EXPANDING INDUSTRIALIZED OFFSITE CONSTRUCTION (IOC) IN CENTRAL APPALACHIA

February 2025

IOC IMPLEMENTATION PLAN

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Executive Summary

DEFINITION

Industrialized Offsite Construction (IOC) *connects onsite, human-based processes with offsite manufacturing of prefabricated building components by integrating industrial principles like mechanization, standardization, automation, digital technologies, and data driven processes. This approach substitutes labor-intensive processes, enhances safety, increases productivity, accelerates project timelines, and improves quality, sustainability, and adaptability to changing demands. Variants of IOC include modular construction, panelized construction, and kit-of-parts construction.*

Over the next decade, the U.S. construction industry will undergo a significant transformation fueled by changing technology, an evolving workforce, and changing market demand. Much of this transformation will likely take the form of "industrialized Offsite Construction" (IOC). This method promises to revolutionize the industry by reducing costs, minimizing timelines, improving quality control, and increasing sustainability of the built environment. Central Appalachia, spreading from western Pennsylvania south to Eastern Tennessee and Western North Carolina, is uniquely positioned to address this industry's needs. Growing an IOC cluster in Central Appalachia leverages the region's blue collar workforce and industrial infrastructure, historically used in the coal and manufacturing industries. Central Appalachian IOC companies will be able to conveniently ship their products to major markets all over the east coast and midwest, serving as a new economic engine for the region.

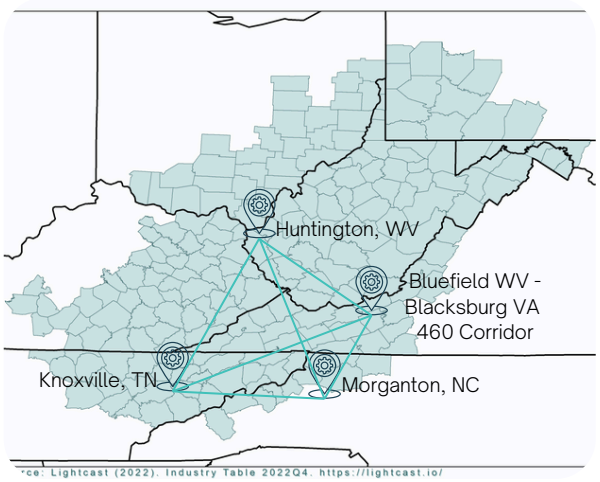
In 2024, a team of industry, education, and economic development professionals examined the potential for growing the IOC industry in Central Appalachia.

The project team conducted:

1. A market analysis using existing industry data and two industry surveys representing the viewpoints of over 70 construction and IOC companies.

2. An occupation and skillshed analysis to understand existing and future workforce needs.

3. Seven three-hour workshops representing over 80 IOC stakeholders from the construction and IOC industry, workforce development and education organizations, financial and regulatory agencies, economic and community development groups, and local and state government.



Central Appalachian Region and Possible Implementation "Living Labs" or Hubs

Key Trends

The broad construction and IOC cluster comprises a range of related industries, including traditional construction, manufacturers of prefabricated homes and products (e.g. modular, panelized, and tiny homes), and professional, scientific, and technical services. Each group contributes unique expertise, workforce demands, and skills critical to an IOC cluster. This broad cluster has started to adopt IOC technology and processes as a solution to address the challenges it faces, such as a shortage of skilled labor, rising costs, quality concerns, safety issues, and slow construction timelines.

The national IOC industry growth rate (2.5%) is expected to be greater than the construction industry growth rate (2.1%) through 2029 [3]. Nevertheless, the global IOC growth rate is expected to continue to outshine U.S. growth. The modular construction market alone is projected to experience a growth rate of 7.8% [4]. With global IOC markets growing significantly faster than national markets, interventions to boost the IOC industry nationally are sorely needed.

Cluster employment in the region was at 336,250 jobs in 2024. The five key manufacturing industries that comprise manufacturers of modular homes, tiny homes, panelized homes, and similar products employed over 7,700 workers in 2024. Five-year job growth projections show a need for over 6,725 new cluster workers, not including the one quarter of existing workers who him retire in the coming decade or two. This demand for a trained, experienced workforce that can adapt to technological changes quickly presents a significant challenge for the cluster's sustained growth nationally and in Central Appalachia.

→ **State of Industry**	**70% of IOC businesses are growing**
→ **Technology**	**Need for automation and skilled labor**
→ **Environment**	**Regulatory constraints and public stigma**
→ **Workforce**	**Aging and high turnover**

Goals & Strategies

GOALS	IMPLEMENTATION STRATEGIES
Address popular stigma against the construction and manufacturing industries	The greatest need highlighted by industry interviews and surveys, the seven regional workshops, and a final one-day, reflective workshop was the need for better outreach and marketing that informs the public and key stakeholders about the changing trends in construction and the needs and benefits that IOC companies and products could provide communities. As such, this initiative would design and conduct a public marketing campaign, using social media and traditional media (e.g. radio) to; pursue targeted outreach to financial institutions; and develop and promote state and local policy & regulatory recommendations (p. 20-21)
Provide accessible technical and business assistance so that individual IOC companies can grow and thrive in Central Appalachia	To grow this cluster, companies that do IOC work or wish to adopt IOC methods need support at the individual level, specifically support with capital access, best practice learning, technology adoption, one-on-one services, and access to qualified workers. This initiative will create a financial network for IOC businesses; convene a regional IOC industry and advocacy group to support mutual growth; provide technology adoption and business services through a concierge program; and get IOC companies involved in schools and workforce development programs (p. 22-23)
Create a robust IOC workforce pipeline	In order to sustain and encourage an adaptive construction and IOC cluster in Central Appalachia, a robust pipeline of skilled, creative, and motivated workers is necessary. To that end, youth must be informed about the cluster and its opportunities, dissuading popular stereotypes and shedding light on the changing nature of the cluster. The development of a module-based curriculum is also necessary; curriculum beginning as early as 4th grade and continuing through adulthood, with multiple points of entry and exit, and offering a dynamic and flexible learning experience that is both comprehensive and adaptive to the evolving needs of learners and the industry. (p. 24-28)
Develop regional "living labs" that focus and integrate technology development, experiential learning, and business development resources	"Living labs" are spaces involving real-world environments and/or challenges where multiple stakeholders can collaborate and collectively solve real-world problems. These hubs would coalesce different industry, workforce, and technological services (described above) while networking and creating access to other hubs' services across Central Appalachia. Based on the working partnerships to-date, four possible hubs have emerged. (p. 29-30)
Foster an adaptive and proactive environment for IOC in Central Appalachia	The construction industry is changing, and IOC will continue to evolve and adapt to evolving market and global environments. As such, Central Appalachia must foster an environment of reflection, continuous learning, and evaluation. IOC programs and living labs should periodically set standards and metrics of success, both individually and collectively within the larger Appalachian IOC ecosystem. This initiative would set regular deadlines and meetings for reflecting on success metrics and outcomes of activities, programs, and strategies, culminating in a final evaluation of the pilot initiative and future steps. (p. 31)

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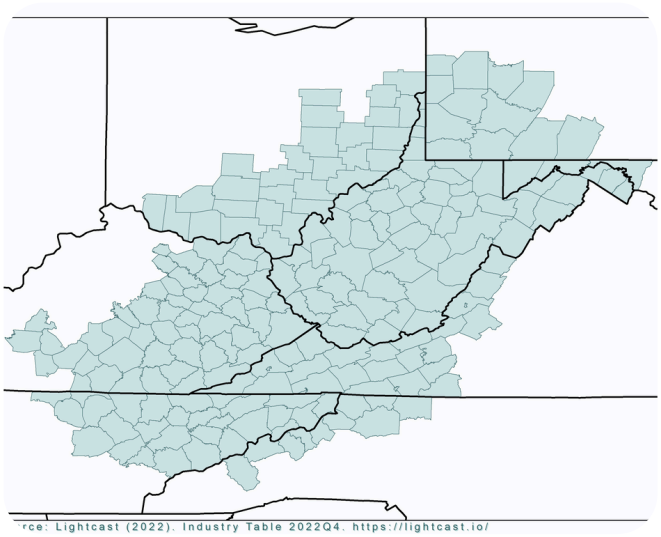
Introduction



Over the next decade, the U.S. construction industry will undergo a significant transformation fueled by changing technology, an evolving workforce, and changing market demand. Much of this transformation will likely take the form of “industrialized Offsite Construction” (IOC). This method promises to revolutionize the industry by reducing costs, minimizing timelines, improving quality control, and increasing sustainability of the built environment. By 2030, the combined U.S. and European IOC market is projected to grow to $130 billion, and if properly leveraged, it could yield $22 billion in annual savings for the construction industry [1]. With local investment to support this transformation, U.S. communities could capture billions of dollars in market share.

Central Appalachia, spreading from western Pennsylvania south to Eastern Tennessee and Western North Carolina, is uniquely positioned to address this industry’s needs. Historically a center of U.S. manufacturing, the region is now undergoing a resurgence in industry job growth, coupled with an entrepreneurial spirit and an established network of educational institutions. These factors make it an ideal location for fostering a state-of-the-art IOC industry cluster that can support national demand and set new standards for construction efficiency and innovation. With appropriate resources and strategies, Central Appalachia could emerge as a strong hub and economic driver of industrialized offsite construction in the United States.

