training necessary for each program of study. Students may acquire hours transferable to a postsecondary institution for the completion of a degree.



Additional opportunities are offered at multiple postsecondary institutions as indicated in the Tennessee Department of Labor and Workforce Dashboard.

High School Diploma	Certificate	Associate	Bachelor's
• Entry Level Welders **($35,810)**	• Welding, Soldering, and Brazing Machine Setters and Operators **($44, 920)**	• Welding Supervisors **($61,702)**	• Manufacturing Engineers **($84,663)**
• Production Workers **($30,550)**	• Welders,Cutters, Solderers, and Brazers **($47,540)**	• First-Line Supervisors of Production and Operating Workers **($63,510)**	• Industrial Production Managers **($97,920)**

Current Secondary Landscape

Over the past three years, the number of schools offering Welding has increased from 100 to 113. In 2022-23, 12,941 students were enrolled in Welding courses which was a significant increase from previous years. This program may not be appropriate for schools that do not have the supporting labor market data. The figures below show the open enrollment analysis for the 2020-21 through the 2022-23 school year and the course enrollment in the Welding program.

Figure 1. Open Enrollment Analysis

School Year	Schools Offering Welding
2020-21	100
2021-22	104
2022-23	113

Figure 5. Student Enrollment by Course

School Year	Principles of Manufacturing	Welding I	Welding II	Manufacturing Practicum	Dual Enrollment Courses
2020-21	4,498	1,899	1,056	193	2,128
2021-22	5,104	2,286	1,045	241	2,999
2022-23	5,377	2,027	917	316	4,304

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Bureau of Labor Statistics, U.S. Department of Labor, O*NET Online, Occupation Specific Information, from https://www.onetonline.org/link/summary/47-2031.00

Career One Stop, U.S. Department of Labor, Fastest-Growing Careers, from https://www.careeronestop.org/Toolkit/Careers/fastest-growing-careers.aspx

Jobs4Tn.gov, The *Demand for STEM Occupations in Tennessee,* from https://www.tn.gov/jobs4tn

Jobs4TN. Occupation Profile. Tennessee Department of Labor and Workforce Development. https://jobs4tnwfs.tn.gov/vosnet/Default.aspxTennessee Department of Labor & Workforce Development, JOBS4TN.GOV, Tennessee's In Demand Occupations to 2026, from https://www.tn.gov/content/dam/tn/workforce/documents/jobs-and-education/InDemandOccupationsto2026.pdf

Tennessee Higher Education Commission. Improving the Pipeline for Tennessee's Workforce: Academic Supply for Occupational Demand Report 2024. https://www.tn.gov/thec/research/supply-and-demand.html

Recommendations

The following includes recommendations for course standards changes to be presented to the State Board of Education (SBE) for consideration in August 2024.

Program of Study	Course	Recommendations
• Industrial Maintenance Technology • Machining Technology • Mechatronics • Welding	Principles of Manufacturing	• Add a standard to highlight the importance of utilizing the engineering design process while working with a team to complete a project. • Add a standard to highlight the importance and integration of CTSOs in the classroom. • Add a standard to emphasize the growing need for data analysis in all career areas. • Add a standard to point out the prominence of Artificial Intelligence.
Industrial Maintenance Technology	Introduction to Industrial Maintenance	Add a standard to focus on data analysis in Industrial Maintenance Technology.
Machining Technology	Principles of Machining I	Add a standard to focus on data analysis in Machining Technology.
Mechatronics	Digital Electronics	Add a standard to focus on data analysis in Mechatronics.
Welding	Welding I	Add a standard to focus on data analysis in Welding.