DEFINITION

Industrialized Offsite Construction (IOC) *connects onsite, human-based processes with offsite manufacturing of prefabricated building components by integrating industrial principles like mechanization, standardization, automation, digital technologies, and data driven processes. This approach substitutes labor-intensive processes, enhances safety, increases productivity, accelerates project timelines, and improves quality, sustainability, and adaptability to changing demands. Variants of IOC include modular construction, panelized construction, and kit-of-parts construction.*

In 2024, a team of industry, education, and economic development professionals examined the potential for growing the IOC industry in Central Appalachia. Over the course of a year, the team conducted:

1. A market analysis using existing industry data and two industry surveys representing the viewpoints of over 70 construction and IOC companies.

2. An occupation and skillshed analysis using existing data from the Bureau of Labor Statistics and Lightcast, a proprietary economic and workforce data tool. This analysis assisted in understanding existing and future workforce needs.

3. Seven three-hour workshops representing over 80 IOC stakeholders from the construction and IOC industry, workforce development and education organizations, financial and regulatory agencies, economic and community development groups, and local and state government.

The full descriptions and outcomes of those pursuits are documented in previous reports. This document summarizes those reports and proposes goals and strategies for fostering an industrialized offsite construction cluster in Central Appalachia.

Industry Trends

The U.S. construction industry has started to adopt IOC as a solution to address the challenges it faces, such as a shortage of skilled labor, rising costs, quality concerns, safety issues, and slow construction timelines [2].

This shift towards IOC, or prefabrication, is partially attributed to the construction industry's lack of innovation in improving the deeply ingrained and stick-built processes that dominate today's market. The absence of innovation, productivity growth and increasing materials costs slow construction and exacerbate the U.S. national housing crisis.

IOC can innovate the residential construction industry by addressing affordable housing, decarbonization, and workforce productivity challenges, based on the information provided by the National Renewable Energy Laboratory [2]. IOC techniques, such as off-site prefabrication and on-site construction automation and solutions are also contributing to reduced costs, faster delivery times, increased energy efficiency, and decarbonization. These technologies include mass timber panels, structural insulated panels (SIPs), pods and volumetric unites, 3D printing technologies, insulated concrete forms (ICFs), and Building Information Modeling (BIM). McKinsey & Company's 2019 report suggests that shifting "from projects to products" could significantly accelerate project timelines by 20-50%, potentially saving the construction sector $20 billion annually and reducing time by 50% through industrialized offsite construction [1].

Government initiatives such as the Home Construction Act, establishing energy efficiency standards, and the Prefabricated Housing and Zoning Enhancement Act of 2024 are facilitating easier manufacturing and purchasing of prefabricated homes in the U.S. Increasing demand for housing and better regulatory pathways to IOC are expected to fuel the growth of the national market. [3]

Key Trends

State of Industry	70% of IOC businesses are growing
Technology	Need for automation and skilled labor
Environment	Regulatory constraints and public stigma
Workforce	Aging and high turnover

About 70 construction and industrialized offsite construction companies responded to a state of the industry survey, and several more provided insights by participating in interviews and workshops.

IOC is growing

In 2024, the U.S. construction industry saw 0.6% revenue growth, while prefabricated home manufacturing experienced 3.9% growth [3]. A significant 70% of survey IOC respondents reported growth, with 30% growing rapidly and 40% steadily. This growth is primarily driven by high demand for housing, which was cited as a key factor by 25% of construction and IOC survey respondents. IOC respondents also cited as drivers: 1) new technology that is helping to cut costs by reducing labor needs, time, and material costs (15%) and 2) companies' work environments and opportunities that attract and retain workers (16%) [4].

The national IOC industry growth rate (2.5%) is expected to be greater than the construction industry growth rate (2.1%) through 2029 [3]. Nevertheless, the global IOC growth rate is expected to continue to outshine U.S. growth. The modular construction market alone is projected to experience a growth rate of 7.8% [4]. With global IOC markets growing significantly faster than national markets, interventions to boost the IOC industry are sorely needed.

Rapid IOC growth implies a substantial jump in production for the average IOC manufacturer. Currently, the average modular factory produces 17.5 modules per week, while the optimal throughput is 27 modules per week based on survey data from manufacturers. On average, factories wanted 58% greater output to reach optimal levels of production. [5] This indicates that factories have room to scale up their production capacity to meet rising demand.

IOC growth is reliant on new, automated technologies and skilled workers

Currently, labor in construction and IOC factories is heavily manual, with 94% of tasks performed manually and only 6% automated. However, IOC industry representative suggested that their optimal balance is a shift to 30% automation and 70% manual labor. Construction and IOC stakeholders highlighted prefabrication and industry-specific production software as the most valuable technologies. Robotics and cobots—human-assisting machines—are also critical in reducing labor demands and enhancing efficiency according to industry respondents. Off-site construction automation, such as prefabrication and modular construction in factory settings, is more common than on-site automation today. [5] However, the industry is on the cusp of a "revitalization of construction automation" driven by advancements in building information modeling (BIM), artificial intelligence (AI), robotics, and internet of things (IoT) technologies. Experts predict that in the coming years, autonomous vehicles and equipment will become commonplace on construction sites, just as autonomous cars will proliferate on roads. [6]

Critical Role of Technology and Innovation [9]		
Roles	Applications	Description
Efficiency and Productivity	Construction Technology	Advances in construction technology can accelerate the production process, reduce costs, and improve the quality of housing.
	Automation and Tools	Innovative tools and automation can enhance productivity, associated job skills, alleviate labor shortages and promote occupational safety.
Cost Reduction	Procurement	Increased throughput production can lead to greater purchasing power by housing producers, allowing savings to be passed on to consumers.
	Materials Science	Innovative materials can be more durable, better quality and can lower long-term maintenance.
	Project Management	Technology can streamline project management, reducing delays and cost overruns.
Sustainability	Operational Costs	Newer technologies can reduce operating costs for residents.
	Waste Reduction	Innovations can minimize waste and save costs in production practices.
Improved Quality of Life	Automation	Technology and home automation can enhance residents' comfort, safety, and reduce operating costs.
	Healthy Buildings	Technology can monitor and improve indoor air quality, lighting, and contribute to residents' health and well-being.
	Connectivity	Digital infrastructure is essential for modern living and working.
Workforce Training and Development	E-Learning Platforms	Technology enables flexible and accessible training programs, reaching more of the possible workforce.
	Virtual Reality (VR) Training	VR can provide immersive training experiences without the need for physical resources.
Economic Growth	Data Analytics	Advanced data analytics can provide informed decisions about housing, market trends, and resource allocation.
	Predictive Maintenance	Technology can enable predictive maintenance improving the quality and durability of buildings.

IOC faces regulatory, financial, and public opinion barriers to growth

IOC industry stakeholders agreed that regulatory constraints, financing difficulties, and low demand due to public stigma hinder industry growth. Current zoning laws, lending institutions, and those who oversee housing and other development tend to not demonstrate an understanding of current housing products, often prohibiting anything that could be perceived as “manufactured housing”.

Critical Role Role of Policy and Regulatory Frameworks [9]		
Roles	Applications	Description
Standards and Quality Control	Safety and Quality	Policies and regulations ensure that housing meets safety and quality standards, protecting residents from substandard living conditions.
	Building Code	Ensures structural integrity and quality standards as well. It can also HINDER the acceptance of innovation and technology, though.
Economic Stability	Income-based Housing Options	Policies can incentivize the development of housing across many levels of income need.
	Job Creation	Regulatory frameworks can support job creation in the construction and housing sectors, contributing to local economic growth.
	Community Engagement	Regulations can encourage public participation in housing and workforce development planning, ensuring that the needs and voices of the community are considered.
	Investment Attraction	Clear and reasonable regulations attract investment by reducing uncertainty and providing a predictable environment for developers and businesses.
Workforce Development	Training Programs	Policies can support education and training programs that prepare the local workforce for jobs in construction, maintenance, and housing-related industries.
	Smart Growth	Regulations can guide planning efforts to engage existing workforce and attract new workers to certain industries.

Critical Role of Financing and Funding [9]		
Roles	Applications	Description
Development and Construction	Affordable Housing Projects	Developing and constructing housing requires funding options, ensuring that individuals and families have access to housing options.
	Infrastructure Improvements	Financing enables roads, utilities, and public services, which support housing projects and overall community growth.
Economic Stability	Job Creation	Investment in housing projects creates jobs in construction, real estate, and related industries, contributing to local economic stability and growth.
	Business Attraction	Adequate housing options make the area more attractive to businesses which rely on a stable and housed workforce.
	Building Performance Initiatives	Financing can reinforce energy-efficient homes, reducing long-term housing costs.
Access to Homeownership	Mortgage Financing	Funding mechanisms such as affordable mortgage programs and down payment assistance help individuals and families achieve homeownership, which can lead to financial stability and wealth accumulation.
	Subsidies and Grants	Financial aid makes housing more accessible to more households, like down-payment assistance, and can prevent housing insecurity.
Community Development	Revitalization Projects	Financing is crucial for urban renewal and neighborhood revitalization projects that improve living conditions, increase property values, and enhance community pride.
	Public Amenities	Funding supports the development of parks, schools, and other public amenities that improve the quality of life and attract residents to the area.
Housing Market Resilience	Preventing Foreclosures	Financial assistance programs can help prevent foreclosures, thereby stabilizing the housing market and protecting property values.
	Rental Assistance	Funding for rental assistance programs ensures that renters can afford their homes, reducing the risk of eviction and homelessness.
Workforce Training and Development	Educational Programs	Funding can increase the likelihood of success for workforce training programs that prepare individuals for jobs in the housing market.
	Skill Development	Investment in training helps develop a skilled workforce that can meet the needs of the local economy.

Critical Role of Public Awareness and Marketing [9]		
Roles	Applications	Description
Attracting Interest in Industrialized Products and Talent	Visibility	Highlights job opportunities and the benefits of living in a particular area, attracts skilled workers and professionals to the region.
	Community Perception	Improves the perception of industrialized products as equally desirable.
Promoting Housing Opportunities	Informed Opportunities	Informs housing users (e.g., homeowners, renters, professionals) about available housing options, including affordable housing programs and attainable housing developments.
	Maximizing Utilization	Attracts others to the market and housing types not typically considered.
Economic Development	Business Attraction	Highlights strengths of the local workforce and housing market to attract businesses and investors.
	Supporting Local Industries	Promotes local industries locally and beyond, driving demand and supporting economic growth.
Access to Resources and Programs	Awareness of Services	Ensures locals are aware of available services, such as training programs, financial assistance, and community resources.
	Increased Participation	Promotes resources and opportunities that encourage participation and improve living and working conditions.
Community Engagement	Building Community	Awareness campaigns can foster a sense of community by keeping residents informed and engaged with local initiatives and events.
	Feedback and Improvement	Engaging with the community through marketing efforts can provide valuable feedback for improving housing and workforce options.
Policy Support	Advocacy and Awareness	Raises awareness for supportive policies and regulations, encouraging public support and advocacy.
	Transparency	Clear and transparent communication through marketing builds trust in local government and housing authorities.

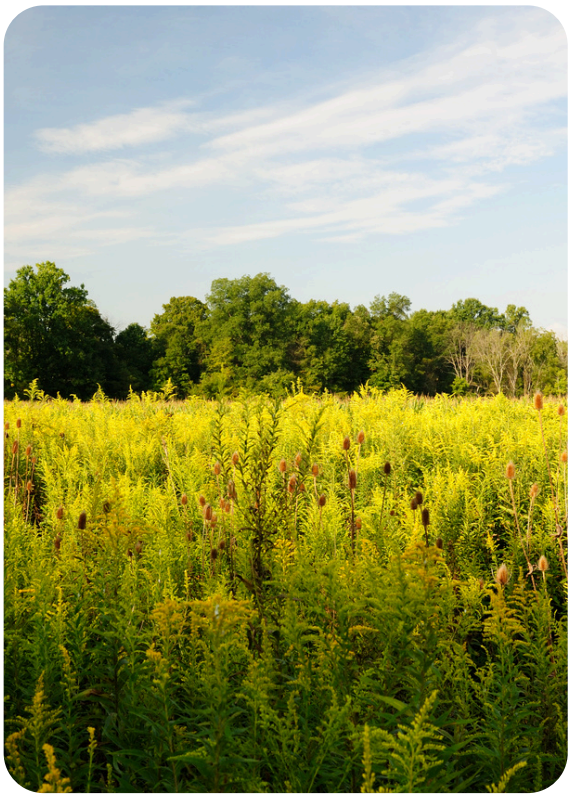
IOC growth necessitates a skilled workforce

Through surveys, interviews, and workshops, construction and IOC stakeholders highlighted:

- A **thin labor market** has made finding labor difficult in general. With a higher ratio of job openings to available workers, people are more able to choose the jobs they want. Whether it is due to better salary options, lack of interest in the kind of work, or societally ingrained prejudice against construction and manufacturing jobs, many workers do not choose construction or IOC.
- Existing **skilled tradespeople are retiring** and a pipeline of tradespeople—at all skill levels—is not present. Many tradespeople are still beginning their trade, and even they are not enough to fill demand.
- Companies have **difficulty implementing apprenticeships and work-based learning**, particularly for youth. While they see these programs as opportunities, barriers exist such as insurance and regulation challenges, limited workforce to support these kinds of programs, and lack of time and resources to set up and participate.
- Many employers have **workforce readiness concerns**, such as low attendance, poor work ethic, and lack of critical thinking skills. They largely blame these deficiencies on how younger workers were prepared for the workforce in schools and at home.
- **High turnover rates** exist, with factory operators reporting difficulty retaining workers long enough for them to realize the benefits of steady employment.
- Specific to workers transitioning from traditional construction to industrial offsite construction, industry representatives note the **culture clash between construction and manufacturing (IOC)**, where each industry has different schedules and work expectations.

Critical Role Role of Education and Training [9]		
Roles	Applications	Description
Skills Development	Employability	Provides the skills necessary to be competitive in the job market, including both hard skills (technical knowledge) and soft skills (communication, teamwork).
	Adaptability	Continuous training ensures that workers can adapt to new technologies and methodologies, making them more versatile and valuable to employers.
Economic Growth	Productivity	A well-trained workforce can lead to higher economic output and growth.
	Creative Thinking	Education encourages creative thinking and problem-solving, which can lead to new directions for business and industry.
Wages and Income	Higher Wages	Education and training can lead to higher-paying jobs.
	Career Advancement	It provides opportunities for career advancement, which can lead to increased job satisfaction and financial stability.
Attainable Housing	Economic Stability	Higher-paying jobs can support better housing options.
	Investment in Housing	Higher income levels can lead to increased investment in housing, both from individuals and from developers looking to capitalize on a more prosperous community.

Trends in Central Appalachia



Central Appalachian construction and IOC trends are similar to national trends. The broad construction and IOC cluster comprises a range of related industries, including manufacturing, construction, and professional, scientific, and technical services. Each group contributes unique expertise, workforce demands, and skills critical to an IOC cluster. Cluster employment in the region was at 336,250 jobs in 2024. The five key manufacturing industries that comprise manufacturers of modular homes, tiny homes, panelized homes, and similar products employed over 7,700 workers in 2024. **Five-year job growth projections show a need for over 6,725 new cluster workers, more than 650 working in the narrower IOC manufacturing cluster.** This number does not include existing positions that will need to be filled after workers retire. About a quarter of the current workforce is 45 years and older, presenting a significant challenge for the cluster's sustained growth. [7]

The table on the next page shows top in-demand occupations for construction and IOC in Central Appalachia. Occupations highlighted in green indicate additional future demand in light of new IOC technology. Notably, while occupations *not* highlighted are more concentrated in the region compared to the nation, the highlighted occupations representing significant future industry demand have lower concentrations compared to the nation. This gap trend is expected to increase over the next five years with higher occupation growth rates nationally (9%) compared to the Central Appalachian region (6%) [7]. To improve these trends, **Central Appalachia would need more than 50,000 additional jobs within the highlighted occupations on the next table. This growth also would entail significant technological advancement among all industries in the region to accommodate for this new skilled talent.**

Top In-Demand IOC Occupations PLUS Industry Expressed Future Demand (18 occupations highlighted in blue are those targeted for future IOC industry growth)		
Occ. Type	SOC Code	Description
Managerial	11-3051	Industrial Production Managers
	11-9021	Construction Managers
	47-1011	First-Line Supervisors of Trades and Extraction Workers
	49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers
Design and Operations	13-1051	Cost Estimators
	13-1082	Project Management Specialists
	15-1200	Computer Occupations
	17-2051	Civil Engineers
	17-2112	Industrial Engineers
	17-3013	Mechanical Drafters
	17-3027	Mechanical Engineering Technologists and Technicians
	27-1021	Commercial and Industrial Designers
Construction	47-2031	Carpenters
	47-2073	Operating Engineers and Other Equipment Operators
	47-2111	Electricians
	47-2141	Painters, Construction and Maintenance
	47-2152	Plumbers, Pipefitters, and Steamfitters
	47-4011	Construction and Building Inspectors
	53-7021	Crane and Tower Operators
Mechanics	49-3042	Mobile Heavy Equipment Mechanics, Except Engines
	49-9021	Heating, Air Conditioning, Mechanics and Installers
	49-9041	Industrial Machinery Mechanics
	49-9071	Maintenance and Repair Workers, General
Manufacturing	51-2028	Electrical, Electronic, and Electromechanical Assemblers
	51-4041	Machinists
	51-4121	Welders, Cutters, Solderers, and Brazers
	51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers
	51-9161	Computer Numerically Controlled Tool Operators
	53-7051	Industrial Truck and Tractor Operators

Key Opportunities

→ Skilled Labor	Tradition of skilled trades and strong pipeline
→ Existing Manufacturing	Industry strengths in wood, furniture, and machinery
→ Cost Advantages	Low cost of labor and real estate
→ Proximity to Markets	Major transportation routes to East Coast and Midwest

Skilled Labor

Despite an aging workforce, the region has a deep tradition of skilled trades, particularly in sectors like building equipment contracting (NAICS 2382) and building finishing contractors (NAICS 2383). These industries have skills that can be transferred to industrialized offsite construction. The region's tradespeople are well-suited for roles in modular construction, which requires precision and specialization, as systems are installed in a controlled factory setting before being transported to job sites.

Long-term industry demand for talent in IOC will require a strong education pipeline from 4th and 5th grades through higher education institutions and professional development groups. Based on industry feedback, these programs will have to engage youth's interest early and counter much of the cultural stigma that has dissuaded people from construction and manufacturing in the past. These programs will not only need to teach technical skillsets but also emphasize how these skills are applied and work together through hands-on, industry-engaged, problem-solving project work. Already, Central Appalachia has more than 1,890 education and workforce development programs through high schools, community colleges, and 4-year institutions. These programs consist of general construction and carpentry; HVAC, plumbing, and electrical; machining, welding, heavy equipment operation, and industrial trades; manufacturing, mechatronics, and robotics; CADD, technical drawing, 3D modeling; and engineering, STEM, and mechanical engineering curriculum. [8]

Existing Manufacturing Base

The manufacturing sectors in Central Appalachia, particularly in wood products, furniture manufacturing, and machinery, provide a strong foundation for the industrialized offsite construction supply chain. Sectors like household and institutional furniture manufacturing (NAICS 3371), which grew by 11% between 2018 and 2023, show that the region has the capacity to produce prefabricated interior components for modular housing and commercial buildings [7]. By integrating these manufacturing capabilities with construction, Central Appalachia can create a regional supply chain for industrialized offsite construction.