2025-26 Proposed Programs and Courses

Industrial Maintenance Technology

2025-26 Program of Study	Year 1	Year 2	Year 3	Year 4
Industrial Maintenance Technology	Principles of Manufacturing (C13H05)	Introduction to Industrial Maintenance (C13H28)	Advanced Industrial Maintenance (C13H29) -or- **Dual Enrollment** Industrial Maintenance Technology I (C13H30) -or- **Dual Enrollment** Industrial Maintenance Technology II (C13H31)	Manufacturing Practicum (C13H08) -or- **Dual Enrollment** Industrial Maintenance Technology III (C13H32) -or- **Dual Enrollment** Industrial Maintenance Technology IV (C13H33) -or- **Dual Enrollment** Industrial Maintenance Technology V (C13H50) -or- **Dual Enrollment** Industrial Maintenance Technology VI (C13H51) -or- **Dual Enrollment** Industrial Maintenance Technology VII (C13H52) -or- **Dual Enrollment** Industrial Maintenance Technology VIII (C13H53) -or- **Dual Enrollment** Industrial

				Maintenance Technology IX (C13H54) -or- **Dual Enrollment** Industrial Maintenance Technology X (C13H55) -or- **WBL** Industrial Maintenance Technology Career Practicum (C13H40)

Machining Technology

2025-26 Program of Study	Year 1	Year 2	Year 3	Year 4
Machining Technology	Principles of Manufacturing (C13H05)	Principles of Machining I (C13H09)	Principles of Machining II (C13H06) -or- **Dual Enrollment** Machining Technology I (C13H01) -or- **Dual Enrollment** Machining Technology II (C13H20)	Manufacturing Practicum (C13H08) -or- **Dual Enrollment** Machining Technology III (C13H34) -or- **Dual Enrollment** Machining Technology IV (C13H35) -or- **Dual Enrollment** Machining Technology V (C13H56) -or- **Dual Enrollment** Machining Technology VI (C13H57) -or- **Dual Enrollment** Machining

				Technology VII (C13H58) -or- **Dual Enrollment** Machining Technology VIII (C13H59) -or- **Dual Enrollment** Machining Technology IX (C13H60) -or- **Dual Enrollment** Machining Technology X (C13H61) -or- **WBL** Machining Technology Career Practicum (C13H41)

Mechatronics

2025-26 Program of Study	Year 1	Year 2	Year 3	Year 4
Mechatronics	Principles of Manufacturing (C13H05)	Digital Electronics (C13H07)	Mechatronics I (C13H16) -or- Robotics & Automated Systems (C13H15) -or- **Dual Enrollment** Mechatronics I (C13H04) -or- **Dual Enrollment** Mechatronics II (C13H21)	Mechatronics II (C13H17) -or- Manufacturing Practicum (C13H08) -or- **Dual Enrollment** Mechatronics III (C13H36) -or- **Dual Enrollment** Mechatronics IV (C13H37) -or- **Dual Enrollment** Mechatronics V (C13H62) -or-

				Dual Enrollment Mechatronics VI (C13H63) -or- **Dual Enrollment** Mechatronics VII (C13H64) -or- **Dual Enrollment** Mechatronics VIII (C13H65) -or- **Dual Enrollment** Mechatronics IX (C13H66) -or- **Dual Enrollment** Mechatronics X (C13H67) -or- **WBL** Mechatronics Career Practicum (C13H42)

Welding

2025-26 Program of Study	Year 1	Year 2	Year 3	Year 4
Welding	Principles of Manufacturing (C13H05)	Welding I (13H12)	Welding II (C13H10) -or- **Dual Enrollment** Welding I (C13H03) -or- **Dual Enrollment** Welding II (C13H18)	Manufacturing Practicum (C13H08) -or- **Dual Enrollment** Welding III (C13H38) -or- **Dual Enrollment** Welding IV (C13H39) -or- **Dual Enrollment** Welding V (C13H44) -or- **Dual Enrollment** Welding VI (C13H45)

				-or- **Dual Enrollment** Welding VII (C13H46) -or- **Dual Enrollment** Welding VIII (C13H47) -or- **Dual Enrollment** Welding IX (C13H48) -or- **Dual Enrollment** Welding X (C13H49) -or- **WBL** Welding Career Practicum (C13H43)

In 2025-26, students will have the option to add courses from the Business, Marketing, and Digital Technology programs to supplement their learning.