Immediate worker needs may be addressed by drawing from:

- **Existing manufacturing and construction workers** who can be upskilled and earn higher wages such as operators, tenders, and settlers; mechanical technicians; power plant technicians and operators; construction workers; and installers, operators, and extractive workers.
- **Declining jobs from services workers** who may need significant training (clerks, tellers, cashiers, bill and account collectors, payroll clerks, telemarketers, and postal service workers) to blue collar workers who would need minimal retraining (prepress technicians, helpers, production workers, brick mason, agriculture managers, and assemblers). All of these transitions pose higher wage opportunities.
- Entry level jobs in service, farming, and construction

Cost Advantages

The cost of labor and real estate in Central Appalachia is generally lower than in other areas of the U.S. This provides a cost advantage for industrialized offsite construction operations that need significant space for factories and fabrication plants. Nationally, regions with lower operational costs are becoming more attractive for offsite construction firms looking to scale their operations. Central Appalachia, with its affordable land and competitive labor costs, could become a hub for these firms.

Proximity to Key Markets

Central Appalachia's location, with access to the Eastern U.S. via major transportation routes, positions it well to serve as a production center for industrialized offsite construction components. The region's proximity to growing metropolitan areas, such as those in the Southeast and Mid-Atlantic, allows it to supply prefabricated building materials to regions where housing shortages and commercial construction needs are high.

Vision and Mission

We wish to make Central Appalachia an innovation hub and driver of industrialized offsite construction, where:

- Companies manufacture sustainable, affordable, and quality housing at scale and install these homes regionally, nationally, and internationally;
- Manufacturers have adopted semi-automated technology to minimize production time and housing costs to consumers while employing highly skilled, high-wage workers;
- The IOC industry offers and is perceived to offer a dynamic workplace in which individuals can actively engage, learn, progress and be satisfied with their work;
- The region offers a strong, robust pipeline of enthusiastic, skilled workers from all walks of life through innovative and connected education and workforce programming starting in elementary school and progressing through high school, community colleges, nonprofit groups, 4-year institutions and even professional and industry development groups;
- The region embraces new technologies and sustainable approaches to building infrastructure for homes and municipalities, ensuring the longevity of the region's culture and environment while adapting to changing conditions.

To achieve this vision, the project team proposes to establish 3-5 hubs across Central Appalachia, where partners will pilot, evaluate, and refine different kinds of programming to grow a regional IOC industry. Programming will support the advancement of five goals, identified as essential to the growth of a diverse and sustainable IOC economy.

5 Goals

Address popular stigma against the construction and manufacturing industries

The greatest need highlighted by industry interviews and surveys, the seven regional workshops, and a final one-day, reflective workshop was the need for better outreach and marketing that informs the public and key stakeholders about the changing trends in construction and the needs and benefits that IOC companies and products could provide communities. This work involves different groups of stakeholders including financial institutions, local government, the education system, and the broader public.

Provide accessible technical and business assistance so that individual IOC companies can grow and thrive in Central Appalachia

In addition to creating an environment that is accepting of the IOC industry and its products, companies that do IOC work or wish to adopt IOC methods need support at the individual level. To encourage the growth of this cluster specifically in Central Appalachia, regional stakeholders must develop and highlight the specific assets supporting the growth of these companies.

Create a robust IOC workforce pipeline

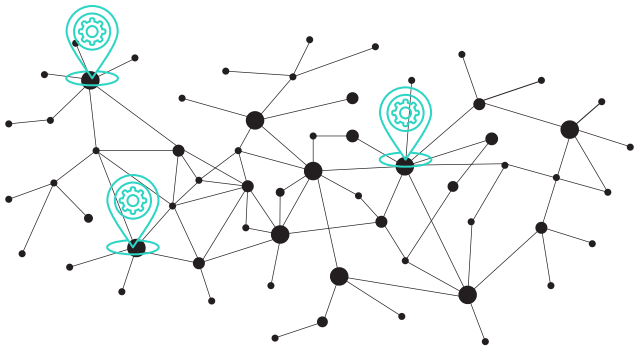
In order to sustain and encourage an adaptive construction and IOC cluster in Central Appalachia, a robust pipeline of skilled, creative, and motivated workers is necessary. To that end, youth must be informed about the cluster and its opportunities, dissuading popular stereotypes and shedding light on the changing nature of the cluster. The development of a module-based curriculum is also necessary; curriculum beginning as early as 4th grade and continuing through adulthood, with multiple points of entry and exit, and offering a dynamic and flexible learning experience that is both comprehensive and adaptive to the evolving needs of learners and the industry.

To achieve this vision, the project team proposes to establish 3-5 hubs across Central Appalachia, where partners will pilot, evaluate, and refine different kinds of programming to grow a regional IOC industry. Programming will support the advancement of five goals, identified as essential to the growth of a diverse and sustainable IOC economy.

5 Goals (continued)

Develop regional "living labs" that focus and integrate technology development, experiential learning, and business development resources

The development of regional hubs across Central Appalachia coalesces different regional services into living labs of industry, workforce, and technological engagement while networking and creating access to other hubs' services across regions. "Living labs" are spaces involving real-world environments and/or challenges where multiple stakeholders can collaborate and collectively solve problems. In the traditional technology-based economic development or innovation ecosystem practice, these hubs would address industry problems through technology development, workforce development (particularly experiential learning opportunities), and other technical assistance for businesses.



Foster an adaptive and proactive environment for IOC in Central Appalachia

The construction industry is changing, and IOC will continue to evolve and adapt to evolving market and global environments. As such, Central Appalachia must foster an environment of reflection, continuous learning, and evaluation. IOC programs and living labs should periodically set standards and metrics of success, both individually and collectively within the larger Appalachian IOC ecosystem.

Goal 1

Address popular stigma against the construction and manufacturing industries

Strategy 1.1: Conduct a public marketing campaign to promote the next generation of construction, highlighting a brighter future of sustainable and affordable housing and infrastructure and the industry and workforce that will make that future vision a reality.

This campaign will have to use a mix of digital and traditional media channels and incorporate larger regional and national communication combined with more local, grassroots efforts, particularly where the industry is more robust (E.g. Southwest Pennsylvania, Eastern Tennessee, the region surrounding Charleston WV, and the New River Mount Rogers region of Virginia). Because Central Appalachia has such a rich and proud history, marketing will have to embrace that traditional culture and aesthetic as it highlights opportunities for growth and change in the future. Examining famous and successful campaigns from the agriculture industry, such as dairy and corn, may inspire specific implementation steps.

Strategy 1.2: Pursue targeted outreach to financial institutions and real estate developers to broaden their understanding and influence their willingness to invest in industrialized offsite construction projects.

CONSTRUCTION FINANCIAL MANAGEMENT ASSOCIATION (CFMA)

American Bankers Association

THE NATIONAL PRIVATE LENDERS CONFERENCE (NPLA)

Example financial industry associations and groups

The stigma against manufactured housing has resulted in greater hesitance among financial institutions to invest in industrialized construction housing—whether that be tiny houses, modular and panelized housing, and modern prefabricated homes. Creating and disseminating data-driven marketing and literature on the financial, economic, and community benefits of these housing products to financial institutions and real estate developers, who finance larger scale developments, may benefit their understanding. Topics to include:

- Case studies highlighting successful industrialized housing developments.
- ROI analyses to demonstrate long-term profitability and risk management
- Comparisons between IOC and stick-built methods such as cost savings, efficiency, and resilience
- Develop site visits and virtual tours of high-quality prefabricated housing projects

Working through larger national professional groups that host conferences and distribute best practice and top trends reports would be an optimal approach to dissemination broadly. Meanwhile, targeting more local, community-driven financial institutions in the region would support growth in Central Appalachia.

Goal 1

Address popular stigma against the construction and manufacturing industries

Strategy 1.3: Develop policy and regulatory recommendations accompanied by outreach and education to local and state regulatory agencies.

Government policies and regulations, particularly at the local level where zoning regulations are implemented, are often outdated and prohibit new types of construction. Historically, some communities have created regulations that effectively eliminate or prohibit any construction related to manufactured housing. Reasons behind these outdated regulations vary from poor quality manufactured housing in the mid-twentieth century to community members' desire to limit the development of mobile home parks. Approaches to and quality of manufacturing of homes and home-related products have changed substantively, however. Developing education material about the benefits of different types of industrialized construction housing for communities and recommended changes to zoning and regulation could facilitate better adoption of IOC products in Central Appalachia and nationally.

A similar effort is being made by drone manufacturing companies who wish to use drone technology for deliveries, first responses efforts, and infrastructure inspections (e.g. bridges). For the past decade or more, companies in collaboration with universities have worked with the Federal Aviation Administration to test these technologies, provide proof of viability for industries and communities, and develop recommended regulatory frameworks for the use of drones in US airspace. An important aspect of this effort is that companies have been very collaborative and proactive in illustrating community benefits and designing regulation recommendations with the input of communities.

Goal 2

Provide accessible technical and business assistance so that individual IOC companies can grow and thrive in Central Appalachia

Strategy 2.1: Create a network of financial institutions and real estate developers ready to support industrialized offsite construction businesses and projects.

Through outreach and marketing to financial institutions and real estate developers, we can identify those agencies who already support IOC or who are open to supporting IOC work. This identified network of financiers can then directly connect with IOC companies. This work can be done at local, regional, and national levels. To keep these stakeholders engaged and maintain an updated resource list for IOC companies, semi-regular outreach to financial institutions and real estate development should be provided through email updates, educational materials, and collaboration opportunities.

Strategy 2.2: Leverage existing business associations and IOC industry groups to bring together a region-specific IOC industry group that will inform and drive sector support services work in Appalachia.

Already entities have mobilized around industrialized offsite construction and are taking steps to grow IOC in the United States. These groups offer insights, best practices, and support to businesses in the construction and IOC fields. Those efforts must be leveraged to intentionally support growth in Central Appalachia. If not, the opportunities will go elsewhere. This effort entails identifying and working with national groups that already work in this realm, identifying those in these organizations who already operate in Central Appalachia, and connecting industry in Central Appalachia with these organizations.

This planning effort already engaged over two dozen industry partners both in and outside of Central Appalachia. The logos below illustrate those who have already offered vital insights and support in this process. Making sure there is ongoing connectivity between national and regional entities as well as Central Appalachian representation among national groups will help to place the region and its industry at the center of IOC growth efforts, ensuring a clear regional voice.

Examples of national groups supporting IOC

Goal 2

Provide accessible technical and business assistance so that individual IOC companies can grow and thrive in Central Appalachia

Strategy 2.3: Develop one or more networked concierge programs in the region that connect IOC and construction businesses to business and technical expertise

During this research, we identified several state-level manufacturing extension partners, industry-driven and community-driven nonprofits, university groups, community colleges, and other business assistance groups that offer general services and one-on-one services in the region. The challenge that businesses have found is navigating these services and knowing which services would meet their needs best.

To increase understanding and strengthen this network of service providers, regular regional events should be hosted to share knowledge of construction and manufacturing industry needs, programming, and services addressing those needs. Hiring and financially supporting embedded concierges who regularly connect with and navigate across different service providers on several geographic levels could help to support a greater Central Appalachian IOC effort while addressing the unique needs of specific construction and IOC businesses.

Specific to technological implementation, results from this study highlighted the following to prioritize with businesses: LEAN manufacturing and continuous process improvement methods, CADD and building information modeling, robotics and cobots for automation, advanced materials and other prefabrication methods.

Strategy 2.4: Get IOC companies involved in schools and workforce development programs.

So IOC companies have access to a pipeline of skilled talent, more connections with school programs and classrooms are needed.

- From 5th grade through middle school, IOC company employees can share their experience and knowledge of IOC to counter popular stigma about the industry and engage student interests in future careers
- At the high school and post-secondary institution levels, IOC companies should connect not only to identify future employees but also shape curriculum by offering hands-on examples and opportunities to apply classroom learning

Goal 3

Create a robust IOC workforce pipeline

Strategy 3.1: Engage youth interest in construction and industrialized construction

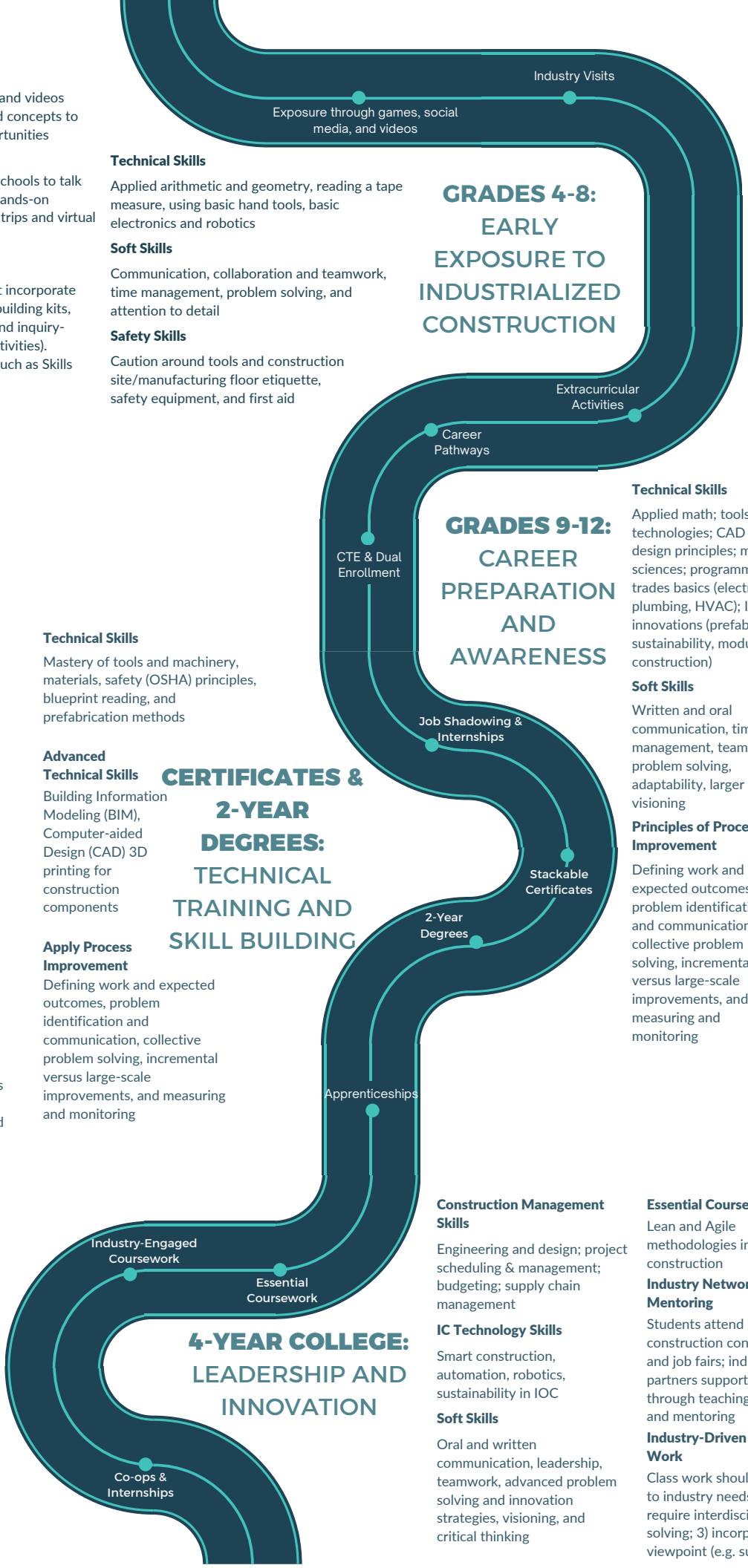
Elementary school curriculum should focus on fun and engaging content, introducing the industry through creative, fast-paced learning experiences that inspire curiosity and excitement about IOC. Through interactive modules, students will begin to explore the endless possibilities of IOC in a playful and accessible way. As students move to high school, curriculum should offer a career preparation pathway, helping them explore technical skills and potential career trajectories. This stage should emphasize engagement through hands-on learning and exploration of various career possibilities, including certificate programs, apprenticeships, and dual enrollment opportunities. High school students should gain insights into the value of pursuing a career in IOC, with clear benefits like job prospects and tangible skill development.

Strategy 3.2: Establish certificate and 2-year degrees aligned with industrialized offsite construction

Through these certificate and 2-year degree programs, learners should engage in a trade-specific education that bridges the gap between fieldwork and office or management roles. They should gain technical expertise in industrialized construction processes, focusing on both hands-on construction and project management skills. The curriculum should prepare students for job placement and career advancement in the IOC industry.

Strategy 3.3: Create construction and IOC-related career pipeline and other marketing material to communicate ongoing career opportunities in the industry cluster

To entice youth and prospective workers to pursue jobs in IOC, marketing material should highlight the career opportunities and clear paths towards achievement in the industry. Material should be widely distributed through workforce development organizations, schools, employers, and social media.



Social media and gaming

Develop social media games and videos centered on IOC projects and concepts to expose children to IOC opportunities

Industry Engagement

IOC and trade workers visit schools to talk with students and facilitate hands-on activities; students take field trips and virtual tours

Extracurriculars

Camps and competitions that incorporate IOC activities (e. g. modular building kits, virtual construction games, and inquiry-based and design-thinking activities). Leverage existing programs such as Skills USA and Career Quest

GRADES 4-8: EARLY EXPOSURE TO INDUSTRIALIZED CONSTRUCTION

Technical Skills

Applied arithmetic and geometry, reading a tape measure, using basic hand tools, basic electronics and robotics

Soft Skills

Communication, collaboration and teamwork, time management, problem solving, and attention to detail

Safety Skills

Caution around tools and construction site/manufacturing floor etiquette, safety equipment, and first aid

Career Pathways

Communicate career pathways and salary/job market data using websites, social media, and teachers

Continuing and Technical Education

Mechatronic-style course modules integrating construction and trades content with project-focused teamwork

Dual Enrollment

Asynchronous, online theory courses combined with hands-on, project-based teamwork and real-world problem-solving activities

Job Shadowing & Internships

One to two week opportunities aligned with course programming

More Industry Engagement

Class visits from industry workers through presentations, advising on coursework, mini-career fairs, and class tours of sites

GRADES 9-12: CAREER PREPARATION AND AWARENESS

Technical Skills

Applied math; tools and technologies; CAD basics; design principles; materials sciences; programming; trades basics (electrical, plumbing, HVAC); IOC innovations (prefabrication, sustainability, modular construction)

Soft Skills

Written and oral communication, time management, teamwork, problem solving, adaptability, larger visioning

Principles of Process Improvement

Defining work and expected outcomes, problem identification and communication, collective problem solving, incremental versus large-scale improvements, and measuring and monitoring

Career Pathways & Job Placement

Show career pathways, salary/job market data, & advancement opportunities; ensure job placement upon completion

Industry Certificates

Industry approved stackable credentialing and micro-certifications (e.g. industrial maintenance, electrical systems)

2-Year Degree Programs

Asynchronous, online theory courses combined with project-based teamwork and real-world problem-solving activities

Apprenticeships

Work with industry professionals to gain on-the-job experience and mentorship

Industry Engagement

Experienced industry workers should consider interacting with students at this level and transferring their skills through mentorships and teaching, industry class visits, and collaborations for part-time work opportunities (On-the-job training)

CERTIFICATES & 2-YEAR DEGREES: TECHNICAL TRAINING AND SKILL BUILDING

Technical Skills

Mastery of tools and machinery, materials, safety (OSHA) principles, blueprint reading, and prefabrication methods

Advanced Technical Skills

Building Information Modeling (BIM), Computer-aided Design (CAD) 3D printing for construction components

Apply Process Improvement

Defining work and expected outcomes, problem identification and communication, collective problem solving, incremental versus large-scale improvements, and measuring and monitoring

4-YEAR COLLEGE: LEADERSHIP AND INNOVATION

Construction Management Skills

Engineering and design; project scheduling & management; budgeting; supply chain management

IC Technology Skills

Smart construction, automation, robotics, sustainability in IOC

Soft Skills

Oral and written communication, leadership, teamwork, advanced problem solving and innovation strategies, visioning, and critical thinking

Essential Coursework

Lean and Agile methodologies in construction

Industry Networking and Mentoring

Students attend construction conferences and job fairs; industry partners support classwork through teaching, advising, and mentoring

Industry-Driven Project Work

Class work should: 1) directly link to industry needs/trends; 2) require interdisciplinary problem solving; 3) incorporate a societal viewpoint (e.g. sustainability)

Studio/Capstone Courses

Applied course that connects students with real-world client to address a design, process improvement, or community challenge

Co-ops and Internships

Semester-long on-site engagement with a company to gain hands-on real-world experience

INDUSTRY PROFESSIONALS: UPSKILLING AND CAREER EXPANSION

Online micro-credentials
Focused on specific areas such as prefabrication technology, sustainable construction practices, and safety management

Leadership and mentorship workshops
As teaching is one of the best means of learning, these workshops are meant to create opportunities for professionals to evolve into mentors and instructors

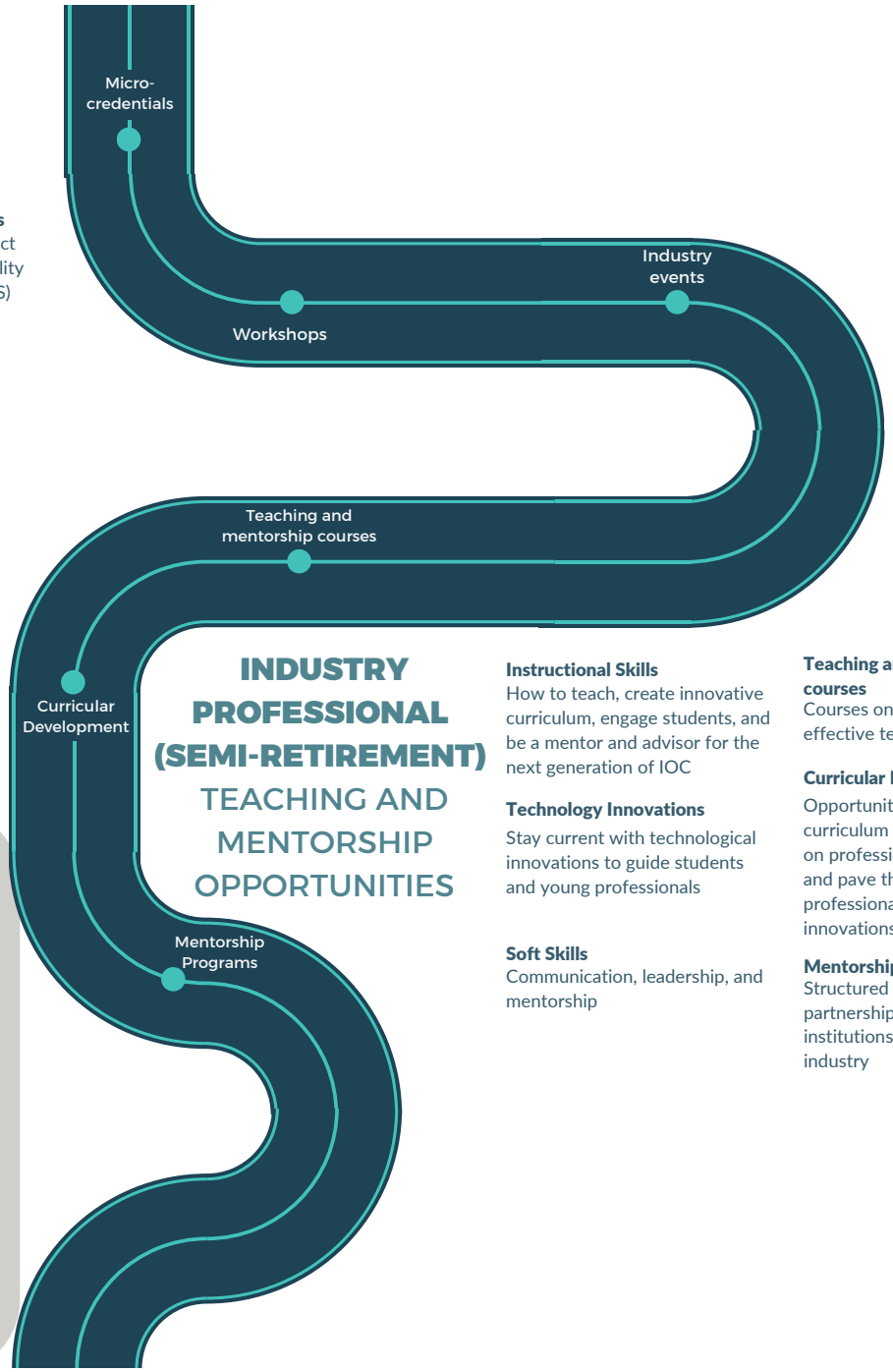
Industry Professional Groups
Industry specific conferences, webinars, and peer networking groups that support life-long learning and adapt to market changes

Advanced Certifications
Lean construction, project management, sustainability certifications (e.g. PHIUS)

Technology Upskilling
Automation, Building Information Modeling (BIM), prefabrication software, and smart technology integration

Soft Skills
Leadership, mentorship, conflict resolution, and strategic thinking

Process Improvement
Application of new technologies to improve efficiency in IOC



INDUSTRY PROFESSIONAL (SEMI-RETIREMENT) TEACHING AND MENTORSHIP OPPORTUNITIES

Instructional Skills
How to teach, create innovative curriculum, engage students, and be a mentor and advisor for the next generation of IOC

Technology Innovations
Stay current with technological innovations to guide students and young professionals

Soft Skills
Communication, leadership, and mentorship

Teaching and mentorship courses
Courses on how to be an effective teacher and mentor

Curricular Development
Opportunities to contribute to curriculum development based on professional experiences and pave the way for future professionals and industry innovations

Mentorship Programs
Structured mentoring through partnerships with educational institutions, nonprofits, and industry

KEY ELEMENTS

Critical Thinking & Problem Solving
Integrated at all levels through case studies and real-world scenarios

Cross-Disciplinary Learning
IC curriculum can integrate with fields like planning, architecture, finance, and public policy

Adaptability & Continuous Improvement
Curriculum continuously updated based on student feedback, industry needs, and technological advances

Partnerships with Industry
Mentorships and on-the-job training are key, with industry input driving the majority of content to ensure market relevance

Micro-Credentialing
Validating skills at each stage of the curriculum, allowing for career flexibility and clear re-entry points at different life stages

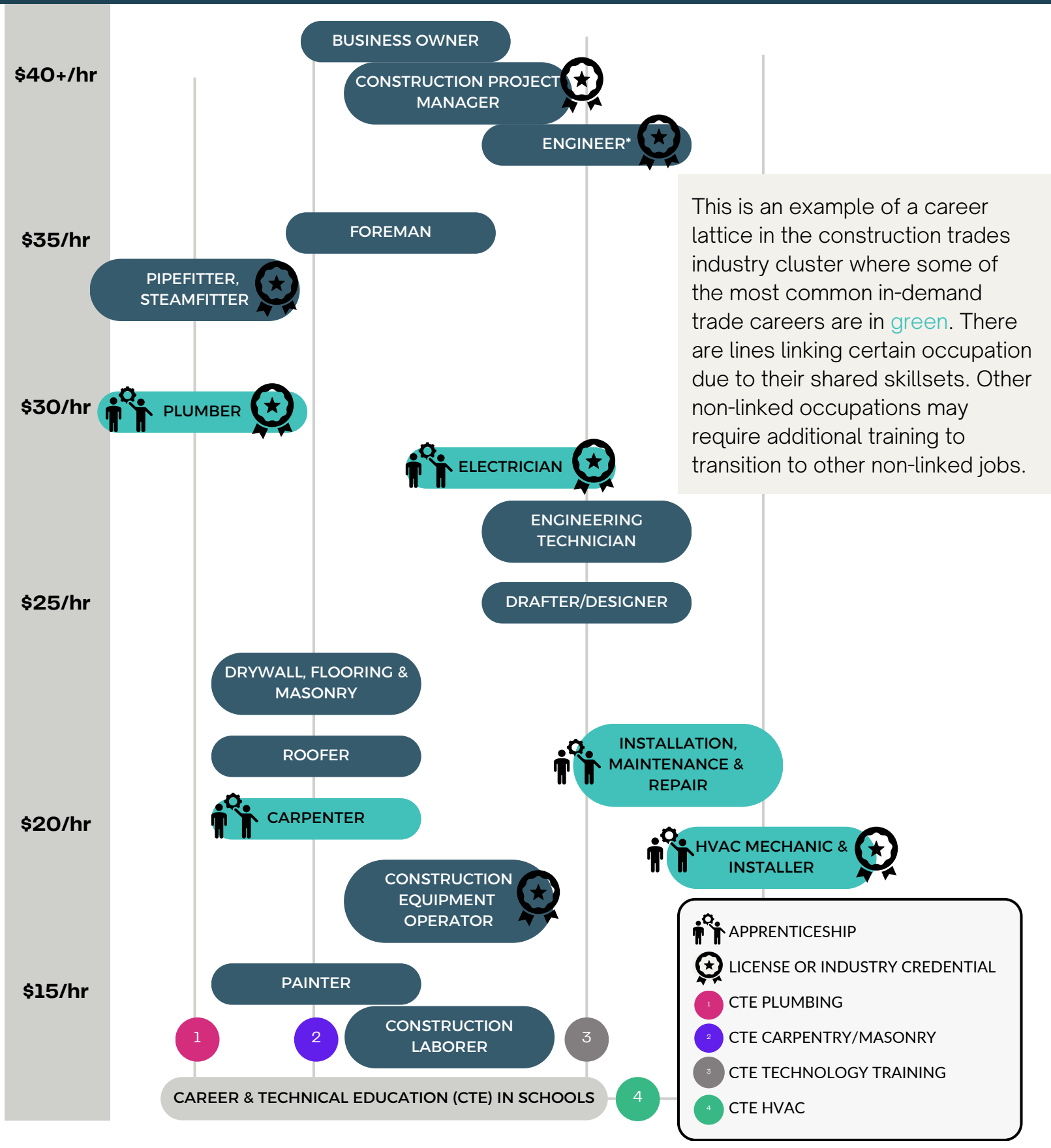
At Every Stage of Education, the Value Proposition Evolves:

- **Elementary:** Focus on making the learning experience fun and captivating, igniting interest in construction.
- **Middle School:** Engage students with applied learning to enrich their understanding of IOC.
- **High School:** Highlight the employment and pay opportunities available in IOC to help students see the tangible rewards of pursuing this path.
- **2-Year Colleges:** Emphasize job placement and career growth to bridge academic learning with industry demands.
- **4-Year Colleges:** Showcase the career trajectory, networking opportunities, and leadership potential within the IOC field.
- **Industry Professionals:** Provide professionals with opportunities to reduce risks, advance their careers, and continue learning as the industry evolves.

Structure of the Curriculum

The roadmap is modular, offering flexible learning objects that are stackable and oriented around real-world problem-based learning. Each 250-minute module includes a mix of synchronous (in-person or online) and asynchronous learning, designed to be manageable and highly relevant for a rapidly changing industry. Modules are customized or semi-customized to individual learning needs, from introductory to advanced.

Example Career Pathway in Construction Trades



This is an example of a career lattice in the construction trades industry cluster where some of the most common in-demand trade careers are in green. There are lines linking certain occupation due to their shared skillsets. Other non-linked occupations may require additional training to transition to other non-linked jobs.

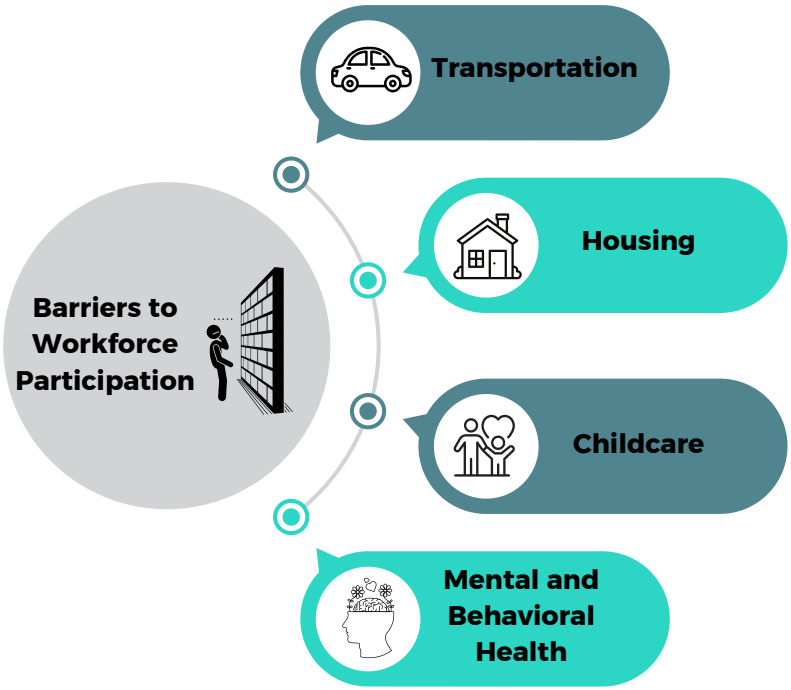
Goal 3

Create a robust IOC workforce pipeline

Strategy 3.4: Identify and address systemic barriers to workforce participation

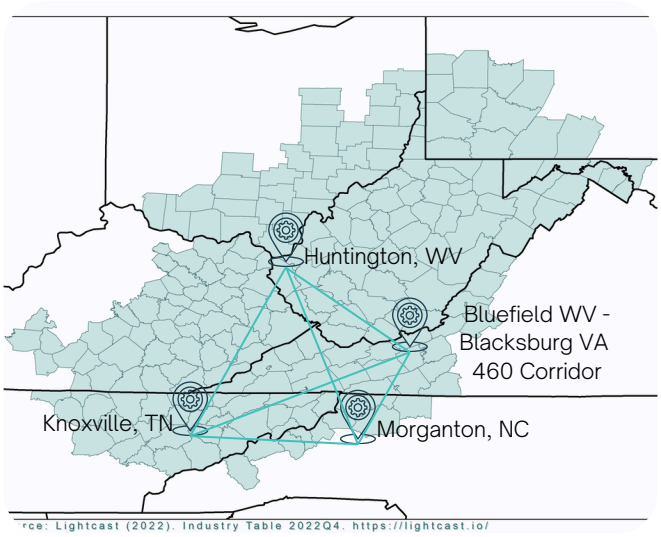
In discussions and across all workshops, stakeholders agreed that Central Appalachia faces serious systemic challenges that would not only detrimentally affect their populations, but also serve as barriers to workforce participation for some workers. For many employers, some of the most common factors leading to absences and withdrawals from work are lack of or poor condition of cars or alternative transportation, limited access to affordable child care, and/or mental or behavioral health challenges. Increasingly, reliable and quality housing is becoming another barrier to gaining and maintaining employment, as the aging housing infrastructure continues to deteriorate.

Historically, many of these barriers have been overcome through community and employer collaboration and the use of social networks as safety nets. Today, we rely more on the transactional relationships developed through our economic system. While this approach can offer more options, many of these services and daily staples have proven to illustrate market failures in the system; many workers do not make an adequate amount of income to afford these essential services and staples.



Goal 4

Develop regional "living labs" that focus and integrate technology development, experiential learning, and business development resources



Possible Central Appalachian Hubs for IOC

"Living labs" are spaces involving real-world environments and/or challenges where multiple stakeholders can collaborate and collectively solve real-world problems. These hubs would coalesces different industry, workforce, and technological services while networking and creating access to other hubs' services across Central Appalachia. Based on the working partnerships to-date, four possible hubs have emerged: Huntington, WV, home of Marshall University and the Coalfield Development nonprofit; a partnership between Bluefield, WV and Virginia Tech in Blacksburg, VA; Knoxville, TN, a prime location for housing manufacturers across eastern Tennessee as well as University of Tennessee, the state's manufacturing extension partner; and Morganton, NC, with partners at West Piedmont Community College and Appalachian State University leading in the development of an industrialized construction tech hub.

Huntington, WV

This hub would feature Marshall University's Advanced Manufacturing Center, a major source of industry engagement. It would also inform workforce development outreach and practices of the IOC initiative, drawing from the experience and success of Coalfield Development in reaching and supporting hard to reach populations in the workforce. This hub could serve as a tremendous example of workforce pipeline development and alignment among different institutions' workforce programming, from elementary upward.

Note that Huntington is also the northern end of an I-73/74 corridor initiative to widen the highway while supporting the economic development of industry and communities along the corridor. The southern end of this corridor is Bluefield, WV, another potential hub.

460 Corridor: Bluefield, WV to Blacksburg, VA

US 460 connects Bluefield, WV with Blacksburg, VA and could serve as a launching point for new IOC businesses and technology. Bluefield's network of resources, coordinated through Bluefield WV Economic Development Authority, has worked with and attracted many businesses in the area such as Omnis Building Technologies. Down the road in Blacksburg, Virginia Tech (VT) has nationally renowned expertise in smart construction and advanced manufacturing. Through efforts like the AM2 Tech Hub initiative, IOC-related startups and companies can collaborate with VT and the state's manufacturing extension partner to commercialize and adopt 3D printing and advanced materials technologies for building construction.

Knoxville, TN

Eastern Tennessee is particularly strong in manufactured housing and IOC, being home to many active IOC manufacturers (e.g. Wind River Built) and industry groups (e.g. AGC East Tennessee). Situated in the middle of this IOC cluster, Knoxville serves a natural hub of economic activity in the region and is home to University of Tennessee (UT), a statewide system the includes the state's manufacturing extension partner and the Center for Industrial Services and Institute for Public Services. With UT Knoxville's strong collaborative network of companies, technical assistance providers, and workforce development, this region is a prime option for a hub that coalesces an assortment of services and expands upon the existing industry cluster.

Morganton, NC

Western North Carolina has developed a partnership consortium focused on developing an industrialized construction ecosystem serving regional affordable housing needs. Focus primarily in the Morganton MSA, consortium partners include Western Piedmont Community College, Howard Building Science, Advanced Energy, the Industrial Commons, and Western Piedmont Council of Governors.

Lessons learned during this western NC IOC ecosystem development and the planning of the Central Appalachian IOC implementation initiative are currently being shared via mutual partners. This partnership could continue in the form of a hub in NC, part of the larger Central Appalachian network.

Strategy	Possible Lead Hubs or Partners
1.1 Public marketing campaign	ADL Ventures, state MEPs
1.2 Outreach to financial institutions	ADL Ventures, UT-Knoxville
1.3 Policy & regulatory development	Virginia Tech, ADL Ventures
2.1 Financial network for IOC businesses	UT-Knoxville, Morganton Hub
2.2 Regional IOC industry and advocacy group	ADL Ventures, UT-Knoxville, Virginia Tech
2.3 Networked business and technical services via concierge program	State MEPs, 460 Corridor and Knoxville Hubs
3.1 Engagement and curriculum for grades 4 through 12	460 Corridor, Huntington, and Morganton Hubs
3.2 Certificate and 2-year degree curriculum for IOC	Huntington, Morganton, and 460 Corridor Hubs
3.3 Youth pipeline and marketing material	Virginia Tech, ADL Ventures, dissemination across all hubs
3.4 Identifying and promoting promising practices in addressing workforce participation barriers	Virginia Tech, dissemination across all hubs

Goal 5

Foster an adaptive and proactive environment for IOC in Central Appalachia

The construction industry is changing, and IOC will continue to evolve and adapt to evolving market and global environments. As such, Central Appalachia must foster an environment of reflection, continuous learning, and evaluation. IOC programs and living labs should periodically set standards and metrics of success, both individually and collectively within the larger Appalachian IOC ecosystem.

Strategy 5.1: Develop measures of success specific to each activity, program, or strategy

Indicators or metrics of success should align with expected outcomes of each activity as it pertains to the growth of an innovation ecosystem for Industrialized Offsite Construction and ultimately growth of IOC businesses and employment in Central Appalachia. Indicators may include those that measure activity outputs, outcomes, and impacts; however, they should logically link to illustrate a theory of change. While activity indicators should remain the same across regions, the degree of success for those measures will vary based on the context of the hub's service area. When developing these measures, implementation partners should consult industry partners to confirm the validity of the measure (i.e. does the measure actually illustrate the desired outcome for industry?). Already, the project team has begun aligning anticipated outcomes of curriculum with success metrics as seen in the next two pages.

Strategy 5.2: Set regular deadlines and meetings for reflecting on success metrics and outcomes of activities, programs, and strategies, culminating in a final evaluation of the pilot initiative and future steps.

Quarterly meetings with key implementation partners and biannual meetings with a larger consortium of stakeholders will ensure that success metrics collected will be less of an administrative exercise and more of a tool for continuous improvement and trouble shooting. Such a schedule and discussions should normalize and encourage reflection.

Exploring Assessment Metrics

While the authors of this roadmap do not wish to dictate measurable success outcomes along this roadmap, we provide some guidance and ideas that could culminate into viable success metrics for future curriculum. A few important points to consider:

- This field of study and work tends to attract people who may not excel within the traditional course framework. Performance assessments that take the form of tests, for instance, may not be the best approach. A more formative approach, which measures project-based work that illustrates learning and application, may better illustrate learning outcomes.
- When evaluating programs like these, it is important to understand the evaluation capacity of the teachers and education institutions, making assessment easy to implement. A balance between what is best to measure and what can be easily measured is important to programmatic success and sustainability.
- The final impacts of this roadmap should be seen at the industry level. While it is important to measure the success of these specific education programs, ultimate success should be determined by students' performance in the workforce. Thus, continued industry engagement and feedback is necessary to assessing overall success.

Stage	Learning Objectives	Expected Outcomes for Industry
Grades 4-8	• Introduce fundamental concepts of IOC, including sustainability, construction basics, and teamwork • Foster interest in STEM (Science, Technology, Engineering, and Math) through hands-on projects and activities • Develop early problem-solving and critical thinking skills through practical IOC examples	• Students demonstrate an understanding of the basic principles of IOC and how it differs from traditional construction • Increased student interest in STEM and construction-related extracurriculars • Ability to apply basic problem-solving techniques to simple construction challenges
Grades 9-12	• Build foundational skills in construction technology, safety standards (OSHA 10/30), and sustainable building practices • Introduce digital tools used in IOC, such as CAD software and BIM • Encourage career exploration through job shadowing, site visits, and mentorship	• Students gain basic certifications (e.g., OSHA 10/30) and demonstrate safe work practices. Students obtain trades professional certification (e.g. PHIUS) • Students create simple digital models or design projects using CAD or BIM software • Increased interest in construction-related college courses or apprenticeships
Certificates and 2-Year Degrees	• Develop technical skills in IOC methods, including offsite fabrication, modular construction, and advanced building materials • Emphasize practical application through hands-on lab work, internships, and cooperative education experiences • Expand understanding of energy-efficient building systems, including PHIUS principles	• Students are proficient in reading and interpreting blueprints and use software to design simple modular components • Graduates demonstrate the ability to perform basic IOC-related tasks under supervision in a job setting • Students complete projects demonstrating knowledge of energy-efficient construction methods

Exploring Assessment Metrics (continued)

Stage	Learning Objectives	Expected Outcomes for Industry
4-Year Degrees	• Gain a comprehensive understanding of IOC processes, including supply chain integration, project management, and Lean principles in Manufacturing and Construction • Master advanced IOC concepts, such as DFMA (Design for Manufacture and Assembly), JIT (Just-In-Time) delivery, and IPD (Integrated Project Delivery) • Explore emerging trends in IOC, including sustainable practices and climate-resilient construction • Integrate advanced digital construction tools, such as VR/AR, for design and project visualization • Foster leadership and communication skills necessary for team-based project execution in IOC	• Graduates can develop and manage IOC projects, including scheduling, budgeting, and resource management • Ability to present IOC design concepts using digital tools and demonstrate virtual walkthroughs of project designs • Graduates effectively lead teams in collaborative IOC projects and communicate technical concepts to diverse audiences
Industry Professionals (continuing education)	• Master advanced IOC concepts, such as DFMA (Design for Manufacture and Assembly), JIT (Just-In-Time) delivery, and IPD (Integrated Project Delivery) • Explore emerging trends in IOC, including sustainable practices and climate-resilient construction • Focus on continuous improvement strategies, leveraging Lean construction practices to streamline operations	• Industry professionals can lead IOC projects from concept through completion, optimizing efficiency and quality • Demonstrated ability to apply cutting-edge techniques to projects, improving sustainability and adaptability • Measurable improvements in project timelines, reduced waste, and cost savings
Retiring Professionals Instructor Pathways (IOC Trainers)	• Equip instructors with curriculum development skills tailored for IOC education and training • Develop skills in mentorship and coaching, focusing on nurturing the next generation of IOC professionals • Ensure understanding of current industry certification requirements and best practices	• Instructors develop engaging training modules that meet industry standards and student needs • Instructors demonstrate effective mentorship, with mentees showing significant progress in their learning objectives • Instructors ensure students meet or exceed industry certification standards

Initial Implementation Steps

First 6 months	**Identify 2-5 implementation hubs. Key factors:** • **Evidence of good partner** • **Identified regional need to grow IOC** • **Capable of small wins**
Years 1-2	**Develop programming:** • **IOC curriculum development 5th grade to community college** • **Create marketing and education materials** • **Hub-specific implementation projects**
Years 2-4	**Pilot programming in hubs and develop sustainability plans**
Year 5	**Assess and evaluate for future expansion**

Resources

In addition to the primary data gathered during this project, the project team has cited several key resources:

[1] Bertram, N., S. Fuchs, J. Mischke, R. Palter, G. Strube, and L. Woetzel (2019). Modular construction: From projects to products. McKinsey & Company. Retrieved from: https://www.mckinsey.com/capabilities/operations/our-insights/modular-construction-from-projects-to-products

[2] Brinkman, G. et al. (June 2021). The North American Renewable Integration Study: A U.S. Perspective. National Renewable Energy Laboratory (NREL). Retrieved from: www.nrel.gov/docs/fy21osti/79224.pdf

[3] IBISWorld (2024). Industry Reports: 23 - Construction in the US and 32199A Prefabricated Home Manufacturing in the U.S.

[4] The Business Research Company. (2024). Modular Construction Global Market Report 2024—Research and Markets. Retrieved from: https://www.researchandmarkets.com/reports/5790844/modular-construction-global-market-report

[5] Narrower IOC business questionnaire

[6] Davis, M. (2022). What Is Construction Automation, and How Will It Drive the Future of Building?

[7] (March 2024). Industry Tables. Lightcast

[8] Database developed by Virginia Tech Center for Economic and Community Engagement, drawing from over a dozen websites including government databases and education institution websites.

[9] Developed by Virginia Center for Housing Research based on seven regional workshops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